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Minerals Yearbook
1971

Volume I

METALS, MINERALS, AND FUELS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR ● Rogers C. B. Morton, Secretary

BUREAU OF MINES ● Elburt F. Osborn, Director

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.

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Foreword

This edition of the Minerals Yearbook marks the 90th year in which an annual report on the minerals industry has been published by the Federal Government. This edition provides a statistical record on global mineral industry performance during 1971, and contains sufficient background information to interpret the year's developments. The general 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 these industries, a statistical summary, and chapters on employment and injuries and on technologic trends.

Volume III, Area Reports: International, presents the latest available 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 chapter, identical with that in Volume I, and a chapter on employment and injuries.

Volume III, Area Reports: International, presents the latest available mineral statistics for more than 130 foreign countries and discusses the importance of minerals to the economies of these nations. A separate chapter reviews minerals and their relationship to the world economy.

The continuous effort of the Bureau of Mines to improve the value of the Yearbook for its users can be aided by comments and suggestions. Toward that end, the constructive comments and suggestions of readers will be welcomed.

ELBURT F. OSBORN, *Director*

Acknowledgments

Volume I, Metals, Minerals, and Fuels, of the Minerals Yearbook is the cooperative effort of the headquarters divisions and offices of the Bureau of Mines Mineral Supply Activity. All chapters in this volume were prepared by these staffs except for the chapter on Injury Experience and Worktime, which was prepared in the Health and Safety Activity.

The collection and compilation of statistical data on the domestic minerals and mineral fuels industries were performed by the statistical staffs of the Divisions of Ferrous Metals, Fossil Fuels, Nonferrous Metals, and Nonmetallic Minerals. These data were compiled from information supplied by mineral producers, processors, and users in response to production and consumption canvasses, and their voluntary response, which is indispensable in preparing this volume, is gratefully acknowledged. The information obtained from individuals 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 concerned has been granted.

Tabular material on U.S. imports and exports, world production, and foreign country trade was compiled in the Office of Technical Data Services. Foreign trade data on 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 many sources, including reports from the Foreign Service, U.S. Department of State.

The Office of Technical Data Services also provided general direction 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 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 some 45 cooperating State agencies. These organizations are listed in the acknowledgment section of Volume II.

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

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Review of the Mineral Industries

By Daniel E. Sullivan [1] and Jeannette I. Baker [2]

During the first half of 1971, rising prices, slacking industrial production, and high unemployment continued to characterize the U.S. economy. By midyear, with problems mounting, the President announced a set of strong measures that were deemed necessary to correct the situation. The New Economic Policy (NEP) included a wage-price freeze, a 10-percent import surcharge, a repeal of the Federal excise tax on automobiles, a cut in foreign economic aid, and a number of tax measures designed to increase employment and ease the balance of payments situation. The program slowed the rate of inflation and eased the international pressures on the dollar. During the second half of 1971 employment rose, but because of an increase in the work force, the unemployment rate did not change. Real gross national product (GNP) increased in the fourth quarter although the Federal Reserve Board (FRB) Index of Industrial Production was sluggish.

Prices continued to rise in the first part of 1971. Consumer prices increased less rapidly in the early part of 1971 because of declining interest rates for home mortgages. When leveled out, the consumer price index began to rise more sharply again, reflecting a continuation of substantial price increases for most goods and services. Excluding mortgage costs, the price increase in the first half of 1971 was close to the 5-percent increase recorded in the second half of 1970. Wholesale prices rose at a 5-percent annual rate in the first 8 months of the year. During the freeze period, industrial commodity prices declined, and farm and food prices declined seasonally. Consumer prices rose less than 2 percent.

Real output grew at a disappointing rate for a recovery period. At market prices, the GNP increased 7.5 percent in 1971. Real GNP expanded 2.7 percent, and the implicit price deflator increased 4.6 percent. When the quarterly data are examined, they show a strong growth in the first quarter, slower growth in the second and third quarters, and a better fourth quarter. Slack inventory demand can be blamed for the slow rate of recovery. The FRB Index of Industrial Production reflected the slow recovery. From November 1970 to August 1971 it had increased only 2.6 percent and was 6 percent below the level of the fall of 1969. The mining and metal sectors reflected the same sluggishness.

There was little reduction in unemployment in 1971. In the first half employment was roughly stable, and unemployment did not change. In the second half of the year, employment grew strongly, but so did the labor force, so unemployment continued at about the same level. The average unemployment rate was 5.9 percent, which was a decade-long high.

A generally expansive monetary policy was in effect in 1971. It was aimed at insuring that the credit needs of the expansion were met without difficulty. Interest rates declined. In early 1971 the growth of the money supply was sluggish but soon grew rapidly until midsummer. Interest rates, which were declining at the beginning of the year, then began to rise. After NEP was implemented, the money supply grew at a slower rate and interest rates declined to levels below those at the beginning of the year. The growth of the money supply for the year was 6.2 percent.

Federal fiscal policy was also expansive. There was a $10 billion increase in the actual budget deficit on the National Income Accounts basis. When NEP was implemented, the excise tax on automobiles was repealed and other taxes were cut.

Official U.S. gold reserves declined slightly during 1971. Most of this was in the first half of the year; the reserve was level during the second half of the year.

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[1] Economist, Office of Economic Analysis.
[2] Commodity research specialist, Office of Technical Data Services.

Bureau of Mines research programs continued to be directed toward developing more effective, efficient, and less costly extraction, processing, and utilization techniques. Programs in health and safety of miners also received prominent attention, as did programs to alleviate the problems in solid waste recovery.

Total world trade increased in 1971, but the growth was not so great as that of 1970. Although U.S. trade increased, the balance of payments situation worsened.

SOURCES AND USES OF MINERALS

Production.—In 1971, domestic production of primary minerals and mineral fuels was valued at $30.7 billion or, in 1967 constant dollars, $26.7 billion. The value of mineral fuels and nonmetals each increased more than 5 percent, and metals declined more than 13 percent.

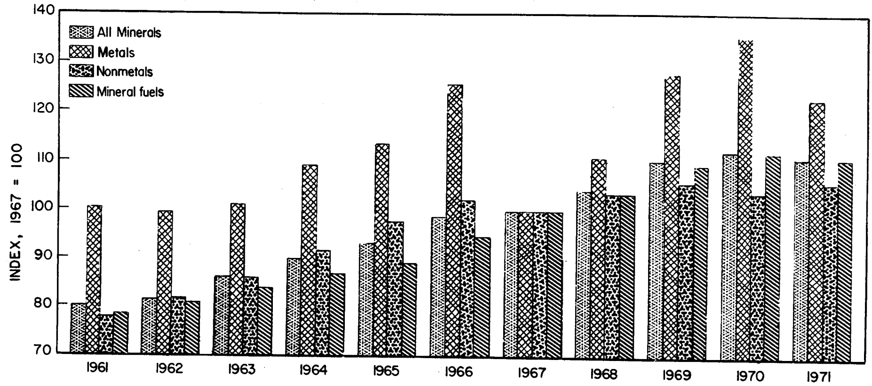

Figure 1.—Indexes of physical volume of mineral production in the United States, by groups.

The Bureau of Mines index of physical volume of mineral production (1967 = 100) declined in 1971; the total index lost 1.5 points for the year. Although the overall average for metals declined from 135.8 to 122.7, there were only small movements in the nonmetals and fuels components of the index. Ferrous metals declined more than 10 percent, and nonferrous metals declined more than 9 percent. Little change was recorded for nonmetals production. Coal declined over 9 percent, and crude oil and natural gas gained less than 1 percent.

These index numbers constitute an updating of the index numbers originally prepared by Y. S. Leong, "Index of the Physical Volume Production of Minerals, 1880–1948," Journal of the American Statistical Association, March 1950. Subsequently, Leong made revisions in his index for 1930–48 to take account of a new natural-gas production series. Using essentially the same methods, the Bureau of Mines has brought the indexes up to date and has converted the entire index to a 1967 base. Leong included 63 series in his index, representing 98 percent of the value of all minerals produced in the United States in the base period 1935–39. The number of series is smaller in the earlier years of the index, partly because new minerals came into production during the long period covered, and partly because data for minerals in production were sometimes not available in the earlier years. Estimates were used in some cases when actual production data were not available. Over the long period covered, the indexes were constructed by linking seven overlapping segments with seven different sets of value weights (value at the mine, actual or estimated). The weighting periods used were 1889–91 for 1880–1903; 1909–13 for 1897–1920; 1923–25 for 1917–39; 1935–39 for 1929–48; 1947–49 for 1941–56; 1957–59 for 1952–64; 1967 for 1962–71. The separate segments of the indexes were spliced to form continuous series covering the entire period by selecting a particular year as the splicing origin and deriving averages of the two segments for a 3- to 5-year period centered on the splicing origin.

During 1971, the FRB Index of Industrial Production (1967 = 100) declined from 106.7 to 106.4. All mining segments except gas and gas liquids also declined. Coal mining, for example, dropped to 99 index points, a 6.3-percent decline. The index for crude oil production declined by 1 percent and natural gas gained 1.5 percent. Metal mining and stone and earth minerals declined by 7.5 and 5.7 percent, respectively.

Industrial production of metals and nonmetals was mixed but generally downward in 1971. Primary metals, iron and steel, and nonferrous metals and products all continued the declines of 1970. Clay, glass, and stone products rebounded and gained 3.6 percent. The FRB monthly indexes of mining production (1967=100) showed a decline in mining activity during the first half of 1971 and a leveling out, except for a dip because of the coal strike, during the second half of the year. Coal followed this trend except for the low in the fall due to the strike and the rebound after the strike. Crude oil and natural gas stayed level for most of the year and declined near yearend. Metal, stone, and earth mining declined during the first half of the year and increased in the second half of the year.

Total mineral energy resources and electricity from hydropower and nuclear power in 1971 was 61,116 billion British thermal units (Btu), slightly less than the total for 1970. Of the fossil fuels group, only natural gas increased. Nuclear power recorded the greatest percentage gain.

In 1971 the domestic supply of both anthracite and bituminous coal declined. Exports of anthracite decreased slightly, and bituminous coal exports declined 20 percent from 71 to 57 million short tons. Imports of bituminous coal increased from 36,000 to 111,000 short tons. The total domestic supply of bituminous coal fell to 494.9 billion short tons; that of anthracite to 7.3 million short tons in 1971.

Production of domestic natural gas increased to 22,493 billion cubic feet, up 2.6 percent. Exports were more than 80 million cubic feet, an increase of 14.9 percent, and imports increased 14 percent to 935 million cubic feet. Total supply of natural gas reached 22,132 billion cubic feet for the year.

Petroleum supply showed a decline in crude oil production to 3,453.9 million barrels, compared with 3,517.5 million barrels in 1970. Exports declined to 0.5 million barrels from 5.0, but imports increased 26.9 percent to 613.4 million barrels. The total supply of crude petroleum increased to 4,087.8 million barrels.

The net supply of principal minerals was generally down in 1971. In the metals category, the net supply of iron ore decreased almost 10 percent, and pig iron decreased more than 10 percent. All other ferrous metals declined except manganese, which increased 5 percent. Most nonferrous metals declined, with aluminum as a notable exception. The general trend in nonmetals was also downward; gypsum and potash were exceptions.

Stocks and Government Stockpile.—The Bureau of Mines index of stocks of crude minerals (1967=100) for metals and nonmetals increased 13 percent to 148 in 1971. Metal stocks jumped 30 percent to 147. Iron ore increased 15 percent; other ferrous ores increased 196 percent owing to increases in molybdenum stocks. Nonferrous metal stocks increased 2 percent. Nonmetallic stocks declined slightly. The index of stocks held by mineral manufacturers, consumers, and dealers declined 3 points in 1971. Metal stocks declined 2 points; but within this group, iron increased 6 points, other ferrous increased 22 points, base nonferrous declined 17 points, and other nonferrous increased 4 points. Nonmetals declined 13 points.

Producer stocks of coal and related products declined; those for petroleum and related products were mixed. Stocks of bituminous coal and lignite declined 2.5 percent. Crude petroleum stocks decreased 6 percent, and gasoline stocks increased 4.4 percent. Natural gas stocks were up 9.9 percent at yearend.

The seasonally adjusted book value of product inventories for selected mineral processing industries showed mixed results in 1971 compared with increases in all categories in 1970. Energy and nonmetals showed decreases in inventories, and primary metals showed increases in inventories. For petroleum and coal products the decrease was 4.2 percent, lowering the value of inventories to $2,433 million. A 14.5-percent decrease in inventories was posted by stone, clay, and glass products, lowering the value of inventories to $2,263 million in December 1971. The seasonally adjusted book value of primary metals inventories totaled $9,195 million, a more than 3.7-percent gain. The primary metals inventories were about equally divided between blast furnaces and steel mills ($4,800 million) and other primary metals ($4,395 million), but the gain was less than 2 percent for the former and 6 percent for the latter. For selected mineral processing industries, the total seasonally adjusted book value of inventories declined 1.1 percent during the year.

Among the components of the Nation's minerals supply was the national stockpile of strategic materials. In terms of market value, aluminum, metallurgical chromite, copper, industrial diamond stones, lead, metallurgical manganese, tin, tungsten, and zinc were all important stockpile commodities during 1971.

Exports.—The total value of selected minerals and mineral products exported declined 21.9 percent in 1971, a sharp contrast to the 26-percent increase in 1970. Accounting for the decline in mineral exports was a 48.2-percent decline in crude and scrap metal exports and a 36-percent decline in manufactured metal exports. Crude nonmetallic mineral exports, and mineral energy resources and related product exports declined 2 and 6 percent respectively; chemical exports and manufactured nonmetallic mineral exports increased 11 and 3 percent, respectively. In 1971 coal was down 8.9 percent, compared with a 64-percent gain in 1970; and metals, which had shown substantial gains in 1970, showed substantial losses in 1971.

Imports.—In 1971 the total value of selected mineral imports advanced more than 7 percent to $9.3 billion. Increases were recorded in all major mineral categories except crude nonmetallics and crude and scrap metals. Imports of mineral energy resources climbed 21 percent, led by a more than 30-percent increase in petroleum products imported. Chemical imports recorded an overall increase of more than 5 percent in 1971. Manufactured nonmetals and metals were up more than 12 and 15 percent, respectively.

Consumption.—The consumption pattern for major mineral products was generally mixed but was down during 1971. Iron ore consumption dropped 11.6 percent in 1971 continuing the declining trend set in 1970, when it dropped 4 percent. Raw steel consumption similarly trended downward, as did all other ferrous metals. Among nonferrous metals only aluminum, lead, zinc, and silver did not decline. Copper declined 1.1 percent, and mercury dropped 14.7 percent.

In the nonmetals category, sulfur consumption increased slightly. Both phosphate rock and potash were up. Mineral energy resources were mixed, with more commodities increasing than decreasing. Bituminous coal consumption was down slightly, and both petroleum and natural gas consumption increased. In general, consumption of metals in 1971 was down, and consumption for both nonmetals and energy was mixed.

In 1971 the demand for electricity increased to 1,718 billion kilowatt-hours, a 4.7-percent increase. Utilities scored a 5.4-percent gain as all categories increased; hydropower increased 7.4 percent; nuclear power, 73.9 percent; and conventional fuel burning plants, 3.8 percent.

Energy consumption in the United States reached a new high in 1971; preliminary estimates indicate that the Nation's 1971 demands for heat, light, and power in all forms required energy equivalent to 68,790 trillion Btu. This is a 2.3-percent increase in consumption over last year, somewhat lower than the 3.5-percent consumption rise of 1970.

Total demand in 1971 was met largely through a combination of increased domestic production of natural gas and petroleum products and increased imports of crude oil and petroleum products.

Electric utilities showed the largest consumption gain, using 6.3 percent more energy for power generation than in 1970. Transportation needs grew by 3.8 percent, and household and commercial uses, 2.6 percent. Industrial uses decreased by slightly more than 1 percent from those of 1970, largely because of the general reduction in industrial activity, and the relatively mild weather in 1971.

Petroleum, including natural gas liquids, supplied 44 percent of all domestic energy needs. Natural gas was next, supplying 33 percent, followed by bituminous coal, 17 percent; water power, 4.1 percent; nuclear power, 0.6 percent; and anthracite, 0.3 percent.

Coal remained the major fuel for generating electric power. Electric utilities accounted for 66.6 percent of all the coal consumed in 1971. Total consumption of bituminous coal and lignite dropped 4.0 percent to 494.9 million tons, largely the result of supply shortages following a 6-week national coal strike. Anthracite consumption declined 11.0 percent to 7.3 million tons.

Domestic demand for natural gas increased in all consuming sectors, to total slightly over 22 trillion cubic feet, a 2.9-percent gain over that of 1970.

Crude oil output declined 1.8 percent from that of 1970. Imports of crude oil increased slightly more than 25 percent with the resumption of deliveries that were less than normal during 1970 because of production restrictions and oil tanker shortages that year. Demand for petroleum products and natural gas liquids rose 3.5 percent to 5.6 billion barrels.

Nuclear power generation increased its small share of the energy market 73.9 percent to 37.9 billion kilowatt-hours. Utility hydropower generation increased 7.4 percent to 267.8 billion kilowatt-hours.

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment in selected minerals mining and manufacturing was significantly lower in 1971. Total mining employment declined over 3 percent to 601,000. Nonmetal mining and quarrying and metal mining all declined significantly after increasing last year. Copper ore mining declined 6.2 percent, and total metal mining employment declined 6.1 percent to 89,000. Among fuels, all selected mineral fuel industries declined, led by bituminous coal at 4.7 percent and oil and gas field services at 3.9 percent. Crude petroleum and natural gas fields employment declined about one-half of 1 percent.

In 1971, minerals manufacturing employment decreased to 850,200. All categories declined, although fuels declined the least, and petroleum refining declined the least among the fuels. In general, employment in minerals mining and manufacturing declined significantly. This decline was reflected in all categories of the selected mineral industries.

Hours and Earnings.—For the total mining sector, hourly earnings advanced 6 percent to $3.88, compared with a 6.7-percent increase in 1970 and a 7.9-percent increase in 1969. Weekly earnings increased at about the same rate as in 1970, and weekly hours worked declined from 43.8 to 43.4. In the metal mining group, average hourly earnings climbed to $4.12; hourly earnings for both copper and iron ore mining were slightly above the average metal mining level. Average weekly hours for metal mining declined from 42.7 to 41.6 hours; average weekly hours for iron ore declined to 40.5; and for copper ore the comparable figure declined to 42.9. The mineral fuels industries recorded hourly earnings of $4.22, a 6.3-percent increase. Once again the highest average hourly and weekly earnings were posted by bituminous coal mining, although average weekly hours fell slightly. Average weekly earnings and hours for crude petroleum and natural gas were up, but average hourly earnings fell slightly.

Average hourly earnings for manufacturing industries rose by 7.9 percent in 1971. In the cement industry hourly earnings gained 9.9 percent, less than the 13-percent gained in 1970. Hourly earnings in the fertilizer industry, which are historically low compared with other mineral commodities, increased over 7.5 percent to $3.13 an hour. Weekly hours were down slightly from 1970 in the fertilizer industry. A 8.3-percent increase in average hourly earnings increased weekly earnings for blast furnaces and steel and rolling mills, in spite of a slight decrease in weekly hours. Although hourly earnings advanced 6.3 percent for nonferrous smelting and refining, a slight decrease in weekly hours caused the growth in weekly earnings to be 5.8 percent. Hourly and weekly earnings for petroleum and related industries climbed over 7 and 6 percent to $4.58 and $194.19, respectively. Little change in working hours was posted for this group.

Labor Turnover Rates.—The accession rate (hires and rehires) for selected mineral industries declined in most categories during 1971. The rate for metal mining declined as did the rates for iron ore and copper ore mining. The only rate that increased was that for blast furnaces and steel and rolling mills. Hires and rehires per thousand employees declined for nonferrous smelting and refining, hydraulic cement, and total manufacturing, although only slightly for the latter two. Accession rates for the fuel industries were down. Most selected mineral industries experienced decreased separation rates in 1971. The exceptions were blast furnaces, steel and rolling mills, nonferrous smelting and refining, and coal mining. The layoff rate for 1971 was varied, up for five industries, down for four, and unchanged for petroleum refining. The layoff rate for blast furnaces and steel and rolling mills climbed from 12 to 30 per thousand employees.

Wages and Salaries.—An upward trend continued for wages and salaries in all industries during 1971. Wages and salaries increased 5.8 percent, to $573 billion, somewhat short of the 6.3-percent increase in 1971. In the mining sector wages and salaries again increased faster than in the manufacturing industries. Total mining wages and salaries increased 4.4 percent to $6.1 billion. Wages and salaries in manufacturing rose 1.3 percent to $160.4 billion. Average earnings per full-time employee for all industries increased 6.5 percent, less than the 6.7-percent increase in 1970. Average earnings in mining increased 6.2 percent, to $9,854, down from last year's 7.6-percent increase. Average earnings in manufacturing increased 5.9 percent, to $8,638 almost matching the increase in mining.

Productivity.—The most recent data on labor productivity in the mineral industry generally showed declines in output per employee, output per production worker, and output per production worker man-hour. Copper mining showed slight gains; iron mining, petroleum, and bituminous coal and lignite mining registered losses in productivity. Copper ore mined per production worker man-hour increased 4.8 percent during 1970 (latest data available) to 121.8 index points; recoverable metal mined per production worker man-hour advanced 4.3 percent to 111.5, the largest percentage advance in the last 5 years. Productivity losses in both crude and usable iron ore were very small. Petroleum refined per production worker man-hour decreased 3.1 percent to 102.8 in 1970. Productivity indexes for bituminous coal and lignite mined per production worker man-hour declined 3.3 percent to 107.2.

PRICES AND COSTS

Index of Average Unit Mine Value.—The index of average unit mine value (1967=100) increased 3 percent in 1970. The total index climbed to 115.0. Fuel made the largest gain, 5.6 percent; nonmetals gained 1 percent, and metals declined 3.1 percent. Ferrous metals increased less than 0.2 percent, and nonferrous base metals declined 8.3 percent. Monetary metals declined slightly, and other nonferrous metals gained slightly. All nonmetallic groups increased with the exception of nonmetallic chemicals. Coal rose almost 4 points, and crude oil and natural gas rose almost 7 points.

Index of Implicit Unit Value.—In 1971 the index of implicit unit value (1967=100) increased 3 percent to 115.1, less than the 1970 increase. The index for ferrous metals was up only slightly, and the average for nonferrous metals fell 7.5 percent. Base metals were down 9 percent, and monetary metals were down 1.4 percent and other nonferrous metals increased 2.5 percent. Nonmetals showed little change in advancing from 103.2 to 104.3. The fuels section increased 5.2 percent from 111.5 to 117.3. Coal increased 2.8 percent, and crude oil and natural gas increased 6.1 percent.

Prices.—During 1971, wholesale prices for metals and metal products increased 2 percent. Within this group prices ranged from a 17.5-percent decline in iron and steel scrap (which increased 25 percent in 1970) to a 10.2-percent increase in pig iron and ferroalloys. Nonferrous scrap declined 17.0 percent, compared with a 2-percent decline in 1970. In spite of the large individual declines in some commodities, the overall average increased because most commodities increased during the year. Prices of most nonmetallics also advanced during the year. Building materials posted large gains. Only three nonmetallic mineral prices declined in 1971; they were phosphates, 1.6 percent; phosphate rock, 11.2 percent; and potassium sulfate, 1.1 percent. Overall nonmetallic mineral products advanced 8.0 percent. Prices of fuel and related products and power increased 7.8 percent in 1971. Anthracite coal increased 10.4 percent and bituminous coal increased 22.0 percent. Coke increased 16.7 percent. Gas fuel prices declined 21.8 percent in 1971, but crude petroleum and petroleum products were up 6.7 and 5.6 percent respectively. The price index for all commodities increased 3.2 percent.

Mineral energy resource prices were up during 1971. Bituminous coal increased almost 25 percent, and anthracite prices increased at lesser percents. Prices of petroleum and petroleum products increased. Crude petroleum, for example, climbed to $3.39 per barrel, a 6.6-percent gain. Gasoline prices advanced 2.4 percent. The prices of residual and distillate fuel oil both gained. The average price of natural gas at the wellhead increased to 18.2¢ per thousand cubic feet.

During 1970 (latest data available), the average cost of electrical energy for the United States rose 0.1 cent to 1.6 cents per kilowatt hour. Both the residential market at 2.1 cents and the commercial and industrial markets at 1.3 cents per kilowatt hour showed no change in the average cost of electrical energy. Only four areas reported a change (all slight increases) in the total cost of electrical energy. They were the Middle Atlantic region, the East North-Central region, the West North-Central region, and the South Atlantic region. Alaska and Hawaii remained the highest cost areas for electrical energy; the East South-Central region remained the lowest cost area.

Principal Metal Mining Expenses.—The index of principal metal mining expenses (1967 = 100) trended upward in 1971. Overall the index climbed 5.5 percent. The labor component of the index also increased by 5.5 percent. The supply component increased 4.7 percent. Fuels increased 7.8 percent, compared with a 4.9-percent increase in 1970. Electrical energy increased 8.4 percent, almost three times the 2.7-percent increase for 1970.

Costs.—A general price rise characterized the index of relative labor costs and productivity for selected minerals. The index of labor costs per unit of output for iron ore recorded a 7.4-point increase, but for copper the comparable gain was 4.2 index points. The index of value of products per man-period was up 4.6 index points for iron ore; the one for copper declined 15.3 index points. The index of labor costs per dollar of product increased for both copper and iron ore.

The price indexes for mining construction and material handling machinery and equipment increased moderately in 1971. The smallest increase was a 0.1-percent change in portable air compressors; the next was a 3-percent change in mining machinery and equipment. The greatest price increase was in specialized construction machinery, which increased more than 6.5 per cent.

INCOME AND INVESTMENT

National Income Generated.—Although national income originating from all industries advanced 7.2 percent in 1971, national income generated in mining declined 0.4 percent. Metal mining declined the most, 12.9 percent; coal mining and nonmetallics declined only fractions. Crude petroleum was the only sector of mining to show a gain in 1971, 4.4 percent. The manufacturing sector increased 3.2 percent to $223 billion. Chemicals and allied products and stone, clay, and glass products increased 4.5 and 7.5 percent, respectively. Petroleum refining and related industries increased only 0.4 percent and primary metal industries declined 1.4 percent. Total national income for all industries reached $856 billion in 1971.

Profits and Dividends.—In 1971 the average annual profit rate on shareholders' equity for manufacturing was 9.7 percent, up 0.4 percent from the exceptional low of 1970. Profit rates for the selected mineral manufacturing corporations were mixed. Primary iron and steel and chemicals and allied products increased slightly; the latter continued to have the highest annual profit rate among selected mineral industries. Stone, clay, and glass products increased 2.2 percentage points to 9.1, which is near the 1969 level. Petroleum refining and related industries experienced only a slight decline of 0.7 percent. Primary nonferrous metals dropped 5.6 percentage points to a profit rate of 5.1 percent, a decline of greater than 50 percent. Total dividends for all manufacturing amounted to more than $15.3 billion, a 1.2-percent gain. Petroleum refining and related industries was the leader in total dividends among the selected mineral industries with a 2.8-percent advance to $3.3 billion. Stone, clay, and glass products and chemicals and allied products both increased more than 4 percent. Primary iron and steel and primary nonferrous metals showed decreases in total dividends of greater than 21 and 15 percent, respectively.

The total number of industrial and commercial failures in 1971 declined 3.9 percent to 10,300, although current liabilities increased 1.5 percent to more than $1.9

billion. In the mining sector 38 failures were reported with current liabilities of $15 million, compared with 54 failures in 1970 and $59 million in current liabilities. Manufacturing failures and liabilities were slightly less in 1971 than in 1970.

New Plant and Equipment.—In 1971, new plant and equipment expenditures by mining firms increased by $270 million to $2.16 billion, compared with a $30 million increase in 1970. The manufacturing industries experienced a decrease in new plant and equipment expenditures from $31.95 billion in 1970 to $29.99 billion in 1971. Among selected mineral manufacturing industries, only petroleum and coal products registered increased expenditures. Chemical and allied products maintained the same expenditure level as 1970; all others posted declines.

Plant and equipment expenditures of foreign affiliates of U.S. companies in mining and smelting gained $501 million or 36 percent during 1971. Mining and smelting expenditures declined for Latin America and increased 31 percent for Europe. An 84-percent gain for Canada and a 55-percent advance in other areas were also posted. Total petroleum expenditures reached $4,642 million, and all reporting areas showed gains. Manufacturing expenditures increased 3.5 percent to $6,751 million. Europe and Canada accounted for 73 percent of total manufacturing plant and equipment expenditures.

Issues of Mining Securities.—In 1971, estimated gross proceeds of new securities offered by the extractive industries totaled $1,283 million, compared with $2,082 million in 1970. Common stock accounted for 82 percent of the proceeds in extractive industry offerings; bonds contributed about 17 percent and preferred stock comprised 1 percent.

Sources and Uses of Funds.—Current data for funds for direct foreign investment by U.S. mining and smelting industries are not available; 1968 data were published last year. When further information becomes available, these tables will be resumed in the yearbook.

Foreign Investment.—The value of U.S. direct investments abroad for all industries amounted to $78.1 billion in 1970 (latest data available). Twenty-eight percent of this figure or $21.8 billion was attributed to investments in petroleum affiliates. Petroleum increased 9.6 percent in 1970, which was significantly greater than the increase in 1969. Sixty-seven percent or $1.3 billion of last year's $1.9 billion advance in the book value of foreign petroleum investments was accounted for by the developed countries. The less developed countries rose by $532 million. In 1970, the book value of Canadian petroleum affiliates gained $.45 billion. The value of petroleum investments for Europe increased by $.67 billion. Investments in less developed countries increased at a faster rate than those of 1969. Both Latin America and Africa experienced a small gain in book value of petroleum investments; Middle East investments fell slightly.

During 1970 U.S. direct investments in foreign mining increased by $.5 billion. Reinvested earnings declined slightly and capital outflows increased to $3.8 billion from less than $.1 billion. Of the total book value at yearend of $6.1 billion in total direct private investment in foreign mining and smelting industries, the developed countries accounted for $3.7 billion and the less developed countries accounted for $2.5 billion.

Foreign direct investments in the U.S. totaled $13.2 billion in 1970. The book value at yearend of foreign petroleum investments totaled almost $3 billion, a 19.6-percent gain, or about double the 1969 advance; of this total, Europe accounted for $2.8 billion or 93 percent. By far the largest foreign investors in the U.S. petroleum industry were the Netherlands, $1.3 billion, and the United Kingdom, $1.2 billion.

TRANSPORTATION

The quantity of selected minerals and mineral energy products transported by rail and water gained in 1970 (latest data available), despite a slight decrease in metals and minerals except fuels. For total mineral products, rail transportation advanced 0.7 percent, and water transportation increased by 2.3 percent. As in previous years, more than half of the selected metals and nonmetals was transported by rail; selected mineral energy resources and related products were generally transported by water. Total selected minerals and mineral energy products accounted for 59 percent of all commodities transported by rail and 84 percent of all commodities transported by water.

In the metals and minerals except fuels category, rail transportation decreased by 3.8 percent to 432.5 million short tons. The quantity transported by water declined 2.9 percent to 240.2 million short tons. Iron ore and concentrates, crushed and broken stone, and sand and gravel continued to be the largest users of rail transport in volume terms. Rail transport for most minerals declined slightly in 1970, except for a 33-percent decline in nonferrous metal scrap, an 11-percent decline in the amount of sand and gravel transported, and a 13-percent decline in the quantity of building cement transported.

In the same category, water transportation decreased 2.9 percent to 240.2 million short tons. Iron ore and concentrates, crushed and broken stone, and sand and gravel were the three largest commodities by volume.

In 1970, 441 million short tons of mineral energy resources and related products were transported by rail, and 558 million short tons were moved by water. Shipments of bituminous coal and lignite accounted for 90 percent of selected mineral energy resources and related products transported by rail.

Coal and crude petroleum continued to be the largest mineral energy resources transported by water. Large amounts of gasoline, distillate fuel oil and residual fuel oil were also moved by water in 1970. The total volume of selected minerals and mineral energy resources and related products transported by water was 951 million short tons, a gain of 2.5 percent for the year.

A total of 915,000 miles of gas pipeline was recorded for 1970 (latest data available), a 2.6-percent advance. Once again, natural gas lines accounted for most of the total pipeline mileage with small amounts distributed among manufactured, mixed, and liquefied petroleum gas. Total petroleum pipeline mileage in 1971 increased to 219,000 miles. Of the total petroleum pipeline mileage reported, 33 percent was in crude-gathering systems in field operations, 34 percent in larger size crude trunklines, and 33 percent in petroleum product pipelines that extend from refineries to distribution terminals.

RESEARCH ACTIVITIES

National expenditures for research and development activities for all industries in 1969 (latest data available) totaled $18.5 billion. Of this amount, $9.9 billion originated from company expenditures and $8.6 billion from government funding. Research and development expenditures in petroleum refining and extraction totaled $572 million, a 6-percent increase from 1968. Almost 92 percent of petroleum research and development activities was financed by private expenditures; government funds supplied the remaining 8 percent. In the chemical and allied products industries, a total of $1.8 billion was channeled to research and development activities, a 5.7-percent gain for the year. Company expenditures in this field were $1.6 billion, and government expenditures were about $0.2 billion.

Bureau of Mines.—During 1971, the programs of the Bureau of Mines continued to emphasize the effective utilization of our natural mineral and fuel resources to insure adequate mineral supplies without objectionable environmental, social, and occupational effects. Mining research studied rock behavior and mine breathing (alternate expansion and contraction of air in old workings). Metallurgy research studied ways to improve recovery of minerals. Waste recycling research studied ways to recover and reuse discarded minerals. Coal research emphasized the production of clean-burning fuels. Petroleum research studied methods of making production more efficient and decreasing environmental side effects. Oil shale development projects continued. Health and safety research continued to emphasize developing technology to minimize hazards related to mineral recovery. Helium research continued, and explosives research continued to develop safer explosives and study the detonation characteristics of explosives. Economic studies continued to focus on the mineral industries, environmental problems, and supply and demand studies.

In the text of the 1970 chapter, the figures shown for Bureau of Mines funding obligations for mining and mineral research and development during fiscal year 1970 were incorrect. The actual total for 1970 was $46.5 million, a 33-percent gain from the previous year. Funds allocated to applied research were $27.6 million or 60 percent of the total. Funds for basic research were $6.2 million or 13 percent of the total, and allocations for development were $12.6 million or 27 percent of the total. During fiscal year 1971, Bureau of Mines funding obligations for mining and mineral research and development reached $60.3 million, a 30-percent gain from the previous year. Funds for applied research increased to $32.2 million or 53 percent of the total. Funds for basic research rose to $6.5 million or 11 percent of the total, and allocations for development advanced to $21.6 million or 36 percent of the total. Obligations for 1972 are estimated to increase by $10 million to $70.3 million, most of which is in development. Total research funds for fiscal year 1970 were also erroneously discussed last year. The correct figure obligated for 1970 was $33.9 million divided as follows: Engineering sciences, $24.0 million; physical sciences, $7.5 million; mathematical sciences, $0.6 million; and environmental sciences, $1.8 million. Total research funds obligated by the Bureau for fiscal year 1971 were $38.7 million, $27.9 million to engineering sciences, $7.4 million to physical sciences, $0.8 million to mathematical sciences, and $2.6 million to environmental sciences. The estimated figure for 1972 shows an increase of 4.7 percent to $40.6 million. Highlights of the accomplishments of Bureau research programs, including work in progress, are as follows:

Mining Research.—Bureau research investigators developed a new concept of rock behavior during mining that is directly applicable to the design of safer mine pillars in a fractured rock mass. Studies demonstrated the feasibility of using polymers to build stronger concrete mine supports; advanced the application of acoustic techniques for monitoring the structural changes that take place in rock during mining and tunneling; and yielded information that will enable equipment manufacturers to design more efficient and longer lasting parts for machines that bore through rock. In related work, laboratory experiments showed that the physical properties of rock can be correlated with cutting efficiency, an important factor in the design of boring machines. Continuing research on blasting technology has indicated the possibility of using relatively inexpensive explosives to achieve a rockbreaking efficiency comparable to that given by high-energy, high-cost products.

Mine breathing is a major obstacle in sealing off abandoned mines against acid mine water. A quantitative relationship of mine breathing to atmospheric pressure fluctuations and the permeability of the strata overlying the mine has been established experimentally. Hazard classification tests for flammable solids, oxidizers, and water-reactive materials were developed for use by the Department of Transportation as a basis for safety regulations governing land, air, and water transport.

Significant improvements in rock mechanics instrumentation were made. Time and temperature creep have been reduced substantially in a newly designed borehole gage used for overcore stress determinations. A biazial inclinometer probe for monitoring displacements transverse to the drill hole is now available. Tunnel stress relaxation gages, having sensitivities 200 percent greater than previous gages, were developed. A multichannel digital data acquisition system designed to withstand the severe underground environment was constructed and proven by field tests.

Pioneering investigations were carried out during the year to formulate and apply thermal fragmentation concepts to primary and secondary breaking of rock. Ground work is being laid for development of a new rock breaking system for secondary fragmentation of both spalling and nonspalling hard rock.

Metallurgy Research.—The Bureau of Mines developed a new method to increase the recovery of fluorine and phosphorus pentoxide (P_2O_5) during the processing of phosphate rock. A potentially large domestic fluoride resource exists in phosphate rock, but in present acidulation practice most of the fluoride is lost to the atmosphere or to the reject sludge. Research has shown that 95 percent of the fluoride and P_2O_5 can be extracted using the Bureau's phosphoric acid acidulation method. The phosphoric acid method can be used on lower grade material than the sulfuric acid process now in commercial use, and it can tolerate coarse feed material that would reduce the cost required for fine grinding. Successful implementation of this method would permit recovery of nearly all the fluoride contained in the nearly 3 million tons of phosphate mined in the United States. This would meet about one-third of the Nation's fluorine requirements and would convert a waste product into a useful commodity.

An improved gold recovery process has been developed by Bureau metallurgists. In the new modification of the carbon-in-pulp process, gold is collected from a cyanide slurry on activated carbon. Gold-bearing carbon is stripped using hot water under pressure yielding a concentrated gold solution and barren carbon for recycle. Pilot plant tests of the new carbon-in-pulp process indicate that commercial use is economically feasible. In another Bureau-developed gold process, simple heap and vat leaching techniques were developed for recovering gold from ores or wastes too low in grade or too limited in quantity to justify the construction of a conventional cyanide leaching plant. Various western gold ores were leached with dilute cyanide-lime solutions, and the gold was recovered by passing the leach solutions through a bed of activated carbon. Gold recoveries of up to 95 percent were obtained. Three western gold mine companies have used the results of the Bureau's research and made heap test leaching experiments ranging in size from 200 to 6,000 tons. Results on ores generally containing less than 0.1 ounce of gold per ton confirm laboratory recoveries.

Rhenium, which is one of the scarcest elements in the earth's crust, is in increasing demand as a cracking catalyst for petroleum refining. An electrooxidation process has been developed by the Bureau that extracts over 99 percent of both rhenium and molybdenum from low-grade molybdenum sulfide concentrates with which rhenium is invariably associated. After extraction by amines and carbon adsorption, over 99 percent of the molybdenum is recovered as high-purity ammonium molybdate and 99 percent of the rhenium as 99.99 percent pure ammonium perrhenate.

In the area that covers both mining and metallurgical investigations, Bureau of Mines scientists completed development and evaluation of X-ray drill-hole probes. The battery-powered 30-pound instruments are designed for logging boreholes 1.8 inches in diameter or larger. In most metal-mining operations, exploratory holes are drilled in order to trace a vein or otherwise determine the distribution of a particular mineral in an ore deposit. This is frequently accomplished by taking a core from the drill hole and analyzing the core sections in a chemical laboratory. A device such as the drill-hole probe that is capable of in situ analysis should therefore find wide application for mineral delineation.

Waste Recycling Research.—The Bureau has developed a process that permits the reclaiming of cobalt and tungsten carbide from worn-out cutting tools, which have been difficult to recycle. The process recovers scrap cemented tungsten carbide by breaking up the cobalt bond between the carbide particles through treatment with molten zinc, which is afterwards distilled off in a vacuum, condensed, and reused. A brittle residue of tungsten carbide and some cobalt remains, which may be ground up and used for making new tool bits without any waste.

The recycling of iron scrap is inhibited by the presence of copper-caused hot shortness. A Bureau-developed process utilizing sodium sulfate injection into molten ferrous scrap is capable of removing copper and other undesirable impurities such as sulfur, lead, and phosphorus. In laboratory tests on scrap charges, copper has been reduced from an initial 0.34 weight-percent to an acceptably low level of 0.06 weight-percent. Further improvement for the process has been confirmed with computer simulation for process design and reclaiming of waste slag.

The Bureau-developed waste-plus-waste recovery methods have shown the technical feasibility of low-cost processes for recovering valuable products from a wide variety of industrial wastes, including those from electroplating, machining, pickling, and phosphatizing operations. Many of these materials contain large annual tonnages of scarce, costly metals. One procedure involved the controlled addition of a waste acid to alkaline cyanide wastes in a ventilated mixing tank. The precipitated valuable metals such as silver, nickel, and copper were separated and recovered by additional processing.

The Bureau developed promising processes for the recovery of precious metals and copper from diverse types of complex electronic scrap. Due to obsolescence and damage, electronic and electrical materials are presently being scrapped at the rate of about 15 thousand tons per year. This scrap averages 100 troy ounces silver; 5 ounces gold; 1 ounce palladium, and lesser amounts of other precious metals per ton. The most promising approach investigated by the Bureau was a smelting process followed by electrolytic treatment to separate precious metals from copper. Smelting tests indicated that low aluminum scrap can be processed to produce crude bullion salable to a copper smelter. An alternative procedure was incorporation of the scrap with the concentrate fed to an industrial copper reverberatory or converter furnace.

Coal Research.—Emphasis in coal research was placed on the production of clean-burning fuels from coal to help satisfy the rapidly expanding need for energy while protecting the quality of the environment.

Design of a prototype plant to demonstrate the SYNTHANE coal gasification process was completed, and plans were formulated for construction of the plant. The pilot plant will be capable of processing 70 tons of raw coal per day into pipeline-quality gas. The Hydrane Process was also developed in another approach to producing a high-Btu gas from coal. This process is based upon the direct reaction of coal with hydrogen to form methane. The process offers potential advantages over other advanced coal gasification schemes since no pretreatment of coal and less process hydrogen are required, and over 90 percent of the product methane results from the direct reaction of hydrogen with the coal. Construction of a 10-pound-per-hour reactor was completed, and testing of the process was started.

In related work to produce a clean-burning, low-Btu gas suitable for industrial fuel, run-of-mine bituminous coal was successfully processed for the first time in the fixed-bed gasifier. The Bureau's gasifier employs a stirrer to break up coke formations, which permits caking coals to be handled. Historically, the preferred feed for fixed-bed gasifiers has been coal particles no smaller than ¾ inch and no larger than 2 inches. In the new tests, run-of-mine coal containing up to 50 percent of particles smaller than ¼ inch was successfully gasified. These findings are significant since coal preparation charges involved in sizing the coal would be reduced substantially, as would the cost of the product fuel gas.

Two promising processes for producing low-ash, low-sulfur oil from coal were developed further. In one process, coal containing over 3 percent sulfur was catalytically converted to a fuel oil of 0.3 percent sulfur. In the second process, coal was successfully liquefied by the action of carbon monoxide and water. By proper selection of operating conditions, conversions of near 90 percent were obtained using either lignite or high-volatile bituminous coal. Both sulfur and ash contents are reduced significantly. In a related study of organic waste, animal manure was successfully converted to a low-sulfur oil by treatment with carbon monoxide and steam.

In studies on coal combustion, the fate of several trace element pollutants was determined. Contrary to most previous assumptions, not all the mercury in coal vaporizes when coal is burned. Fly ash samples taken from laboratory combustors operated under controlled conditions and from several powerplants all contained mercury. The amount varied from 9 to 70 percent of the original mercury in the coal. In another study, related to the emission of nitrogen oxides from powerplants, tests showed that from 40 to 80 percent of the nitrogen in coal was converted to nitrogen oxides during combustion.

The advantages of preheating coal before charging it to a coke oven were demonstrated in a cooperative study with a steel company. Preheating permitted reducing the amount of expensive low-volatile coal in the coking blend from 20 to 10 weight-percent with essentially no change in coke quality. Coking time was reduced by 20 percent, and liquor make was cut in half.

Petroleum Research.—The objective of fluid injection studies is to increase recovery from known oil reservoirs by application of fluid-injection technology and production-stimulation techniques.

Studies of the East Canton oilfield in Ohio were continued. Comparison of reservoir-rock properties determined from well logs with those obtained from core analyses indicated that the highly fractured nature of the East Canton formation prevents accurate evaluation from core analyses alone. Graphs and simple equations were developed that enable individual operators to predict waterflood performance for their own properties. Primary oil recovery, as determined by average decline-curve analyses, was forecast at about 43,000 barrels per well. Data developed in these studies also can be used to determine whether newly drilled wells will be profitable producers, if completed. If results are negative, high completion costs can be avoided.

Pressure buildup tests of limited duration were conducted at an oilfield in the

Bradford, Pa., area in an attempt to delineate the subsurface fracture system that controls fluid movement in the reservoir. Forty wells were involved in the tests. The results will be plotted, and a fracture system hypothesis will be formulated to determine where communication exists in the reservoir. Early results indicate that the technique will be useful in mapping subsurface fracture systems in petroleum reservoirs.

Research was conducted in a gas-storage reservoir in Hocking County, Ohio, to determine why hydraulically induced vertical fractures tend to follow a certain direction. Data from observations and measurements on the surface and from surface and subsurface cores from a well in the area were compared with information obtained on hydraulically induced vertical fractures in the reservoir. Direction of the maximum horizontal stress in an outcrop formation correlated well with the direction taken by the induced fractures. Data and diagrams from the surface observations were also consistent with measurements of the subsurface cores, and both appeared indicative of the present fracturing trend in the reservoir area. Thus, information from both surface and subsurface observations and measurements apparently can help the petroleum engineer carry out fracturing operations that achieve optimum gas reservoir performance, be it production or storage.

Research is now in progress on correlation of organic and inorganic properties of crude oils to serve as "fingerprints" in identifying the source of marine oil spills when the source is not known. Such correlations were used in determining the subsurface formation from which oil escaped into California's Santa Barbara Channel. The data are also in use to test theories of reservoir properties affecting oil production, and to study the origin of oil and gas, and the possible effects of oil migration on crude oil composition.

The program on fuels combustion and vehicular technology is oriented toward determining how the fuel, engine, and exhaust system can be modified for optimum reduction of reactive and toxic exhaust emissions.

Evaluation of the emissions characteristics of synthetic natural gas as alternative engine fuels will permit engines to be operated with emissions lower than is possible with gasoline or even natural gas. This advantage is accompanied by a loss in power that could lead to marginal vehicular performance. Preliminary tests using gases made from coal indicate that, because of the hydrogen content, these gases could be one of the more attractive engine fuels of the future.

Progress was made in establishing a laboratory for the analysis and eventual classification of tar sand deposits. The analytical laboratory represents the first step in research planned for the eventual development of ecologically acceptable methods for producing petroleum from tar sands. Acceptable procedures and equipment were developed for analyzing basic reservoir and strength properties of consolidated tar sand samples. More than 60 core and outcrop samples from 15 tar sand deposits in Utah were analyzed for compressive strength, oil (tar) saturation, and physical properties—density, porosity, and permeability—in developing the analytical methods.

The use of solvents to stimulate the production of unusually viscous crude oils known to be present in large quantities is being studied in the laboratory and field. Several solvents were tested to evaluate their effectiveness with six crude oils from California and one from Kansas. The solvents ranged from rather broad refinery cuts to pure chemical compounds. The results showed a considerable range in the effectiveness of the different solvents in reducing viscosity and in increasing recovery from the sand-packed columns. Although the laboratory results were not incomplete agreement, in general the most effective solvents were aromatic hydrocarbons having low molecular weights.

Oil Shale Research.—Knowledge concerning the oil-shale deposits of the Green River Formation was considerably extended by Bureau assays representing 12,000 feet of core samples. These samples were taken by industrial concerns and subsequently evaluated by the Bureau in connection with the Department's currently proposed Prototype Oil-Shale Leasing Program.

Research on development of in situ techniques for production of shale oil received increasing emphasis with both field experiments and supporting laboratory and large-scale simulation experiments featuring 10- and 150-ton-capacity retorts. Field work included completion of evaluative work on the first successful in situ experiment near Rock Springs, Wyo. Reports on this and on the first phase of field experiments in hydraulic fracturing of oil shale were published. The 10th run of the 150-ton retort was completed in a series designed to determine optimum in situ retorting parameters under closely controlled simulation conditions. Lean oil shale, 10.7 gallons per ton, obtained from the Uinta Basin, Utah, was successfully retorted in the 10-ton retort, demonstrating the possibility of utilizing low-grade shales. A new field experiment was begun in which hot gases are being supplied to furnish retorting heat in situ rather than direct combustion of a portion of the shale. This work is also located near Rock Springs, but at considerably greater depth than the earlier successful test.

In other research to assist development of an oil-shale industry under conditions that ensure full protection of the environment, Colorado State University completed multiton field tests of the pollution potential of spent shale piles under snowfall conditions, using both artificial and natural snowfall. This work was supported by a Bureau research grant. The Bureau also studied reduction of the organic content of retort waste waters by electrooxidation. Reductions from approximately 10,000 to 800 parts per million were achieved.

A new technique using wide-line-nuclear-magnetic resonance was developed for assaying oil shales. The new method is relatively rapid in comparison with the standard Fischer assay method and gives results that approximate those of the standard method.

Economic Analysis.—The Bureau's program of economic analysis continued to be concerned with the economic forces at work within the mineral industry and with relationships between the industry and the national economy. The purpose of the activity continues to be to provide government decision makers with appropriate information and up-to-date analysis of the existing situation, future trends, alternative courses of action, and the impact of choosing any of the alternatives. The economic analyses program seeks to provide the general methodology needed for such analysis, as well as information relevant to problem-solving in the field of mineral economics. Forecasting methodology research and development and problems involving the environment were major subjects of research.

Health and Safety.—Major efforts have been directed by the Bureau towards improving and securing the health and safety of miners. Continued trials have established the usefulness of infrared scanners to detect zones of potential roof falls in mines. Although existing equipment is not suitable for use in coal mines on a routine basis, improved versions are now being developed. If this technique for detection of loose rock proves practical it will be a significant contribution to mine safety.

A prototype audiodosimeter to measure an individual miner's exposure to noise was developed. It can indicate an exposure between 0 and 150 percent of that allowable for an 8-hour day, and it signals when noise exposure reaches the danger zone. The first coal mine remote surveillance and communications system will be installed in the Bureau's experimental mine at Bruceton, Pa. From a surface monitoring station this system will permit the surveillance of methane, carbon monoxide, smoke, temperature, and ventilation levels at each of 10 locations within the mine and between any mine station and the surface monitor stations.

In research on methane control, side-looking airborne radar proved effective in detecting the presence, in coal mining areas, of structural geological features that could not be observed otherwise. The lineations observed could be related to the multiple gas zones overlying the coal mines in that area. As long as coal is mined from gaseous seams underground, control of methane will be a problem. The Bureau has conducted fundamental studies into the flow patterns of methane and the mechanisms whereby it reaches the mine opening. At present, methane is diluted by supplying and distributing sufficient air to keep it below a combustible concentration. Bureau research is directed toward minimizing and controlling the quantity of methane entering and accumulating in the mine.

There is a need in some coal mining operations, both bituminous and anthracite coal mines, to detonate more than 20 electric blasting caps at a time. A new engineering prototype blasting machine designed to fire 50 electric blasting caps and meet the safety criteria for use in gassy mines has been developed. The design criteria that have been developed are directly applicable to the fabrication of safer blasting machines of smaller capacity.

In the other areas of mine fire and explosion prevention, new design criteria were established for explosion-proof bulkheads.

A fly ash-cement mixture was found to be the most promising of a series of candidate materials for bulkhead construction. Research has been conducted on two types of bulkheads; one of fly ash-cement slurry, the other of concrete block. Rules for bulkhead construction will be recommended; the locations of bulkheads, the piping for gas-air exchanges, the preparations of sites for bulkheads and specific construction requirements have been specified in some detail.

In evaluating techniques for plugging abandoned oil and gas wells to eliminate hazards from release of explosive gases when the wells are penetrated by mining machines, four wells intersecting the Pittsburgh coalbed were sealed by an experimental technique that is based on methods used in the petroleum industry. The protective pillar surrounding one of these plugged wells was mined through, and all tests with a sensitive tracer indicate continuing effectiveness of the plug in preventing reservoir gas from entering through the well hole. If evaluation under various conditions and in other areas proves the technique to be applicable, standards can be promulgated so that these pillars can be mined through without special permits. Being able to mine through these random pillars protecting oil and gas wells that intersect coalbeds will enable coal operators to improve the ventilation system, simplify the haulage system, use longwall and shortwall mining if other conditions are favorable, improve roof conditions by better control of the mining cycle, and recover a significant quantity of the coal that is now left behind.

Almost all mining equipment is powered by electricity. Underground power distribution systems operate on both alternating and direct current and many mines utilize both. These varying electrical systems utilizing voltages of 4,160 volts are a major source of industrial-type accidents. A very complete survey of underground power distribution systems has been completed with a statistical analysis of electrical accidents and a discussion of the causes of such accidents. Studies are now being initiated to find alternate power systems that would prove safer than those now in use.

Explosives and Explosions Research.—The development of safer explosives for use in underground mines, and research on detonation characteristics of explosives continued to be major areas of research. Because of the inherent safety of "slurry-type" explosives and blasting agents, the Bureau has been working on development of such an explosive that would be suitable for use in underground mines with inherent explosive hazards. Formulations have been developed that have the safety characteristics of permissible explosives in flammable atmospheres and have a reasonable storage life. Fires and explosions due to methane and float coal dust were also major research areas. Mathematical models and computerized techniques were used extensively in a number of fundamental detonation studies. Computer programs for coupled gas dynamics/kinetics in and downstream from a rarefaction wave were used to predict the formulation of secondary shocks owing to heat release and merger of compression waves. Secondary shocks were experimentally observed in the rarefaction wave behind the air shock arising from the detonation of various condensed explosives in a heavy-walled cannon.

The formulation of explosives that generate low concentrations of toxic fumes is continuing. Tentative results from experiments with ammonium nitrate-fuel oil charges containing selected additives indicated a reduction of from 60 to 75 percent in the concentration of oxides of nitrogen is possible.

Helium Research.—Since 1917 the Bureau of Mines has conducted a continuing project designed primarily to identify potential sources of helium. Under the project, samples of natural gas are obtained on a voluntary basis from wells, fields, and pipelines in the United States and foreign countries. These samples are analyzed for all major components, including helium, at the Division of Helium laboratory in Amarillo, Tex. Results of such analyses are published as part of the regular Bureau of Mines publication series.

During 1971, some 475 gas samples were analyzed, and the analyses prepared for publication. These samples were collected from 17 states and two foreign countries. Additionally, the analyses of 377 gas samples obtained and analyzed during 1970 were published during 1971. In total, the project has resulted in 13 publications containing the analyses of almost 10,000 natural gas samples. In addition, the analyses are available as a magnetic tape for use with data processing equipment.

LEGISLATION AND GOVERNMENT PROGRAMS

The most significant governmental action during 1971 was the NEP, announced by the President August 15, 1971. It included an immediate 90-day freeze on wages, prices and rents; a 10-percent import surcharge; a proposed repeal of the Federal excise tax on automobiles; a proposed tax credit for new investment in equipment to create jobs and raise productivity; a proposed change in the effective date from January 1, 1973, to January 1, 1972, of an increase in personal income tax exemptions; a 10-percent cut in foreign economic aid; and suspension of the convertibility of the dollar into gold.

Some of the above actions involved powers granted the President by law; the others were passed without great difficulty.

Only three laws passed in 1971 dealt directly with minerals. They all dealt with import regulations for selected minerals.

As of December 31, 1971, the acquisition cost of strategic materials in government inventories totaled $6.2 billion with a market value of $6.8 billion. Included in these government inventories were $2.6 billion of materials (market value) considered in excess of stockpile needs. In calendar 1971, $235 million worth of mineral commodities were disposed of, a 25-percent increase from the 1970 figure. Major mineral stockpile items sold during the year with a sales value of at least $5 million each included bauxite, copper, fluorspar, manganese (metallurgical), nickel, tin, and tungsten.

WORLD REVIEW

World Economy.—The 1971 world economic situation continued to be dominated by a severe imbalance in external payments among industrial countries. In response to this situation several European countries made adjustments in their exchange rate situation, with West Germany and the Netherlands floating their currencies. The situation culminated when the United States suspended the convertibility of the dollar into gold. For the rest of the year currencies were allowed to fluctuate somewhat.

Inflation continued to be a major problem. All industrial countries had price increases, and most other countries followed the trend.

Most countries experienced moderate growth in their GNP. West Germany had a 10.8-percent advance, which was less than that of 1970. Canada's GNP advanced 9 percent from the 1970 level.

World Production.—World production of most major minerals increased moderately in 1971. The United Nations (UN) indexes of world mineral industry production (1963=100) for the extractive industries increased 5 points to 149. In the metals category, production declined in Latin America and increased in Eastern Europe, but the world total was unchanged. Total output of coal increased only one point to 105 in 1971, with the non-communist world declining two index points and Eastern Europe increasing four points. World production of crude oil and natural gas increased 7 index points to 174. Most areas increased, with the exception of the figure for U.S., and Canada which remained constant. Latin America declined 3 points to 118. Industrial output as measured by UN overall production indexes in the processing industries rose 7 points to 166 in 1971.

World Trade.—The value of world trade in all commodities increased slightly more than 14 percent to $311.4 billion in 1970. This more than matches the 14-percent increase in 1969. Mineral commodities exports totaled $68.0 billion, a 17-percent gain. Once again metals accounted for the larger part of the mineral commodity trade. In 1970, metals exports amounted to $36.9 billion, a significant rise of 19 percent from 1969. Within the metals group, ores, concentrates and scrap and iron and steel exports increased 24 percent; nonferrous metals exports increased less than 11 percent. Nonmetals advanced almost 7 percent. World trade in mineral fuels totaled $28.7 billion, a 15-percent increase compared with an 8-percent increase in 1969. In general, except for nonferrous metals, trade increased at a greater rate in 1970 than in 1969 for metals, nonmetals, and fuels.

World Prices.—The mineral commodity export price indexes (1963=100) registered large increases in fuels and crude minerals prices in 1971. Metallic ore prices were up moderately. In 1971 the price index for metals increased 4 index points to 126.

Fuel prices climbed 22 index points to 127, and crude mineral prices climbed 18 index points from 109 in 1970 to 127 in 1971. Total minerals prices increased significantly in both developed and developing areas, while nonferrous base metal prices declined 16 points to 151 in developed areas and 31 points to 160 in developing areas in 1971.

Table 1.—Value of mineral production,[1] exports and imports, by groups

(Millions)

Mineral group	1967 Production	1967 Exports [2]	1967 Imports [2]	1968 Production	1968 Exports [2]	1968 Imports [2]	1969 Production	1969 Exports [2]	1969 Imports [2]
Metals and nonmetals except fuels:									
Nonmetals	$5,200	$241	$414	r $5,449	$246	$490	$5,624	$222	$491
Metals	2,333	171	1,117	2,703	241	1,161	3,332	246	1,094
Total [3]	7,533	412	1,531	r 8,152	487	1,651	8,956	467	1,586
Mineral fuels	16,195	601	1,289	16,820	539	1,309	17,965	632	1,428
Grand total [3]	23,729	1,013	2,820	24,971	1,026	2,960	26,921	1,099	3,014

Mineral group	1970 Production	1970 Exports [2]	1970 Imports [2]	1971 Production	1971 Exports [2]	1971 Imports [2]
Metals and nonmetals except fuels:						
Nonmetals	$5,711	$225	r $551	$6,073	$226	$573
Metals	3,926	322	r 1,249	3,394	192	1,047
Total [3]	9,637	547	r 1,799	9,467	418	1,620
Mineral fuels	r 20,152	r 1,120	r 1,567	21,258	1,016	2,076
Grand total [3]	r 29,789	r 1,667	r 3,366	30,726	1,434	3,696

r Revised.
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]

(Millions)

Mineral group	1967	1968	1969	1970	1971 p
Metals and nonmetals except fuels:					
Nonmetals	$5,200	r $5,374	$5,498	$5,534	$5,823
Metals	2,333	2,574	2,964	3,051	2,777
Total	7,533	r 7,948	8,462	8,585	8,600
Mineral fuels	16,195	16,753	16,948	18,074	18,123
Grand total	[2] 23,729	r 24,701	25,410	26,659	26,723

p Preliminary. r Revised.
1 Value deflated by the index of implicit unit value.
2 Data may not add to totals shown because of independent rounding.

Table 3.—Indexes of the physical volume of mineral production, by groups and subgroups

(1967 = 100)

Year	All minerals	Metals							Nonmetals				Fuels		
		Average	Ferrous	Nonferrous					Average	Construction	Chemical	Other	Average	Coal	Crude oil and natural gas
				Average	Base	Monetary	Other								
1880	4.4	15.9	7.9	20.5	6.2	106.3	11.6		3.2	6.9	0.5	1.9	3.0	15.2	0.6
1881	4.9	16.7	7.9	21.5	7.6	108.3	11.8		3.6	7.7	.5	2.4	3.4	18.1	.7
1882	5.5	17.8	9.7	22.1	8.8	108.5	10.1		3.7	7.9	.5	2.4	4.1	21.5	.7
1883	5.7	18.0	9.8	22.4	10.4	103.4	9.0		3.8	8.2	.6	2.5	4.3	24.0	.5
1884	5.9	18.3	8.6	23.6	11.7	107.6	6.1		4.0	8.5	.6	3.1	4.5	24.7	.7
1885	6.0	18.7	8.6	24.2	12.5	107.9	6.2		4.3	8.9	.8	2.7	4.4	23.5	.7
1886	6.7	20.4	11.4	25.3	12.2	117.4	5.7		4.5	9.3	.7	2.6	5.3	26.2	1.1
1887	7.4	21.8	12.8	26.6	14.1	117.1	6.6		4.8	10.3	.7	2.8	6.0	29.5	1.4
1888	7.8	23.7	13.6	29.0	16.5	122.9	6.4		5.0	10.4	.8	2.9	6.3	29.6	1.7
1889	8.4	25.3	16.3	29.8	16.8	128.7	5.1		5.9	12.5	.8	2.5	6.6	32.0	1.6
1890	9.0	27.0	18.0	31.6	18.2	134.5	4.4		6.3	13.7	.9	3.8	6.9	33.4	1.8
1891	9.2	28.1	16.3	34.2	20.7	140.3	4.5		6.3	13.4	1.0	4.7	7.2	34.6	1.8
1892	9.7	30.7	18.3	37.2	23.6	147.1	5.5		6.6	13.9	1.1	4.5	7.4	36.6	1.6
1893	9.2	28.2	12.9	36.4	22.3	147.5	5.9		5.8	11.6	1.2	4.4	7.4	37.3	1.6
1894	8.9	27.9	13.2	35.9	23.3	139.4	6.0		5.5	10.7	1.3	4.9	7.1	35.1	1.6
1895	9.9	32.3	17.9	40.4	25.2	160.7	7.2		5.5	10.7	1.4	4.2	7.9	39.7	1.6
1896	10.2	35.6	17.9	45.3	29.4	176.5	6.1		5.5	10.2	1.3	4.3	7.9	39.1	1.8
1897	10.6	37.5	19.5	47.1	31.9	177.5	5.4		6.0	10.8	1.6	4.8	8.2	40.5	1.8
1898	11.2	40.4	21.7	52.3	34.0	191.0	6.4		6.0	10.0	1.8	6.0	8.7	44.1	1.8
1899	12.5	44.3	27.5	52.9	36.3	203.0	6.4		7.3	11.4	2.3	6.2	9.8	51.3	1.9
1900	13.1	48.2	30.7	57.2	39.6	221.9	5.7		7.4	10.9	2.5	9.0	10.2	54.0	2.1
1901	13.9	48.3	32.1	56.3	39.8	218.5	5.9		9.1	13.1	2.5	9.3	11.2	59.6	2.2
1902	14.3	52.4	39.4	58.6	43.1	221.9	6.9		10.1	14.2	2.8	9.4	11.1	58.3	2.6
1903	16.3	52.1	38.7	58.4	45.4	207.2	7.5		10.4	14.6	2.8	10.3	13.5	72.3	2.8
1904	16.4	53.3	30.7	65.3	52.0	224.3	7.4		11.4	15.3	3.5	10.2	13.6	71.1	3.2
1905	18.5	62.9	47.1	70.2	56.4	239.9	6.6		11.9	16.2	4.4	11.3	15.1	78.9	3.6
1906	19.3	67.6	53.0	74.1	58.4	260.2	6.3		12.4	16.7	4.7	13.3	15.6	66.8	3.6
1907	21.1	66.1	54.9	69.1	55.8	234.8	5.9		12.7	17.1	4.7	14.2	18.2	95.3	4.3
1908	19.6	61.6	39.9	72.7	59.6	242.4	4.7		12.1	15.9	5.3	11.8	16.7	83.7	4.6
1909	22.1	75.1	57.0	83.5	70.8	264.4	6.5		14.0	19.0	5.0	14.3	18.2	91.3	4.9
1910	23.5	76.2	63.3	81.4	69.4	255.4	6.7		14.4	19.5	5.0	16.0	19.9	98.9	5.5
1911	23.2	72.4	48.7	84.2	72.0	263.1	7.1		14.2	19.0	5.4	15.3	20.1	98.9	5.7
1912	25.0	80.5	61.1	89.3	80.0	259.2	7.9		15.4	19.3	7.6	16.4	21.1	104.6	5.9
1913	26.4	83.8	68.9	90.0	81.1	256.0	8.1		15.6	20.3	6.7	18.7	22.7	111.7	6.5
1914	24.6	73.7	46.0	87.8	77.7	259.0	7.7		14.8	19.5	6.1	17.0	21.7	101.8	6.8
1915	26.6	90.9	62.0	105.2	98.8	276.6	10.1		14.5	18.8	6.3	17.7	22.5	104.7	7.3
1916	30.2	112.3	84.9	125.0	127.4	267.7	12.9		15.2	18.9	7.6	21.7	24.8	114.7	8.1
1917	31.7	108.6	86.0	118.6	123.2	237.4	18.7		14.6	16.0	10.1	22.6	27.6	127.1	9.2
1918	31.9	101.4	77.5	112.0	120.0	206.0	16.2		12.1	12.0	10.4	22.0	29.8	132.2	9.5
1919	28.0	76.2	63.8	79.9	82.2	170.5	10.1		12.4	13.2	9.0	18.7	27.3	109.6	10.2
1920	32.3	80.1	69.5	81.7	86.4	160.5	10.6		14.4	15.0	10.8	25.2	32.3	127.8	11.8
1921	27.3	41.9	28.6	48.7	43.7	148.4	3.1		12.4	13.4	8.7	15.7	29.6	103.4	12.4
1922	29.0	63.4	46.0	71.1	72.5	163.2	4.7		15.2	16.6	10.3	22.4	29.1	90.7	14.6
1923	39.5	86.9	68.4	92.9	100.2	178.0	7.1		19.3	21.6	11.4	28.6	40.3	128.8	19.5
1924	37.2	82.6	53.7	97.9	108.3	172.5	6.3		19.3	22.5	9.6	30.2	37.4	113.5	19.4
1925	38.5	90.2	62.2	103.9	116.9	169.7	7.2		21.2	24.8	10.5	32.4	38.0	109.5	20.9

1926	41.8	93.7	67.2	105.6	120.5	162.1	8.2	22.5	26.0	11.8	33.0	41.8	126.9	21.6
1927	42.5	88.3	62.0	100.8	115.2	153.7	7.7	23.7	27.6	12.3	32.7	42.9	116.1	25.2
1928	42.4	90.6	62.6	104.3	119.6	153.3	10.4	23.9	27.5	12.8	34.4	42.4	111.5	25.6
1929	46.1	99.8	73.0	111.3	128.8	153.1	13.7	25.0	28.3	14.5	36.2	46.4	116.6	29.3
1930	41.0	77.7	58.6	85.2	96.9	139.8	13.0	22.5	24.6	15.0	33.4	41.9	103.6	26.6
1931	34.5	52.9	31.8	65.0	70.9	125.5	10.1	17.5	18.9	12.7	23.1	36.9	85.8	24.5
1932	27.9	30.1	10.4	43.7	38.8	124.2	6.3	12.1	13.2	8.2	15.6	32.2	70.0	22.5
1933	30.6	34.3	19.0	43.7	37.5	124.7	9.7	12.7	12.2	11.3	22.4	35.2	69.6	25.2
1934	33.1	43.5	27.1	52.7	43.6	154.4	14.9	14.6	14.7	12.2	23.1	37.0	80.9	25.6
1935	35.5	55.5	33.8	67.8	59.4	187.7	18.5	15.3	14.7	13.7	26.5	39.0	81.2	28.1
1936	42.1	76.2	53.3	87.0	81.8	222.9	21.0	21.6	22.7	16.3	34.8	43.9	93.4	31.0
1937	47.0	99.6	79.5	104.8	105.0	246.3	23.9	23.1	23.0	19.6	36.6	47.9	93.5	35.9
1938	40.6	68.0	37.2	86.9	75.0	245.8	22.3	20.8	21.6	17.4	23.8	42.9	75.1	34.3
1939	45.0	87.4	59.7	101.0	92.7	266.6	24.6	24.3	26.1	18.0	30.2	46.0	84.7	35.8
1940	49.9	106.5	82.7	114.3	109.0	280.6	37.0	26.3	27.1	21.7	34.5	50.2	95.8	38.1
1941	54.8	120.9	103.1	121.4	118.6	272.4	60.6	32.3	32.9	26.2	50.4	53.4	106.6	39.5
1942	57.8	131.1	121.8	124.7	129.5	202.2	120.8	34.3	34.4	28.7	51.2	55.8	119.6	39.4
1943	58.8	132.1	119.8	129.4	127.5	96.8	310.1	30.2	28.1	29.2	52.3	59.0	121.1	42.6
1944	60.7	114.0	107.4	109.6	115.3	75.1	218.4	27.7	24.1	31.5	46.1	63.9	127.5	47.3
1945	58.5	92.3	98.1	81.4	95.4	68.8	74.0	27.9	24.3	31.7	46.0	62.9	117.6	48.6
1946	57.9	76.4	77.9	70.7	79.3	90.6	43.3	33.2	31.2	32.5	57.2	62.0	111.9	49.2
1947	64.8	98.4	100.7	92.6	100.4	126.3	53.1	38.0	35.7	38.2	63.6	68.2	127.8	52.7
1948	67.4	101.1	109.0	91.7	99.6	124.4	51.5	41.1	39.2	39.8	68.2	70.6	122.4	57.4
1949	58.6	91.1	91.5	86.9	93.8	120.2	51.5	40.1	39.1	37.9	59.7	60.2	89.8	53.1
1950	65.3	105.3	106.5	100.1	106.8	145.3	59.3	46.1	44.8	43.6	70.2	66.4	103.9	57.2
1951	71.6	113.5	127.0	100.0	107.7	124.7	77.9	50.8	48.7	47.8	83.0	73.1	106.1	65.3
1952	70.0	106.6	109.7	104.4	106.1	120.6	96.8	53.0	52.0	49.5	77.3	71.1	94.0	66.6
1953	71.2	113.6	133.3	98.5	100.0	121.5	86.0	54.7	53.7	52.1	74.3	71.1	89.4	68.7
1954	68.3	91.0	94.5	88.1	90.2	115.7	70.2	59.4	59.7	55.0	68.6	68.6	77.3	67.8
1955	75.4	109.8	124.0	95.0	103.9	117.8	64.7	65.6	67.2	56.4	79.4	74.8	89.3	72.6
1956	79.4	110.5	115.9	105.4	113.3	117.2	77.6	69.7	71.1	60.9	84.4	79.2	96.4	76.7
1957	79.1	113.1	121.8	104.1	111.0	115.2	79.5	68.6	71.2	57.8	77.2	78.9	93.9	77.2
1958	73.5	87.4	80.1	95.1	97.1	108.6	83.5	70.1	74.1	55.3	72.4	73.2	78.2	73.3
1959	77.1	82.2	73.3	91.3	84.7	99.9	106.3	77.0	81.3	60.7	81.7	76.6	78.3	77.5
1960	79.1	104.4	100.0	108.9	104.9	102.0	123.1	76.1	79.6	62.3	81.7	77.5	78.4	78.3
1961	80.1	100.3	88.2	112.6	111.5	101.4	120.4	77.8	81.7	64.0	79.7	78.6	75.8	79.9
1962	82.4	99.4	82.8	115.6	118.0	103.7	113.0	81.5	86.1	66.1	81.4	80.7	78.9	81.8
1963	86.2	100.9	87.5	113.0	118.0	98.9	100.3	86.0	90.1	69.5	85.9	84.4	85.6	84.7
1964	89.8	109.0	98.9	117.6	123.0	101.0	101.4	91.5	96.1	76.3	91.3	86.7	90.1	86.4
1965	93.5	114.5	100.9	125.6	132.7	115.0	89.8	97.6	100.6	87.8	97.2	89.2	93.7	88.5
1966	98.7	126.2	109.2	131.0	138.4	123.9	90.4	101.9	103.2	97.0	105.2	94.5	96.9	94.3
1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1968	104.1	110.8	102.4	117.6	120.4	97.1	113.9	103.4	104.6	98.9	106.5	103.4	98.5	104.2
1969	110.1	127.9	110.9	141.7	149.6	115.5	111.0	105.5	106.6	101.4	107.3	109.1	100.9	110.5
1970	112.1	135.8	109.3	157.4	167.3	123.9	119.5	103.4	103.1	103.1	109.1	111.7	108.3	112.0
1971 p	110.6	122.7	97.8	142.9	151.0	108.9	116.1	105.5	105.7	104.4	107.3	110.5	98.2	112.5

p Preliminary.

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

(1967 =100)

	1967	1968	1969	1970	1971 p
Mining:					
Coal	100.0	98.2	101.1	105.7	99.0
Crude oil and natural gas:					
Crude oil	100.0	103.2	104.8	109.4	108.3
Gas and gas liquids:					
Average [1]	100.0	104.0	106.9	109.7	111.3
Average coal, oil, and gas	100.0	103.2	106.1	109.2	107.5
Metal	100.0	111.4	124.8	131.3	121.4
Stone and earth minerals	100.0	103.7	102.8	98.8	93.2
Average	100.0	106.8	111.7	112.0	104.6
Average mining	100.0	103.9	107.2	109.7	107.0
Industrial production:					
Primary metals	100.0	103.2	114.1	106.9	100.9
Iron and steel	100.0	103.6	113.0	105.3	96.5
Nonferrous metals and products	100.0	102.6	116.0	109.7	108.7
Clay, glass, and stone production	100.0	106.0	112.5	106.3	110.1
Average industrial production	100.0	105.8	110.7	106.7	106.4

p Preliminary.

[1] Includes oil and gas drilling.

Source: Federal Reserve System, Board of Governors. Federal Reserve Statistical Release, March 15, 1972 and Detailed Industrial Production Series, January 1954–March 1971, 1971 Revision.

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: Total [2]		Crude oil and natural gas: Crude oil		Metal, stone, earth minerals		Metal mining		Stone and earth minerals	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
January	109.5	111.1	107.7	110.6	98.1	112.3	109.5	110.3	107.9	111.1	117.1	113.6	139.3	140.1	102.0	95.6
February	109.2	110.1	108.3	109.3	106.9	108.8	108.6	109.3	107.5	110.1	113.1	113.6	140.0	139.0	94.8	96.3
March	109.1	111.4	108.0	111.4	109.2	116.2	107.9	110.6	107.4	112.7	114.7	111.6	137.5	135.1	99.1	95.6
April	108.7	110.4	108.2	111.4	102.8	115.5	109.0	114.3	109.1	111.9	110.9	106.5	124.7	124.7	101.5	94.2
May	108.6	108.6	108.8	109.6	110.5	110.2	108.7	109.6	107.5	109.5	107.9	104.6	123.5	122.6	97.3	92.4
June	107.1	108.9	107.0	109.9	102.3	109.4	107.9	110.0	106.2	109.8	107.4	104.9	117.5	117.3	100.6	96.4
July	106.5	105.7	105.5	109.2	102.3	109.4	106.2	109.2	103.9	107.8	110.4	91.6	122.3	93.5	102.4	90.2
August	108.8	106.5	108.6	108.9	108.8	109.4	108.7	108.8	108.2	107.0	110.4	96.8	129.1	104.8	97.6	91.4
September	110.9	106.0	111.3	108.0	109.7	109.7	111.5	107.7	112.3	104.7	110.0	98.1	130.5	109.7	96.2	90.1
October	112.4	97.7	112.3	96.7	108.7	29.1	112.9	107.3	114.5	105.4	113.0	102.0	134.3	117.1	98.6	91.7
November	113.7	102.3	112.6	100.2	107.9	55.7	113.4	107.2	114.7	105.0	118.6	110.9	148.5	136.7	98.4	93.4
December	112.1	107.7	r 111.0	106.8	103.6	112.4	112.3	106.0	113.1	104.2	116.4	111.1	144.7	137.7	97.3	92.7
Average	109.7	p 107.0	109.2	p 107.5	105.7	p 99.0	109.7	p 111.3	109.4	p 108.3	112.0	p 104.6	131.3	p 121.4	98.8	p 93.2

p Preliminary. r Revised.
[1] Including fuels.
[2] Total includes oil and gas drilling.
Source: Federal Reserve System, Board of Governors. Federal Reserve Bulletin. V. 58, No. 3 and No. 5, March and May 1972, pp. A60–61. Detailed Industrial Production Series, January 1954–March 1971, 1971 Revision, 111 pages. Federal Reserve Monthly Statistical Release, Sept. 15, 1971, through Apr. 14, 1972.

Table 6.—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	
1967	311	13,904	20,087	18,100	r 2,347	80	r 54,829
1968	291	13,664	21,548	18,593	r 2,349	130	r 56,575
1969	266	13,957	22,838	18,886	r 2,648	146	r 58,741
1970	247	14,820	24,154	19,772	2,631	229	61,853
1971 p	222	13,451	24,788	19,422	2,829	404	61,116

p Preliminary. r Revised.

[1] Heat values employed for bituminous coal and lignite are: 1967, 12,580 Btu; 1968, 12,530 Btu; 1969, 12,450 Btu; 1970, 12,290 Btu; and 1971, 12,180 Btu.

[2] Heat values employed for crude petroleum are 1967, 5,628,540 Btu per barrel; 1968, 5,585,016 Btu; 1969, 5,601,070 Btu; 1970, 5,620,900 Btu; and 1971, 5,623,200 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 10,432 Btu per net kilowatt-hour in 1967; 10,398 Btu in 1968; 10,447 Btu in 1969; 10,494 Btu in 1970; and 10,494 Btu in 1971 for hydropower. Energy input for nuclear power in 1971 is converted at an average heat rate of 10,660 Btu per net kilowatt-hour based on information from the Atomic Energy Commission.

Table 7.—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				
1967	274	11,982	18,250	23,191	2,144	r 2,344	80	r 58,265
1968	258	12,401	19,580	24,607	2,445	r 2,342	130	r 61,763
1969	224	12,509	21,020	26,029	2,392	r 2,659	146	r 64,979
1970	210	12,488	22,029	27,126	2,488	2,650	229	67,220
1971 p	186	11,887	22,819	28,141	2,508	2,845	404	68,790
				PERCENT				
1967	0.5	20.6	31.3	39.8	3.7	4.0	0.1	100.0
1968	.4	20.1	31.7	r 39.8	4.0	r 3.8	.2	100.0
1969	.3	19.3	r 32.3	40.1	3.7	r 4.1	.2	100.0
1970	.3	18.6	32.8	40.4	3.7	3.9	.3	100.0
1971 p	.3	17.3	33.2	40.9	3.6	4.1	.6	100.0

p Preliminary. r Revised.

[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, 12,470 Btu per pound in 1967; 12,430 Btu per pound in 1968; 12,330 Btu per pound in 1969; 12,110 Btu per pound in 1970; and 12,010 Btu per pound in 1971. 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 kerosene and kerosene-type jet fuel; 5,825,000 for distillate; 6,287,000 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, 1,032 Btu in 1967 and 1968, 1,031 Btu in 1969, 1970 and 1971; natural gas liquids weighted average British thermal units; natural gasoline and cycle products 110,000 Btu per gallon; LP-gases, 95,000 per gallon; and ethane, 71,390 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 10,432 Btu per net kilowatt-hour in 1967; 10,398 Btu in 1968; 10,447 Btu in 1969; 10,494 Btu in 1970; and 10,494 Btu in 1971 for hydropower. Energy input for nuclear power in 1971 is converted at an average heat rate of 10,660 Btu per net kilowatt-hour based on information from the Atomic Energy Commission.

Table 8.—Gross consumption of energy resources, by major sources and consuming sectors [1]

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas dry [1]	Petroleum [2]	Hydropower [3]	Nuclear power [3]	Total gross energy inputs [4]	Utility electricity distributed [5]	Total sector energy inputs [6]
HOUSEHOLD AND COMMERCIAL									
1967	128	457	6,223	6,206	--	--	13,014	2,257	15,271
1968	121	408	6,451	6,128	--	--	13,108	2,467	15,575
1969	107	340	6,890	6,268	--	--	13,605	2,752	16,357
1970	103	324	7,108	6,453	--	--	13,988	3,000	16,988
1971 p	98	304	7,366	6,538	--	--	14,306	3,161	17,467
INDUSTRIAL									
1967	90	5,110	8,599	4,298	r 36	--	r 18,133	1,868	r 20,001
1968	80	5,044	9,274	4,820	r 35	--	r 19,253	2,044	r 21,297
1969	70	4,981	9,885	5,047	r 34	--	r 20,017	2,155	r 22,172
1970	59	4,943	10,161	5,139	34	--	20,336	2,210	22,546
1971 p	47	4,203	10,570	5,133	34	--	19,987	2,329	22,316
TRANSPORTATION [7]									
1967	NA	13	594	13,542	--	--	14,149	17	14,166
1968	NA	11	610	14,681	--	--	15,302	18	15,320
1969	NA	8	651	15,249	--	--	15,908	17	15,925
1970	NA	8	745	15,720	--	--	16,473	16	16,489
1971 p	NA	6	766	16,330	--	--	17,102	17	17,119
ELECTRICITY GENERATION, UTILITIES [3]									
1967	55	6,402	2,834	1,013	2,308	80	12,692	4,142	--
1968	56	6,938	3,245	1,181	r 2,307	130	r 13,857	4,529	--
1969	47	7,180	3,594	1,628	2,625	146	15,220	4,924	--
1970	48	7,213	4,015	2,087	2,616	229	16,208	5,226	--
1971 p	42	7,374	4,117	2,475	2,811	404	17,223	5,507	--
MISCELLANEOUS AND UNACCOUNTED FOR									
1967	1	--	--	276	--	--	277	--	--
1968	1	--	--	242	--	--	243	--	--
1969	--	--	--	229	--	--	229	--	--
1970	--	--	--	215	--	--	215	--	--
1971 p	−1	--	--	173	--	--	172	--	--
TOTAL GROSS ENERGY INPUTS									
1967	274	11,982	18,250	25,335	r 2,344	80	r 58,265	--	--
1968	258	12,401	19,580	27,052	r 2,342	130	r 61,763	--	--
1969	224	12,509	21,020	28,421	r 2,659	146	r 64,979	--	--
1970	210	12,488	22,029	29,614	2,650	229	67,220	--	--
1971 p	186	11,887	22,819	30,649	2,845	404	68,790	--	--

p Preliminary. r Revised. NA Not available.

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 10,432 Btu per net kilowatt-hour in 1967; 10,398 Btu in 1968; 10,447 Btu in 1969; 10,494 Btu in 1970; and 10,494 Btu in 1971 for hydropower. Energy input for nuclear power in 1971 is converted at an average heat rate of 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 time it is incorporated in the economy, whether energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or the derivatives) and outputs of hydropower and nuclear power converted to theoretical energy 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 historical series in the Edison Electric Institute Yearbook. Conversion of electricity to energy equivalent by sectors was made at the value of contained energy corresponding to 100-percent 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.

Table 9.—Domestic supply and demand for coal

	1970		1971 p	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
ANTHRACITE				
Supply:				
Production [1]	9,729.0	247.1	8,727.0	221.7
Exports [2]	−1,481.0	−37.6	−1,389.0	−35.3
Imports	--	--	--	--
Stock change; withdrawals (+), additions (−)	NA	NA	NA	NA
Losses, gains, unaccounted for	--	--	--	--
Total	8,248.0	209.5	7,338.0	186.4
Demand by major consuming sectors: [3]				
Household and commercial [4]	4,042.0	102.7	3,850.0	97.8
Industrial [5]	2,309.0	58.6	1,842.0	46.8
Transportation [6]	(7)	(7)	(7)	(7)
Electric generation, utilities	1,897.0	48.2	1,646.0	41.8
Total	8,248.0	209.5	7,338.0	186.4
BITUMINOUS COAL AND LIGNITE				
Supply:				
Production [1]	602,932.0	14,820.1	552,192.0	13,451.4
Exports	−70,944.0	−1,920.8	−56,633.0	−1,534.5
Imports	36.0	0.9	111.0	2.8
Stock change; withdrawals (+), additions (−)	−11,777.0	−295.6	2,553.0	61.3
Losses, gains, unaccounted for	−4,628.0	−116.3	−3,361.0	−94.4
Total	515,619.0	12,488.3	494,862.0	11,886.6
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial [4]	12,072.0	323.8	11,351.0	303.9
Industrial [5]	178,718.0	4,792.7	152,097.0	4,071.4
Coal carbonized for coke [8]	(96,009.0)	(2,575.7)	(82,809.0)	(2,216.6)
Transportation [6]	298.0	8.0	207.0	5.5
Electric generation, utilities	318,921.0	7,213.4	326,280.0	7,373.9
Total	510,009.0	12,337.9	489,935.0	11,754.7
Raw material: Industrial [9]				
Crude light oil	1,220.0	32.7	1,008.0	27.0
Crude coal tar	4,390.0	117.7	3,919.0	104.9
Total	5,610.0	150.4	4,927.0	131.9
Grand total	515,619.0	12,488.3	494,862.0	11,886.6

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 represents 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] Includes bunkers and military transportation.
[7] Data not available. Believed to be small and of minor significance.
[8] Figures in parentheses are not added into totals.
[9] Coal equivalent based on Btu value of raw materials for coal chemicals.

Table 10.—Domestic supply and demand for natural gas

	1970		1971 p	
	Million cubic feet	Trillion Btu	Million cubic feet	Trillion Btu
Supply:				
Production [1]	21,920,642	24,153.5	22,493,012	24,787.6
Exports	−69,813	−72.0	−80,212	−82.7
Imports	820,780	846.2	934,548	963.5
Stock change; withdrawals (+), additions (−)	−398,160	−410.5	−331,768	−342.1
Transfers out, extraction loss [2]	−906,413	−2,487.8	−883,127	−2,507.7
Losses, gains, unaccounted for	--	--	--	--
Total	21,367,036	22,029.4	22,132,453	22,818.6
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	6,894,007	7,107.7	7,144,389	7,365.9
Industrial [3]	9,190,960	9,475.9	9,603,790	9,901.5
Transportation	722,166	744.6	742,592	765.6
Electricity generation, utilities	3,894,019	4,014.7	3,992,983	4,116.8
Total	20,701,152	21,342.9	21,483,754	22,149.8
Raw material: Industrial [4]				
Carbon black	85,884	88.5	63,699	65.7
Other chemicals [5]	580,000	598.0	585,000	603.1
Total	665,884	686.5	648,699	668.8
Grand total	21,367,036	22,029.4	22,132,453	22,818.6

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 vented and wasted. British thermal unit value of production is for wet gas prior to extraction of natural gas liquids. Higher values assigned to extraction loss are reflected in value of 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 73,390 Btu per gallon. (Prior to 1967, ethane production was included with LPG in converting to Btu values.)

[3] Includes transmission losses of 227,650 million cubic feet in 1970 and 338,999 million cubic feet in 1971.

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

[5] Estimated from partial data.

Note: Conversion factor for dry gas is 1,031 Btu per cubic foot.

Table 11.—Domestic supply and demand for petroleum [1]

	1970		1971 p	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu
Supply:				
Crude oil: [2]				
Production	3,517.5	19,771.6	3,453.9	19,421.8
Exports	−5.0	−28.1	−0.5	−2.8
Imports	[3] 483.2	2,716.2	[3] 613.4	3,449.1
Stock change; withdrawals (+), additions (−)	−11.1	−62.4	16.7	93.9
Losses, transfers for use as crude, unaccounted for	−17.1	−96.1	4.3	24.2
Total	3,967.5	22,301.2	4,087.8	22,986.2
Petroleum input runs to stills:				
Crude oil [2]	3,967.5	22,301.2	4,087.8	22,986.2
Transfers in, natural gas liquids [4]	278.3	1,237.0	284.9	1,267.9
Other hydrocarbons	6.2	34.8	6.1	34.3
Total	4,252.0	23,573.0	4,378.8	24,288.4
Output:				
Refined products	4,252.0	23,573.0	4,378.8	24,288.4
Unfinished oils, net	38.1	239.5	43.6	274.1
Overage or loss	131.1	726.8	139.4	793.8
Total	4,421.2	24,539.3	4,561.8	25,356.3
Exports	−89.5	−518.9	−81.2	−465.3
Imports	764.8	4,672.0	817.2	4,961.3
Stock change, including natural gas liquids	−26.6	−146.8	−42.8	−236.3
Transfers in, natural gas liquids [4 5]	327.6	1,250.8	332.9	1,239.8
Losses, gains, unaccounted for	−33.0	−182.2	−37.4	−206.5
Total	5,364.5	29,614.2	5,550.5	30,649.3
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	965.3	5,370.8	981.2	5,430.0
Industrial	546.5	3,251.6	541.8	3,218.5
Transportation [6]	2,902.8	15,592.1	3,018.6	16,203.6
Electricity generation, utilities	333.8	2,087.2	396.2	2,475.1
Other, not specified	23.2	133.2	17.2	90.5
Total	4,771.6	26,434.9	4,955.0	27,417.7
Raw material: [7]				
Petrochemical feedstock offtake	304.1	1,371.9	301.4	1,388.8
Other nonfuel use	273.9	1,725.2	279.2	1,760.5
Total	578.0	3,097.1	580.6	3,149.3
Miscellaneous and unaccounted for	14.9	82.2	14.9	82.3
Total	5,364.5	29,614.2	5,550.5	30,649.3

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 net 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 95,000 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 12.—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
1970												
Fuel and power:												
Liquefied gases	180.2	722.8	27.0	108.3	31.8	127.5	--	--	4.9	19.7	243.9	978.3
Jet fuels:												
Naphtha type	--	--	--	--	90.9	486.8	--	--	--	--	90.9	486.8
Kerosine type	--	--	--	--	262.1	1,486.1	--	--	--	--	262.1	1,486.1
Total	--	--	--	--	353.0	1,972.9	--	--	--	--	353.0	1,972.9
Gasoline	--	--	--	--	2,131.2	11,184.5	--	--	--	--	2,131.2	11,184.5
Kerosine	73.2	415.0	22.8	129.3	--	--	--	--	--	--	96.0	544.3
Distillate fuel	525.3	3,059.9	104.1	606.4	269.7	1,571.0	24.8	144.5	3.3	19.2	927.2	5,401.0
Residual fuel	186.6	1,173.1	176.6	1,110.3	117.1	736.2	309.0	1,942.7	15.0	94.3	804.3	5,056.6
Still gas	--	--	163.9	983.4	--	--	--	--	--	--	163.9	983.4
Petroleum coke	--	--	52.1	313.9	--	--	--	--	--	--	52.1	313.9
Total	965.3	5,370.8	546.5	3,251.6	2,902.8	15,592.1	333.8	2,087.2	23.2	133.2	4,771.6	26,434.9
Raw material: [3]												
Special naphthas	--	--	31.4	164.8	--	--	--	--	--	--	31.4	164.8
Lubes [4] and waxes	--	--	33.3	199.5	21.0	127.4	--	--	--	--	54.3	326.9
Petroleum coke [5]	--	--	25.1	151.2	--	--	--	--	--	--	25.1	151.2
Asphalt and road oil	163.1	1,082.3	--	--	--	--	--	--	--	--	163.1	1,082.3
Petrochemical feedstock offtake:												
Liquefied refinery gas [6]	--	--	41.2	165.3	--	--	--	--	--	--	41.2	165.3
Liquefied petroleum gas [6 7]	--	--	161.7	648.6	--	--	--	--	--	--	161.7	648.6
Naphtha (−400 degrees)	--	--	57.3	300.7	--	--	--	--	--	--	57.3	300.7
Still gas	--	--	12.6	75.6	--	--	--	--	--	--	12.6	75.6
Miscellaneous (+400 degrees)	--	--	31.3	181.7	--	--	--	--	--	--	31.3	181.7
Total	163.1	1,082.3	393.9	1,887.4	21.0	127.4	--	--	--	--	578.0	3,097.1
Miscellaneous and unaccounted for	--	--	--	--	--	--	--	--	14.9	82.2	14.9	82.2
Total domestic product demand	1,128.4	6,453.1	940.4	5,139.0	2,923.8	15,719.5	333.8	2,087.2	38.1	215.4	5,364.5	29,614.2

See footnotes at end of Table.

Table 12.—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
1971 p												
Fuel and power:												
Liquefied gases	197.4	791.8	29.7	119.1	32.6	130.8	--	--	6.2	24.8	265.9	1,066.5
Jet fuels:												
Naphtha type	--	--	--	--	94.7	497.0	--	--	--	--	94.7	497.0
Kerosine type	--	--	--	--	271.9	1,541.7	--	--	--	--	271.9	1,541.7
Total	--	--	--	--	366.6	2,038.7	--	--	--	--	366.6	2,038.7
Gasoline	--	--	--	--	2,213.2	11,614.9	--	--	--	--	2,213.2	11,614.9
Kerosene	69.6	394.6	21.3	120.8	--	--	--	--	--	--	90.9	515.4
Distillate fuel	533.7	3,108.8	104.6	609.3	291.2	1,696.2	34.2	199.2	7.6	44.3	971.3	5,657.8
Residual fuel	180.5	1,134.8	177.0	1,112.8	115.0	723.0	362.0	2,275.9	3.4	21.4	837.9	5,267.9
Still gas	--	--	157.0	942.0	--	--	--	--	--	--	157.0	942.0
Petroleum coke	--	--	52.2	314.5	--	--	--	--	--	--	52.2	314.5
Total	981.2	5,430.0	541.8	3,218.5	3,018.6	16,203.6	396.2	2,475.1	17.2	90.5	4,955.0	27,417.7
Raw material: [3]												
Special naphthas	--	--	29.8	156.4	--	--	--	--	--	--	29.8	156.4
Lubes [4] and waxes	--	--	33.7	201.6	20.9	126.8	--	--	--	--	54.6	328.4
Petroleum coke [5]	--	--	27.8	167.5	--	--	--	--	--	--	27.8	167.5
Asphalt and road oil	167.0	1,108.2	--	--	--	--	--	--	--	--	167.0	1,108.2
Petrochemical feedstock offtake:												
Liquefied refinery gas [6]	--	--	41.4	166.1	--	--	--	--	--	--	41.4	166.1
Liquefied petroleum gas [6, 7]	--	--	149.5	599.6	--	--	--	--	--	--	149.5	599.6
Naphtha (−400 degrees)	--	--	56.8	298.1	--	--	--	--	--	--	56.8	298.1
Still gas	--	--	16.2	97.2	--	--	--	--	--	--	16.2	97.2
Miscellaneous (+400 degrees)	--	--	37.5	227.8	--	--	--	--	--	--	37.5	227.8
Total	167.0	1,108.2	392.7	1,914.3	20.9	126.8	--	--	--	--	580.6	3,149.3
Miscellaneous and unaccounted for	--	--	--	--	--	--	--	--	14.9	82.3	14.9	82.3
Total domestic product demand	1,148.2	6,538.2	934.5	5,132.8	3,039.5	16,330.4	396.2	2,475.1	32.1	172.8	5,550.5	30,649.3

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 13.—Net supply of principal minerals, by component [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			
	1970	1971		1970	1971	1970	1971	1970	1971	1970	1971
FERROUS METALS											
Iron ore thousand long tons	126,575	114,169	−9.8	66	66	--	--	34	34	4	3
Pig iron	91,211	81,604	−10.5	100	100	--	--	[2]	[2]	[2]	[2]
Steel ingot	137,739	135,729	−1.5	90	86	--	--	10	14	5	3
Chromite (Cr_2O_3)	606	555	−8.4	--	--	--	--	100	100	6	6
Cobalt	12	11	−8.3	54	50	--	--	46	50	8	4
Manganese	831	873	+5.1	1	[2]	--	--	99	100	2	6
Molybdenum	27	24	−11.1	100	99	--	--	[2]	1	51	49
Nickel	157	155	−1.3	8	9	9	12	83	79	17	14
Tungsten	3	3	--	95	95	--	--	5	5	76	24
OTHER METALS											
Aluminum	3,881	4,452	+14.7	86	82	3	4	11	14	14	6
Antimony	38	31	−18.4	3	3	48	55	49	42	1	3
Beryl ore (BeO) short tons	W	W	W	W	W	--	--	W	W	--	--
Cadmium do	4,483	5,604	+25.0	73	69	--	--	27	31	4	1
Copper	2,578	2,261	−12.3	65	66	19	20	16	14	3	2
Lead	1,449	1,443	−0.4	39	40	41	41	20	19	1	1
Magnesium	90	103	+14.4	96	95	2	2	2	3	28	19
Mercury 76-pound flasks	52,666	55,510	+5.4	48	28	14	27	38	45	8	12
Platinum group thousand troy ounces	1,369	1,208	−11.8	1	2	20	17	79	81	23	25
Tin thousand long tons	64	61	−4.7	NA	NA	28	28	72	72	9	6
Titanium concentrate (TiO_2)											
Ilmenite and slag	717	573	−20.1	68	68	--	--	32	32	[2]	[2]
Rutile	243	215	−11.5	--	--	--	--	100	100	--	--
Uranium concentrate (U_3O_8)	14	13	−7.1	93	92	--	--	7	8	--	--
Zinc	1,353	1,381	+2.1	40	35	7	7	53	58	[2]	1
NONMETALS											
Asbestos	736	760	+3.3	16	16	--	--	84	84	5	6
Barite, crude	1,560	1,309	−16.1	55	63	--	--	45	37	--	--
Bromine	175	178	+1.7	100	100	--	--	--	--	--	--
Clays	52,864	54,757	+3.6	100	100	--	--	[2]	[2]	4	4
Fluorspar, finished	1,347	1,332	−1.1	20	20	--	--	80	80	[3] 1	1
Gypsum	23,974	25,999	+8.4	75	77	--	--	25	23	[2]	[2]
Mica (except scrap)	112	119	+6.3	95	94	--	--	5	6	7	6
Phosphate rock (P_2O_5)	8,338	8,113	−2.7	99	99	--	--	1	1	31	34
Potash (K_2O equivalent)	4,730	4,794	+1.4	51	48	--	--	49	52	10	11
Salt, common	49,009	47,262	−3.6	93	92	--	--	7	8	1	1
Sand and gravel million tons	944	920	−2.5	100	100	--	--	[2]	[2]	[2]	[2]
Stone, crushed do	865	872	+0.8	100	100	--	--	NA	NA	[2]	[2]
Sulfur, all forms thousand long tons	9,785	9,463	−3.3	85	87	--	--	15	13	13	14
Talc and allied minerals	953	918	−3.7	97	98	--	--	3	2	10	13

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

(Millions)

Year and month	Shipments [1]			Net new orders			Unfilled orders at end of period		
	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]
1967	$45,867	$22,846	$23,021	$45,393	$23,037	$22,356	$7,019	$3,644	$3,375
1968	50,457	24,901	25,556	49,790	24,380	25,410	6,327	3,100	3,227
1969	57,137	26,493	30,644	58,491	27,281	31,210	7,657	3,896	3,761
1970 [r]	55,740	25,733	30,007	55,031	25,696	29,335	6,687	3,727	2,960
1971	58,546	27,563	30,983	57,576	26,859	30,717	5,708	3,011	2,697
1971:									
January	4,624	2,202	2,422	5,558	3,032	2,526	7,621	4,557	3,064
February	4,780	2,327	2,453	5,139	2,656	2,483	7,980	4,886	3,094
March	5,014	2,401	2,613	5,155	2,494	2,661	8,121	4,979	3,142
April	5,385	2,667	2,718	4,882	2,290	2,592	7,618	4,602	3,016
May	5,501	2,641	2,860	4,800	2,079	2,721	6,917	4,040	2,877
June	5,404	2,750	2,654	4,536	1,945	2,591	6,049	3,235	2,814
July	5,312	2,940	2,372	4,434	2,030	2,404	5,173	2,325	2,848
August	3,991	[r]1,457	2,534	4,184	1,701	2,483	5,366	2,569	2,797
September	4,270	1,706	2,564	4,517	2,020	2,497	5,612	2,883	2,729
October	4,421	1,901	2,520	4,488	1,953	2,535	5,680	2,936	2,744
November	4,825	2,212	2,613	4,809	2,246	2,563	5,664	2,970	2,694
December	4,804	2,205	2,599	4,848	2,246	2,602	5,708	3,011	2,697

[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. 48–52, No. 3, March 1968–72, pp. S-5, S-6, S-7.

Table 15.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend

(1967 =100)

Yearend	Metals and nonmetals [1]	Metals				Nonmetals [1]
		Total	Iron ore	Other ferrous	Nonferrous	
1967	100	100	100	100	100	100
1968	121	120	123	119	100	123
1969	118	104	106	83	107	136
1970	131	113	118	93	99	154
1971 p	148	147	136	275	101	150

p Preliminary.
[1] Excludes fuels.

Table 16.—Index of stocks of mineral manufacturers, consumers, and dealers at yearend

(1967 =100)

Yearend	Metals and nonmetals [1]	Metals					Non-metals [1]
		Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	
1967	100	100	100	100	100	100	100
1968	96	96	95	109	105	78	102
1969	93	93	85	103	110	74	91
1970	106	106	93	113	126	93	101
1971 p	103	104	99	135	109	97	88

p Preliminary.
[1] Excludes fuels.

Table 17.—Physical stocks of mineral energy resources and related products at yearend

(Producers' stocks, unless otherwise indicated)

Fuels	1967	1968	1969	1970	1971 p
Coal and related products: [1]					
Bituminous coal and lignite [2] short tons	95,408,000	85,525,000	80,482,000	92,275,000	89,985,000
Coke do	5,467,532	5,985,025	3,120,000	4,113,000	3,510,000
Petroleum and related products:					
Carbon black thousand pounds	264,247	224,170	208,020	296,087	296,028
Crude petroleum and petroleum products thousand barrels	944,111	r 997,572	980,123	1,017,861	1,043,947
Crude petroleum do	248,970	272,193	265,227	276,367	259,648
Natural gas liquids do	(3)	(3)	(3)	(3)	(3)
Natural gasoline, plant condensate, and isopentane do	5,782	5,466	5,704	7,046	6,176
Gasoline do	207,980	211,526	217,392	214,348	223,771
Special naphthas do	5,748	5,829	6,292	6,193	5,384
Liquefied gases [4] do	64,165	76,160	59,602	67,043	94,713
Distillate fuel oil do	159,703	173,158	171,714	195,271	190,622
Residual fuel oil do	65,597	67,359	58,395	53,994	59,681
Petroleum asphalt do	19,939	20,055	16,753	15,779	21,202
Other products do	166,227	r 165,826	r 179,044	181,820	182,750
Natural gas [5] billion cubic feet	2,648	2,746	2,852	3,207	3,523

p Preliminary. r Revised.
[1] Series on anthracite stocks in ground storage has been discontinued.
[2] Stocks at industrial, consumer, and retail yards and on upper lake docks.
[3] Now distributed among petroleum products shown below.
[4] Includes ethane.
[5] American Gas Association.

Table 18.—Seasonally adjusted book value of product inventories for selected mineral processing industries

(Millions)

End of year or month	Petroleum and coal products	Stone, clay, glass products	Primary metals		
			Blast furnace and steel mills	Other primary metals [1]	Total
1967: December	$1,971	$1,952	$4,319	$3,325	$7,644
1968: December	2,118	2,219	4,039	3,513	7,552
1969: December	2,274	2,483	4,312	3,740	8,052
1970: December	2,539	2,648	4,717	4,145	8,862
1971:					
December	2,433	2,263	4,800	4,395	9,195
January	2,407	2,281	5,102	4,341	9,443
February	2,381	2,263	5,117	4,370	9,487
March	2,348	2,267	5,138	4,360	9,498
April	2,351	2,265	5,040	4,293	9,333
May	2,375	2,269	4,985	4,251	9,236
June	2,402	2,280	4,815	4,355	9,170
July	2,397	2,293	4,464	4,357	8,821
August	2,471	2,302	4,635	4,318	8,953
September	2,459	2,293	4,875	4,355	9,230
October	2,474	2,296	4,875	4,408	9,283
November	2,484	2,272	4,784	4,417	9,201

[1] "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. 48–52, No. 3, March 1968–72, pp. 5–6.

Table 19.—Value of selected minerals and mineral products exported and imported by the United States in 1971, by commodity group and commodity [1]

(Thousands)

SITC code [2]	Commodity	Exports	Imports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	$95,528	$11,168
273	Stone, sand and gravel	17,589	21,059
274	Sulfur and unroasted iron pyrites	27,915	27,244
275	Natural abrasives (including industrial diamonds)	34,821	47,443
276	Other crude minerals	137,783	169,473
	Total [3]	313,637	276,387
	Metals (crude and scrap):		
281	Iron ores and concentrates	38,147	450,644
282	Iron and steel scrap	215,399	13,551
283	Ores and concentrates of nonferrous base metals	110,344	465,037
284	Nonferrous metal scrap	105,971	64,924
285	Platinum and platinum-group metal ores and concentrates	15,240	23,018
286	Uranium and thorium ores and concentrates	751	384
	Total	485,852	1,017,558
	Mineral energy resources and related products:		
321	Coal, coke, briquets (including peat)	950,742	22,015
331	Petroleum, crude and partly refined	5,981	1,861,055
332	Petroleum products, except chemicals	472,938	1,438,683
341	Gas, natural and manufactured	67,730	369,293
	Total	1,497,391	3,691,046
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, and halogen salts	272,590	285,205
514	Other inorganic chemicals	149,790	66,894
515	Radioactive and associated materials except uranium and thorium	235,591	73,239
521	Mineral tar, crude chemicals from coal, petroleum, natural gas	32,753	7,212
	Total	690,724	432,550
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, fabricated building materials, except glass and clay	18,632	78,141
662	Clay and refractory construction materials	68,298	39,879
663	Mineral manufactures, not elsewhere specified	82,238	34,825
	Total	169,168	152,845
	Metals (manufactured):		
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot, ferroalloys	31,347	106,542
672	Iron or steel ingots and other primary forms	86,458	37,255
673	Iron or steel bars, rods, angles, shapes, sections	84,113	664,635
674	Iron or steel universals, plates, or sheets	190,180	1,365,214
675	Iron or steel hoops and strips	42,620	51,449
676	Iron or steel rails and railway track construction materials	13,124	4,204
677	Iron or steel wire (excluding wire rod)	13,717	128,299
678	Iron or steel tubes, pipes, fittings	233,852	347,235
679	Iron or steel castings or forgings, unworked	95,647	9,396
681	Silver, platinum, platinum-group metals	41,060	120,441
682	Copper and copper alloys	265,039	460,489
683	Nickel and nickel alloys	57,313	272,140
684	Aluminum and aluminum alloys	196,603	322,192
685	Lead and lead alloys	3,890	48,912
686	Zinc and zinc alloys	6,531	97,469
687	Tin and tin alloys	7,421	167,181
688	Uranium and thorium metals and alloys	944	--
689	Miscellaneous nonferrous base metals	58,797	56,541
	Total [3]	1,428,654	4,259,594
	Grand Total	4,585,426	9,829,980

[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 International 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 1971, table 1. U.S. Exports, Commodity and Country, FT 410, December 1971, table 1.

Table 20.—Percentage distribution of exports of selected minerals and mineral fuels and related products by area of destination, 1971

SITC code [1]	Commodity	North America [2]	South America	Europe	Asia	Africa	Oceania	Soviet bloc [3]	Undesignated areas [4]
271	Fertilizers, crude	31	6	33	30	--	[5]	[5]	[5]
273	Stone, sand and gravel	80	3	7	5	[5]	[5]	--	5
274	Sulfur and unroasted iron pyrites	4	17	66	1	6	6	--	[5]
275	Natural abrasives, including industrial diamonds	12	4	51	27	2	3	[5]	1
276	Crude minerals, not elsewhere specified	29	6	42	17	1	4	[5]	1
281	Iron ore and concentrates	45	--	[5]	55	--	--	--	[5]
282	Iron and steel scrap	22	4	30	43	[5]	--	1	[5]
283	Ores and concentrates of nonferrous base metal	14	1	62	20	1	1	1	[5]
284	Nonferrous metal scrap	19	1	48	32	[5]	--	[5]	[5]
286	Uranium and thorium ores and concentrates	100	--	--	--	--	--	--	[5]
321	Coke, coal, briquets, including peat	25	7	30	37	[5]	[5]	1	[5]
331	Petroleum, crude and partly refined	47	--	14	39	[5]	--	--	[5]
332	Petroleum products, except chemicals	24	12	30	24	5	4	[5]	1
341	Gas, natural and manufactured	61	[5]	[5]	39	--	[5]	--	[5]
513	Inorganic chemical elements, oxides, halogen salts	34	14	21	10	6	3	11	1
514	Other inorganic chemicals	31	13	25	18	4	6	1	2
515	Radioactive and associated materials	18	[5]	59	23	[5]	[5]	--	[5]
521	Mineral tar and crude chemicals from coal, petroleum, and natural gas	13	10	58	18	[5]	[5]	--	1
661	Lime, cement, fabricated building materials except glass and clay	44	4	40	6	1	[5]	1	4
662	Clay and refractory construction materials	44	16	21	11	3	3	[5]	2
663	Mineral manufactures, not elsewhere specified	39	7	32	11	3	4	[5]	4
671	Pig iron, sponge iron, iron or steel powders and shot, ferroalloys	31	9	31	23	1	3	1	1
672	Iron and steel ingots and other primary forms	29	15	28	28	[5]	[5]	--	[5]
673	Iron and steel bars, rods, angles, shapes, sections	47	10	9	29	2	1	[5]	2
674	Iron and steel plates and sheets	32	10	16	37	2	1	1	1
675	Iron and steel hoop and strip	51	6	28	11	1	1	[5]	2
676	Iron and steel rails and railway track construction material	33	45	2	10	7	1	--	2
677	Iron and steel wire (except insulated electric)	49	6	24	14	1	2	[5]	4
678	Iron and steel tubes, pipes, fittings	36	16	13	20	11	2	[5]	2
679	Iron and steel castings and forgings (rough)	81	2	9	5	2	[5]	[5]	1
681	Silver, platinum, platinum-group metals	5	1	60	33	[5]	[5]	[5]	1
682	Copper and copper alloys	16	10	57	16	[5]	[5]	[5]	1
683	Nickel and nickel alloys	27	4	57	9	[5]	2	--	1
684	Aluminum and aluminum alloys	41	7	30	17	3	1	[5]	1
685	Lead and lead alloys	24	8	38	23	[5]	--	--	7
686	Zinc and zinc alloys	45	3	27	19	1	1	--	4
687	Tin and tin alloys	8	3	2	85	--	--	--	2
688	Uranium and thorium and their alloys	88	--	8	3	--	--	--	1
689	Base metals and alloys, not elsewhere specified	20	9	54	14	[5]	1	[5]	2

[1] Standard International Trade Classification.
[2] Includes Trinidad and Netherlands Antilles.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, Peoples' 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. Exports Schedule B, Commodity and Country. FT 410, December 1971, table 2.

Table 21.—Percentage distribution of imports of principal minerals and mineral fuels and related products, by area of origin, 1971

SITC code [1]	Commodity	North America	South America	Europe	Asia	Africa	Oceania	Soviet bloc [2]
2713000	Phosphates, crude and apatite	98	--	--	2	--	--	--
2732100	Gypsum	99	[3]	1	--	--	--	--
2743000	Sulfur	100	--	[3]	[3]	--	--	[3]
2752400	Natural abrasives	3	--	94	3	[3]	--	[3]
2762200	Graphite, natural	34	7	25	17	17	--	[3]
2762500	Magnesia, refractory and caustic calcined, crude magnesite	2	--	85	9	--	1	3
2763000	Salt	90	6	2	[3]	2	--	--
2764000	Asbestos	94	--	[3]	--	6	--	[3]
2765200	Mica, including scrap	[3]	28	1	65	6	--	[3]
2765420	Fluorspar	68	--	31	--	1	--	--
2769300	Barite, crude	33	24	37	[3]	6	--	--
2769500	Talc	18	--	55	27	--	--	--
2810000	Iron ore and concentrates	59	33	1	[3]	4	3	--
2820000	Iron and steel scrap	94	--	6	--	[3]	[3]	--
2831100	Copper ores and concentrates	66	34	--	--	[3]	[3]	--
2833000	Bauxite	71	28	[3]	--	[3]	1	--
2834000	Lead ores and concentrates	62	25	[3]	--	[3]	13	--
2835000	Zinc ores and concentrates	86	11	1	[3]	1	1	--
2836000	Tin ores and concentrates	[3]	100	--	--	--	--	--
2837000	Manganese ores and concentrates	3	35	--	1	55	6	--
2839100	Chrome ores	--	--	[3]	46	19	--	35
2839200	Tungsten ores and concentrates	62	24	--	--	--	14	--
2839310	Tantalum, molybdenum, and vanadium ores and concentrates	38	41	4	2	11	4	--
2839820 2839330	Titanium ores and concentrates	10	--	--	4	5	81	--
2839340	Zirconium ore	1	--	1	--	7	91	--
2839910	Antimony ores and needles	12	30	2	1	55	[3]	--
2839920	Beryllium ores and concentrates	[3]	68	[3]	--	30	2	--
2839930	Columbium ores and concentrates	12	55	5	3	25	--	--
2840200	Copper waste and scrap	98	[3]	2	--	--	--	--
2840300	Nickel waste and scrap	53	--	47	--	--	[3]	--
2840400	Aluminum waste and scrap	57	--	42	[3]	--	--	1
2840500	Magnesium waste and scrap	29	--	65	--	6	[3]	--
2840600	Lead waste and scrap	100	--	--	--	--	--	--
2840700	Zinc waste and scrap	100	--	[3]	--	--	--	--
2840900	Tin waste and scrap	34	--	11	19	36	--	--
2850140 2850240	Platinum-group metals, ores, concentrates, waste	39	4	38	8	6	5	--
2860000	Thorium ores and concentrates	--	--	--	43	--	57	--
3214000 3218000 3219000	Coal, coke, briquets	83	[3]	11	[3]	6	--	--
3310000	Petroleum, crude and partly refined	46	26	[3]	19	9	[3]	--
3320000	Petroleum products, except chemicals	47	41	8	4	[3]	[3]	[3]
3410000	Gases, natural and manufactured	97	2	[3]	[3]	1	--	--
5132500	Mercury, including waste and scrap	81	3	10	5	--	--	1
5136500	Alumina	23	20	7	3	[3]	47	[3]
5210000	Mineral tar and crude chemicals from coal, petroleum, and natural gas	12	--	84	4	--	--	[3]
5613000	Potassic fertilizers and fertilizer materials	95	--	2	3	[3]	[3]	--

[1] Standard International Trade Classification.
[2] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, Peoples' 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 1971, table 2.

Table 22.—Consumption of major mineral products, mineral fuels, and electricity 1970, 1971, and projections

Commodity		1970	1971 p	Projections [1]	Average annual growth rate 1947–65 (percent)
MINERAL PRODUCTS					
Ferrous metals:					
Iron ore	thousand long tons	135,000	119,379	240,000–330,000	+0.8
Raw steel (production)	thousand short tons	131,514	120,443	NA	+1.5
Chromite ores (gross weight)				3,150–4,700	
Metallurgical grade	do	912	720	NA	+4.0
Refractory grade	do	278	193	NA	+.8
Chemical grade	do	213	180	NA	+2.0
Manganese ore (35 percent or more Mn)	do	2,364	2,010	3,400–4,300	+1.9
Molybdenum (Mo content)	thousand pounds	45,337	40,950	150,500–206,500	[2] +5.2
Tungsten (W content)	do	16,700	11,622	60,000–93,000	+3.6
Nonferrous metals:					
Aluminum (apparent consumption)	thousand short tons	4,519	5,074	22,400–44,400	+7.4
Antimony, primary	short tons	13,937	13,707	28,000–52,000	−1.5
Copper, refined	thousand short tons	2,043	2,020	8,950–14,350	+1.0
Lead, primary and secondary	do	1,361	1,432	2,520–4,140	--
Zinc, all classes	do	1,572	1,651	2,460–4,700	+1.3
Mercury, primary	76-pound flasks	61,503	52,475	120,000–180,000	+3.4
Platinum-group metals	thousand troy ounces	1,389	1,376	2,315–4,195	+6.9
Silver (industrial consumption)	do	128,404	129,146	280,000–560,000	NA
Ilmenite and titanium slag (estimated TiO_2 content)	short tons	609,188	588,808	1,800,000–4,300,000	+4.8
Uranium (U_3O_8 content, production)	do	12,905	12,273	72,000–81,000	+4.9
Nonmetals:					
Asbestos (apparent consumption)	thousand short tons	729	759	1,285–1,865	+.8
Cement (production)	million barrels	395	417	NA	+3.7
Clays (apparent consumption)	thousand short tons	54,853	--	136,500–203,500	+2.1
Lime (sold or used)	do	19,747	19,591	NA	+5.3
Phosphate rock (P_2O_5 content, apparent consumption)	do	12,066	12,553	20,165–35,520	+4.9
Potash (K_2O content, apparent consumption)	do	4,730	4,794	10,240–18,675	+6.4
Salt (apparent consumption)	do	49,009	47,262	NA	+4.6
Sand and gravel	million short tons	944	920	3,153–3,990	[3] +4.2
Stone, crushed (sold or used)	do	868	874	2,460–4,025	+8.1
Sulfur, all forms (apparent consumption)	thousand long tons	9,134	9,180	23,000–37,000	+3.0
MINERAL ENERGY RESOURCES AND ELECTRICITY					
Bituminous coal	million short tons	516	495	1,275–2,639	−1.1
Coal carbonized for coke [4]	do	(96)	(83)	(62)	(−.6)
Anthracite	do	8	7	1–4	−7.1
Petroleum products and natural gas liquids	million barrels	5,365	5,551	7,343–16,412	+4.3
Natural gas, dry [5]	billion cubic feet	22,046	22,677	34,800–55,700	+7.3
Electricity, generation, net	million kilowatt hours	1,639,771	1,717,520	NA	+7.6
Utilities	do	1,531,609	1,613,936	[6] 9,036,400	+8.2
Hydropower [7]	do	249,416	267,820	[6] 632,000	+1.9
Nuclear power	do	21,797	37,899	[6] 5,491,000	[8] +54.0
Conventional fuel-burning plants	do	1,262,355	1,309,716	2,961,000	+9.2
Industrial	do	108,162	103,585	NA	+3.9
Total energy resources inputs	trillion Btu	67,220	68,790	168,600	+2.7

p Preliminary. NA Not available.
[1] All projections are for the year 2000.
[2] Growth rate 1956–65.
[3] Growth rate 1954–65.
[4] Figures in parentheses are not added into totals.
[5] Residue gas excludes extraction loss but includes transmission loss.
[6] Morrison, Warren E., and Charles L. Readling. An Energy Model for the United States, Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000. Bureau of Mines Inf. Cir. 8384, 1968, 127 pages.
[7] Net generation, adjusted for net imports or exports. The bulk of net trade is hydropower with an undetermined amount of steam plant power.
[8] Growth rate 1957–65.

Table 23.—Electrical energy sales to ultimate consumers

(Million kilowatt hours)

Region	Total consumption	Residential	Industrial and commercial	Total consumption	Residential	Industrial and commercial
	1967			1968		
New England	43,361	15,437	26,496	47,386	16,970	28,946
Middle Atlantic	164,125	45,410	108,184	176,158	49,854	115,301
East North-Central	219,554	61,238	149,630	238,138	67,080	161,679
West North-Central	71,481	27,138	41,950	77,624	29,644	45,375
South Atlantic	161,567	55,692	99,916	180,463	63,790	109,589
East South-Central	115,851	31,166	83,027	122,608	36,033	84,770
West South-Central	113,125	32,739	74,872	126,160	37,070	83,202
Mountain	49,342	13,157	33,774	53,157	14,164	36,513
Pacific	164,998	48,210	108,502	176,682	51,640	116,230
Alaska and Hawaii	3,619	1,338	2,184	3,945	1,447	2,380
Total United States	1,107,023	331,525	728,535	1,202,321	367,692	783,985
	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

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utility Industry, 1967–70.

Table 24.—Total employment in selected mineral industries

(Thousands)

	r 1967	r 1968	r 1969	1970	1971
MINING					
Metal:					
Iron ores	25.6	25.3	25.6	26.2	24.5
Copper ores	25.4	28.1	33.7	37.0	34.7
Total [1]	79.2	82.0	89.4	94.8	89.0
Nonmetal mining and quarrying	119.6	116.2	115.6	116.0	113.0
Fuels:					
Bituminous	132.0	126.4	129.5	138.8	132.3
Other coal	6.8	5.8	5.7	5.6	5.4
Crude petroleum and natural gas fields	149.7	148.1	145.0	141.7	141.0
Oil and gas field services	126.2	127.5	133.9	125.2	120.3
Total	414.7	407.8	414.1	411.3	399.0
Total mining	613.5	606.0	619.1	622.1	601.0
MANUFACTURING					
Minerals:					
Fertilizers, complete and mixing only	41.0	39.7	39.6	40.5	38.2
Cement, hydraulic	35.1	34.7	34.9	34.1	32.0
Blast furnaces, steelworks, rolling mills	555.5	555.5	561.1	549.6	506.3
Nonferrous smelting and refining	76.4	78.1	86.2	86.3	83.9
Total	708.0	708.0	721.8	710.5	660.4
Fuels:					
Petroleum refining	147.9	150.1	144.7	153.4	153.1
Other petroleum and coal products	35.3	36.7	38.2	38.5	36.7
Total [2]	183.2	186.8	182.9	191.9	189.8
Total manufacturing	891.2	894.8	904.7	902.4	850.2

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings, United States, 1909–70, Bull. 1312–7, 1971, 602 pages. Employment and Earnings. V. 17, No. 9, March 1971, and v. 18, No. 9, March 1972, table B–2.

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

	1967	1968	1969	1970	1971
MINING					
Metal:					
Iron ores:					
Weekly earnings	$138.60	$144.70	$153.18	$162.99	$169.70
Weekly hours	42.0	41.7	41.4	41.9	40.5
Hourly earnings	$3.30	$3.47	$3.70	$3.89	$4.19
Copper ores:					
Weekly earnings	$140.18	$161.68	$169.00	$175.67	$178.46
Weekly hours	43.0	47.0	46.3	44.7	42.9
Hourly earnings	$3.26	$3.44	$3.65	$3.93	$4.16
Total: [1]					
Weekly earnings	$136.40	$148.09	$157.32	$165.68	$171.39
Weekly hours	42.1	43.3	43.1	42.7	41.6
Hourly earnings	$3.24	$3.42	$3.65	$3.88	$4.12
Nonmetallic mining and quarrying:					
Weekly earnings	$128.82	$136.50	$149.11	$155.56	$165.23
Weekly hours	45.2	44.9	45.6	44.7	44.9
Hourly earnings	$2.85	$3.04	$3.27	$3.48	$3.68
Fuels:					
Total coal mining:					
Weekly earnings	$151.23	$153.20	$166.74	$183.96	$194.00
Weekly hours	40.5	40.0	39.7	40.7	[2] 40.6
Hourly earnings	$3.72	$3.83	$4.20	$4.52	[2] $4.79
Bituminous coal:					
Weekly earnings	$153.28	$155.17	$169.18	$186.46	$196.02
Weekly hours	40.7	40.2	39.9	40.8	[2] 40.6
Hourly earnings	$3.75	$3.86	$4.24	$4.57	[2] $4.85
Crude petroleum and natural gas:					
Weekly earnings	$132.60	$137.97	$147.19	$155.88	$159.75
Weekly hours	40.8	40.7	41.0	40.7	42.6
Hourly earnings	$3.25	$3.39	$3.59	$3.83	$3.75
Total fuels: [3]					
Weekly earnings	$137.94	$143.59	$156.55	$166.35	$173.59
Weekly hours	41.9	41.7	42.2	42.1	41.8
Hourly earnings	$3.30	$3.46	$3.73	$3.97	$4.22
Total mining: [3]					
Weekly earnings	$131.80	$141.20	$152.67	$160.07	$167.94
Weekly hours	43.9	44.3	44.6	43.8	43.4
Hourly earnings	$3.00	$3.20	$3.43	$3.66	$3.88
MANUFACTURING					
Fertilizers, complete and mixing only:					
Weekly earnings	$104.98	$108.54	$116.14	$123.68	$132.71
Weekly hours	43.2	42.4	42.7	42.5	42.4
Hourly earnings	$2.43	$2.56	$2.72	$2.91	$3.13
Cement, hydraulic:					
Weekly earnings	$133.40	$144.35	$155.87	$176.81	$194.37
Weekly hours	41.3	41.6	41.9	41.8	41.8
Hourly earnings	$3.23	$3.47	$3.72	$4.23	$4.65
Blast furnaces, steel and rolling mills:					
Weekly earnings	$145.16	$155.86	$168.51	$168.38	$181.43
Weekly hours	40.1	40.8	41.2	39.9	39.7
Hourly earnings	$3.62	$3.82	$4.09	$4.22	$4.57
Nonferrous smelting and refining:					
Weekly earnings	$134.30	$144.08	$152.64	$157.63	$166.83
Weekly hours	42.1	42.5	42.4	41.7	41.5
Hourly earnings	$3.19	$3.39	$3.60	$3.78	$4.02
Petroleum refining and related industries:					
Weekly earnings	$152.87	$159.38	$170.40	$182.33	$194.19
Weekly hours	42.7	42.5	42.6	42.7	42.4
Hourly earnings	$3.58	$3.75	$4.00	$4.27	$4.58
Petroleum refining:					
Weekly earnings	$159.09	$166.27	$178.08	$189.93	$202.44
Weekly hours	42.2	42.2	42.1	42.3	42.0
Hourly earnings	$3.77	$3.94	$4.23	$4.49	$4.82
Other petroleum and coal products:					
Weekly earnings	$129.51	$135.91	$147.52	$157.52	$166.44
Weekly hours	44.2	43.7	44.3	44.0	43.8
Hourly earnings	$2.93	$3.11	$3.33	$3.58	$3.80
Total manufacturing: [3]					
Weekly earnings	$143.86	$153.68	$165.47	$168.76	$181.30
Weekly hours	40.7	41.3	41.7	40.5	40.5
Hourly earnings	$3.53	$3.73	$3.99	$4.16	$4.49

[1] Includes other metal mining not shown.
[2] 11-month average.
[3] 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 pages. Employment and Earnings. V. 17, No. 9, March 1971, and v. 18, No. 9, March 1972, table C–2.

Table 26.—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:										
1969	47	24	33	34	38	r 33	32	26	17	20
1970	40	21	27	26	38	31	37	23	16	21
1971	39	20	35	23	29	23	28	18	13	19
Total separation rate:										
1969	49	24	r 27	33	r 34	31	24	26	17	18
1970	48	32	33	30	37	36	29	26	18	16
1971	42	19	46	31	33	31	28	20	16	17
Layoff rate:										
1969	12	7	r 3	3	r 4	8	1	4	3	r 4
1970	18	16	12	5	6	15	1	7	5	2
1971	16	7	30	11	7	14	4	6	5	3

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings, United States, 1909–70. Bull. 1312–7, September 1971, 602 pp. Employment and Earnings. V. 17, No. 9, March 1971, and v. 18, No. 9, March 1972, table D–2.

Table 27.—Wages, salaries, and average annual earnings in the United States

	1969	1970	1971 p	Percent change 1969–70	Percent change 1970–71
Wages and salaries:					
All industries, total________millions__	r $509,690	$541,927	$573,456	+ 6.3	+ 5.8
Mining______________________do____	5,387	5,825	6,080	+ 8.1	+ 4.4
Manufacturing_______________do____	157,562	158,316	160,443	+.5	+ 1.3
Average earnings per full-time employee:					
All industries, total_________________	r 7,098	7,571	8,061	+ 6.7	+ 6.5
Mining____________________________	8,619	9,275	9,854	+ 7.6	+ 6.2
Manufacturing_____________________	7,775	8,155	8,638	+ 4.9	+ 5.9

p Preliminary. r Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 52, No. 7, July 1972, tables 6.2 and 6.5.

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
1966______________	114.1	104.3	103.0	96.6	96.2	96.1
1967______________	100.0	100.0	100.0	100.0	100.0	100.0
1968______________	121.1	119.8	109.6	108.2	109.2	110.0
1969______________	132.7	125.2	116.2	112.9	115.4	117.1
1970 p_____________	134.3	126.6	121.8	111.5	113.3	113.7
	Copper, recoverable metal mined per—			Iron, usable ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1966______________	116.3	106.3	105.0	103.1	102.7	102.5
1967______________	100.0	100.0	100.0	100.0	100.0	100.0
1968______________	114.3	113.1	103.4	103.4	104.4	105.1
1969______________	122.0	115.1	106.9	105.0	107.4	108.9
1970 p_____________	122.9	115.9	111.5	104.6	106.3	106.6
	Petroleum, refined per—			Bituminous coal and lignite mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1966______________	97.9	98.1	107.9	97.0	96.0	97.1
1967______________	100.0	100.0	100.0	100.0	100.0	100.0
1968______________	103.1	103.9	105.1	103.8	104.5	103.7
1969______________	103.4	104.0	106.1	110.9	113.4	110.9
1970 p_____________	102.7	103.0	102.8	107.2	110.3	107.2

p Preliminary.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Index of Output per Man-hour Selected Industries 1939 and 1947–70. BLS Bull. 1692, 1971, 158 pp.

Table 29.—Index of average unit mine value of minerals produced 1967–1971

(1967 = 100)

	1967	1968	1969	1970	1971 p
METALS					
Ferrous	100.0	102.0	104.1	109.4	109.6
Nonferrous:					
Base	100.0	r 106.5	r 120.0	141.9	130.1
Monetary	100.0	r 125.2	118.0	109.1	108.8
Other	100.0	100.8	95.4	129.1	130.6
Average	100.0	r 107.3	r 115.3	136.4	128.1
Average all metals	100.0	104.5	r 109.4	122.1	118.3
NONMETALS					
Construction	100.0	101.5	103.5	107.8	109.4
Chemical	100.0	102.9	97.9	87.3	85.0
Other	100.0	103.3	111.2	108.5	115.2
Average	100.0	101.9	102.6	103.2	104.2
FUELS					
Coal	100.0	101.3	108.0	135.4	139.3
Crude oil and natural gas	100.0	101.4	107.9	108.5	115.2
Average	100.0	100.4	106.1	111.8	118.1
Overall average	100.0	101.1	105.6	111.7	115.0

p Preliminary.

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

(1967 = 100)

	1967	1968	1969	1970	1971 p
METALS					
Ferrous	100.0	101.9	104.1	109.1	109.4
Nonferrous:					
Base	100.0	106.7	120.4	143.4	130.5
Monetary	100.0	125.1	118.0	109.5	108.0
Other	100.0	100.4	95.6	129.7	132.9
Average	100.0	107.2	117.7	139.8	129.3
Average all metals	100.0	105.0	112.4	128.7	122.2
NONMETALS					
Construction	100.0	101.0	103.0	107.7	109.2
Chemical	100.0	102.4	97.8	87.4	85.4
Other	100.0	97.5	111.0	108.8	115.4
Average	100.0	101.4	102.3	103.2	104.3
FUELS					
Coal	100.0	101.2	108.0	135.4	139.2
Crude oil and natural gas	100.0	101.4	107.9	108.5	115.1
Average	100.0	100.4	106.0	111.5	117.3
Overall average	100.0	101.1	105.9	111.8	115.1

p Preliminary.

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

(1967 = 100 unless otherwise stated)

Commodity	Annual average 1970	Annual average 1971	Percent change from 1970
Metals and metal products	116.7	119.0	+ 2.0
Iron and steel	115.1	121.8	+ 5.8
Iron ore	100.1	103.0	+ 2.9
Iron and steel scrap	138.9	114.6	−17.5
Semifinished steel products	112.2	122.7	+ 9.4
Finished steel products	114.2	123.0	+ 7.7
Foundry and forge shop products	112.1	119.2	+ 6.3
Pig iron and ferroalloys	114.6	126.3	+10.2
Nonferrous metals	125.0	116.0	− 7.2
Primary metal refinery shapes	128.1	117.5	− 8.3
Aluminum ingot	r 113.2	101.4	−10.4
Lead, pig, common	112.1	99.0	−11.7
Zinc, slab, prime western	110.3	112.2	+ 1.7
Nonferrous scrap	124.8	103.6	−17.0
Nonmetallic mineral products	113.3	122.4	+ 8.0
Concrete ingredients	114.6	121.9	+ 6.4
Sand, gravel, and crushed stone	113.5	119.1	+ 4.9
Structural clay products	109.8	114.2	+ 4.0
Gypsum products	100.0	106.8	+ 6.8
Other nonmetallic minerals	112.2	124.1	+10.6
Building lime	110.5	118.5	+ 7.2
Insulation materials	123.1	131.7	+ 7.0
Bituminous binders	104.1	121.8	+17.0
Fertilizer materials	74.9	75.9	+ 1.3
Nitrogenates	69.3	71.7	+ 3.5
Phosphates	80.0	78.7	− 1.6
Phosphate rock	89.9	79.8	−11.2
Potash	97.7	100.4	+ 2.8
Muriate, domestic	96.3	99.8	+ 3.6
Sulfate	104.4	103.3	− 1.1
Fuels and related products and power	105.9	114.2	+ 7.8
Coal	150.0	181.8	+21.2
Anthracite	131.3	145.0	+10.4
Bituminous	151.5	184.9	+22.0
Coke	127.4	148.7	+16.7
Gas fuels	138.1	108.0	−21.8
Electric power	105.5	113.6	+ 7.7
Petroleum products, refined	101.1	106.8	+ 5.6
Crude petroleum	106.1	113.2	+ 6.7
All commodities other than farm and food	110.0	114.0	+ 3.6
All commodities	110.4	113.9	+ 3.2

r Revised.
1 January 1958 = 100.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January-December 1971, tables 2, 2A, and 6; January–February 1972, tables 4 and 6.

Table 32.—Comparative mineral energy resource prices

Fuel	1969	1970	1971
Bituminous coal: Average prices, cost of coal at merchant coke ovens dollars per net ton	10.75	12.28	15.32
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:			
Chestnut dollars	14.12	15.67	16.79
Pea do	12.14	13.87	15.28
Buckwheat, No. 1 do	11.53	13.26	14.83
Petroleum and petroleum products:			
Crude petroleum, average price per barrel at well do	3.09	3.18	3.39
Gasoline, average dealers' net price (excluding taxes) of gasoline in 55 U.S. cities [1] cents per gallon	17.11	17.68	18.11
Residual fuel oil:			
No. 6 fuel, maximum 1 percent sulfur, at Philadelphia [1] dollars per barrel (refinery)	2.32	3.16	4.21
Bunker C, average price for all Gulf ports [1] do	1.47	2.44	2.81
Distillate fuel oil:			
No. 2 distillate, average of high and low prices at Philadelphia [1] cents per gallon (refinery)	10.90	11.08	11.78
No. 2 distillate, average price for all Gulf ports [1] do	9.24	9.41	9.80
Natural gas:			
Average U.S. value at well cents per thousand cubic feet	16.7	17.1	18.2
Average U.S. value at point of consumption do	51.5	53.6	57.7

1 Platt's Oil Price Handbook.

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

(Cents per million Btu)

	1968			1969			1970		
	Coal	Oil	Gas	Coal	Oil	Gas	Coal	Oil	Gas
New England	34.3	29.4	32.0	36.9	28.3	33.7	41.9	32.8	35.3
Middle Atlantic	28.3	35.0	35.8	30.0	33.6	35.6	36.1	40.2	38.3
East North-Central	25.2	64.6	28.0	26.4	62.0	31.6	30.4	56.7	37.1
West North-Central	25.1	52.6	24.5	26.2	51.8	24.9	28.2	59.0	25.6
South Atlantic	27.0	32.3	31.6	28.4	30.4	31.6	36.1	31.9	34.7
East South-Central	20.1	55.2	23.9	21.1	51.1	24.3	23.6	54.1	25.3
West South-Central	21.5	38.2	20.1	31.1	36.9	20.5	40.1	44.6	21.1
Mountain	20.4	26.8	25.9	20.6	27.3	27.3	19.8	28.2	29.3
Pacific	--	32.0	30.7	--	34.5	31.2	--	36.8	32.4
United States	25.5	32.8	25.1	26.6	31.9	25.4	31.1	36.6	27.0

Source: National Coal Association. Steam-Electric Plant Factors. 1969–71, table 2.

Table 34.—Cost of electrical energy

(Cents per kilowatt hour)

	1968			1969			1970		
	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial
New England	2.2	2.7	1.9	2.2	2.6	1.8	2.2	2.6	1.9
Middle Atlantic	1.9	2.6	1.5	1.8	2.5	1.5	1.9	2.6	1.6
East North-Central	1.6	2.3	1.3	1.6	2.3	1.4	1.7	2.3	1.4
West North-Central	1.9	2.4	1.6	1.9	2.4	1.6	2.0	2.4	1.7
South Atlantic	1.5	2.0	1.3	1.5	1.9	1.3	1.6	1.9	1.3
East South-Central	.9	1.3	.8	1.0	1.3	.8	1.0	1.4	.9
West South-Central	1.5	2.2	1.2	1.5	2.2	1.2	1.5	2.1	1.2
Mountain	1.5	2.2	1.2	1.5	2.1	1.2	1.5	2.1	1.2
Pacific	1.2	1.7	1.0	1.2	1.6	1.0	1.2	1.7	1.1
Alaska and Hawaii	2.4	2.9	2.2	2.4	2.8	2.1	2.4	2.8	2.1
United States	1.5	2.1	1.3	1.5	2.1	1.3	1.6	2.1	1.3

Source: Edison Electric Institute. Statistical Yearbook of the Electrical Utilities Industry. 1968–70.

Table 35.—Price index of principal metal mining expenses [1]

(1967 = 100)

Year	Total	Labor	Supplies	Fuel	Electrical energy
1967	100.0	100.0	100.0	100.0	100.0
1968	101.4	101.0	102.4	98.8	100.8
1969	104.2	103.5	106.1	101.0	102.0
1970	108.6	108.1	110.5	105.9	104.8
1971 p	114.6	114.0	115.7	114.2	113.6

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.—Indexes of relative labor costs and productivity for iron ore and copper [1]

(1967 = 100)

Year	Iron ore [2]	Copper [2]
	INDEX OF LABOR COSTS PER UNIT OF OUTPUT	
1967	100.0	100.0
1968	100.1	102.0
1969	102.3	104.8
1970	109.2	106.9
1971 p	116.6	111.1
	INDEX OF VALUE OF PRODUCT PER MAN-PERIOD	
1967	100.0	100.0
1968	105.1	113.0
1969	109.6	135.3
1970	110.5	170.1
1971 p	115.1	154.8
	INDEX OF LABOR COSTS PER DOLLAR OF PRODUCT	
1967	100.0	100.0
1968	100.1	93.4
1969	102.3	82.8
1970	106.7	70.9
1971 p	110.3	82.4

p Preliminary.
[1] Index of labor costs per unit of output, index of value of product per man-period, and index of labor costs per dollar of product are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes.
[2] Indexes are for recoverable metal.

Table 37.—Price indexes for selected cost items in minerals and mineral fuels production

(1967 = 100, unless otherwise specified)

Commodity	1971 January	1971 December	Change from January (percent)	Annual average 1970	Annual average 1971	Change from 1970 (percent)
Coal	176.0	190.2	+ 8.1	150.0	181.8	+21.2
Coke	145.9	150.5	+ 3.2	127.4	148.7	+16.7
Gas fuels	109.3	107.9	− 1.3	138.1	108.0	−21.8
Petroleum products, refined	107.9	106.1	− 1.7	101.1	106.8	+ 5.6
Industrial chemicals	101.8	101.1	− .7	100.9	102.0	+ 1.1
Lumber	113.0	143.8	+27.3	113.7	135.5	+19.2
Explosives	113.1	113.2	+ .1	106.1	113.2	+ 6.7
Construction machinery and equipment	120.2	123.2	+ 2.5	115.5	121.4	+ 5.1

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, March 1971 and January 1972; March 1971–January 1972 issues, table 6 used to figure annual average for explosives.

Table 38.—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
1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1968	105.7	103.4	106.4	104.9	105.2	97.0	105.3	104.4	106.8
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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, January 1968–1971, table 2A; March 1971–January 1972, table 6.

Table 39.—National income originated in the mineral industries

Industry	Income, millions			Change from 1970 (percent)
	1969 r	1970	1971 p	
Mining	$6,775	$7,672	$7,642	−0.4
Metal mining	975	1,181	1,029	−12.9
Coal mining	1,494	2,160	2,159	(1)
Crude petroleum and natural gas	3,055	3,046	3,179	+4.4
Mining and quarrying of nonmetallic minerals	1,251	1,285	1,275	−.8
Manufacturing	222,270	216,284	223,167	+3.2
Chemicals and allied products	16,143	16,247	16,985	+4.5
Petroleum refining and related industries	6,329	6,603	6,629	(1)
Stone, clay, and glass products	6,978	6,928	7,445	+7.5
Primary metal industries	16,377	15,993	15,763	−1.4
All industries	766,049	798,633	855,748	+7.2

p Preliminary. r Revised.
[1] Less than ½ unit.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, V. 52, No. 7, July 1972, table 1.12.

Table 40.—Annual average profit rates on shareholders' equity, after taxes, and total dividends, selected mineral manufacturing corporations

Industry	Annual profit rate (percent)			Total dividends (millions)		
	1970	1971	Change from 1970	1970	1971	Change from 1970 (percent)
All manufacturing [1]	9.3	9.7	+0.4	$15,070	$15,251	+1.2
Primary metals	7.0	4.8	−2.2	1,197	976	−18.5
Primary iron and steel	4.3	4.5	+.2	596	469	−21.3
Primary nonferrous metals	10.7	5.1	−5.6	602	508	−15.6
Stone, clay, and glass products	6.9	9.1	+2.2	342	358	+4.7
Chemicals and allied products	11.5	11.8	+.3	1,925	2,003	+4.1
Petroleum refining and related industries	11.0	10.3	−.7	3,177	3,267	+2.8
Petroleum refining	11.0	10.3	−.7	3,159	3,258	+3.1

[1] Except newspapers.

Source: Federal Trade Commission, Securities and Exchange Commission. Quarterly Financial Report for Manufacturing Corporations, 1st Quarter and 4th Quarter, 1971, tables 4 and 8.

Table 41.—Industrial and commercial failures and liabilities in mining and manufacturing

Industry	1969	1970	1971
Mining: [1]			
Number of failures	34	54	38
Current liabilities ... thousands	$15,104	$59,046	$15,463
Manufacturing:			
Number of failures	1,459	1,981	1,894
Current liabilities ... thousands	$391,346	$758,795	$697,148
All industrial and commercial industries:			
Number of failures	9,154	10,748	10,326
Current liabilities ... thousands	$1,142,113	$1,887,754	$1,916,929

[1] Including fuels.

Source: Dun and Bradstreet, Inc., Business Economics Department. Monthly Failure Report, K–12, No. 12, Jan. 27, 1971, 4 pp.; K–13, No. 12, Jan. 21, 1972, 4 pp.

Table 42.—Expenditures for new plant and equipment by firms in mining and selected mineral manufacturing industries

(Billions)

Industry	1969	1970	1971
Mining [1]	$1.86	$1.89	$2.16
Manufacturing:			
Primary iron and steel	1.83	1.68	1.37
Primary nonferrous metals	1.10	1.24	1.08
Stone, clay, glass products	1.07	.99	.85
Chemical and allied products	3.10	3.44	3.44
Petroleum and coal products	5.63	5.62	5.85
All manufacturing	31.68	31.95	29.99

[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 51, No. 3, March 1971, p. 20, table 6; v. 52, No. 3, March 1972, p. 20, table 8.

Table 43.—Plant and equipment expenditures of foreign affiliates of U.S. companies by area and industry

(Millions)

Area and country	1969 Mining and smelting	1969 Petroleum	1969 Manufacturing	1970 Mining and smelting	1970 Petroleum	1970 Manufacturing	1971 [1] Mining and smelting	1971 [1] Petroleum	1971 [1] Manufacturing
Canada	$340	$629	$1,036	$413	$726	$1,159	$762	$796	$1,110
Latin America	497	r 501	r 611	477	514	669	359	553	698
Europe	r 10	876	2,539	16	974	3,614	21	1,145	3,846
All other areas	r 285	1,634	r 791	478	1,594	1,081	743	2,148	1,098
Total [2]	r 1,132	r 3,640	r 4,976	1,384	3,808	6,524	1,885	4,642	6,751

r Revised.
[1] Projected.
[2] 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. 51, No. 9, September 1971, pp. 29–30.

Table 44.—Estimated gross proceeds of new corporate securities offered for cash in 1971 [1]

Type of security	Total corporate Millions	Total corporate Percent	Manufacturing Millions	Manufacturing Percent	Extractive [2] Millions	Extractive [2] Percent
Bonds	$32,129	71.3	$9,426	81.4	$221	17.2
Preferred stock	3,670	8.1	264	2.3	17	1.3
Common stock	9,291	20.6	1,888	16.3	1,045	81.5
Total	45,090	100.0	11,578	100.0	1,283	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. 31, No. 3, March 1972, p. 19.

Table 45.—Direct private investment of U.S. companies in foreign petroleum industries in 1970 p

(Millions; 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	9,466	1,055	228	11,746	47,887	3,221	2,059	53,111
Canada	4,361	283	170	4,809	21,127	915	791	22,801
Europe	3,821	661	--	5,488	21,651	1,904	954	24,471
Japan	447	65	29	540	1,244	132	119	1,491
Australia, New Zealand, and South Africa	837	46	29	909	3,865	270	195	4,348
Developing countries	7,830	461	125	8,377	23,130 (Developing countries through International, unallocated, combined)	956	575	21,417
Latin American Republics and other Western Hemisphere	3,722	154	65	3,929		559	402	14,683
Other Africa	1,598	299	52	1,916		319	105	2,612
Middle East	1,654	–132	–29	1,466		–134	–25	1,645
Other Asia and Pacific	856	140	37	1,066		212	93	2,477
International, unallocated	1,708	–24	117	1,667		226	251	3,563
Total [1]	19,004	1,492	470	21,790	71,016	4,403	2,885	78,091

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. 51, No. 10, October 1971, pp. 28–29, and 32.

Table 46.—Direct private investments of the United States in foreign mining and smelting industries in 1970 p

(Millions)

	Book value at yearend	Net capital outflows	Undistributed earnings of subsidiaries	Earnings [1]	Income [2]
Developed countries	$3,657	$231	$111	$411	$287
Canada	3,014	158	87	294	201
Europe	71	−5	4	8	--
Japan	--	--	--	--	--
Australia, New Zealand, South Africa	572	78	19	109	87
Australia	478	65	22	70	52
South Africa, Republic of	90	9	−2	39	35
Developing countries	2,481	148	1	336	322
Latin American Republics, total	1,384	58	−26	177	185
Mexico	151	14	−1	4	5
Panama	19	--	--	--	--
Brazil	127	NA	NA	NA	NA
Chile	455	25	−22	59	62
Peru	426	−21	--	54	54
Other Western Hemisphere	652	75	--	103	106
Other Africa	350	−20	27	58	32
Middle East	3	--	--	--	--
Other Asia and Pacific	91	36	(3)	−2	−1
International, unallocated	--	--	--	--	--
Total, all areas [4]	6,137	379	113	748	609

p Preliminary. NA Not available.
[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] Less than ½ unit.
[4] 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. 51, No. 10, October 1971, p. 32.

Table 47.—Value of foreign direct investments in the United States

(Millions)

Industry	1966	1967	1968	1969	1970 p
Total	$9,054	$9,923	$10,815	$11,818	$13,209
Petroleum	1,740	1,885	2,261	2,493	2,981

p Preliminary.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 50, No. 10, October 1970, p. 35; v. 51, No. 10, October 1971, p. 38.

Table 48.—Railroad and water transportation of selected minerals and mineral energy products in the United States

(Thousand short tons)

Products	Rail[1] 1969	Rail[1] 1970	Rail[1] Change from 1969 (percent)	Water[2] 1969	Water[2] 1970	Water[2] Change from 1969 (percent)
Metals and minerals except fuels:						
Iron ore and concentrates	104,701	104,208	−0.5	78,881	75,175	−4.7
Iron and steel scrap	29,673	28,183	−5.0	1,869	1,812	−3.1
Pig iron	4,609	4,628	+.4	591	422	−28.6
Iron and steel ingot, plates, bars, rods, tubing, other primary products	52,726	48,907	−7.2	7,892	9,356	+18.6
Bauxite and other aluminum ores and concentrates	4,271	4,473	+4.7	674	893	+32.5
Other nonferrous ores and concentrates	17,464	17,977	+2.9	1,363	1,604	+17.7
Nonferrous metals and alloys	10,238	9,857	−3.7	642	627	−2.3
Nonferrous metal scrap	3,605	2,426	−32.7	57	43	−24.6
Slag	1,888	1,508	−20.1	524	385	−26.5
Sand and gravel	58,935	52,305	−11.3	82,893	73,946	−10.8
Stone, crushed and broken	66,310	61,794	−6.8			
Limestone flux and calcareous stone	--	--	--	33,224	34,115	+2.7
Cement, building	24,207	21,120	−12.8	10,820	10,735	−.8
Lime	6,391	6,346	−.7	503	671	+33.4
Phosphate rock	30,870	31,926	+3.4	5,380	5,830	+8.4
Clays, ceramic and refractory materials	3,372	3,002	−11.0	1,966	2,086	+6.1
Sulfur, dry	2,891	3,147	+8.9	104	84	−19.2
Sulfur, liquid				8,021	8,368	+4.3
Gypsum and plaster rock	635	553	−12.9	808	662	−18.1
Other nonmetallic minerals except fuels	8,377	10,622	+26.8	6,879	7,335	+6.6
Fertilizer and fertilizer materials	18,479	19,503	+5.5	4,266	6,048	+41.8
Total	449,642	432,485	−3.8	247,357	240,197	−2.9
Mineral energy resources and related products:						
Coal:						
Anthracite	6,956	5,792	−16.7	153,035	154,142	+.7
Bituminous and lignite	376,336	398,830	+6.0			
Coke	1,787	1,547	−13.4	615	965	+56.9
Crude petroleum	552	502	−9.1	109,683	116,301	+6.0
Gasoline	2,401	2,051	−14.6	85,363	88,700	+3.9
Jet fuel				14,417	12,930	−10.3
Kerosene	232	160	−31.0	7,451	7,222	−3.1
Distillate fuel oil	1,616	1,461	−9.6	77,839	76,286	−2.0
Residual fuel oil	4,637	4,664	+.6	64,331	78,791	+22.5
Asphalt, tar, land pitches	2,755	2,626	−4.7	8,087	8,634	+6.8
Liquefied petroleum gases and coal gases	7,590	7,709	+1.6	1,342	1,967	+46.6
Other petroleum and coal products[3]	13,563	16,051	+18.3	10,350	11,837	+14.4
Total	418,425	441,393	+5.5	532,513	557,775	+4.7
Total mineral products	868,067	873,878	+.7	779,870	797,972	+2.3
Grand total, all commodities	1,472,619	1,484,919	+.8	927,399	950,727	+2.5
Mineral products, percent of grand total:						
Metals and minerals except fuels	30.5	29.1	−.5	26.7	25.3	−5.3
Mineral energy resources and related products	28.4	29.7	+4.6	57.4	58.7	+2.3
Total mineral products[4]	58.9	58.9	--	84.1	83.9	−.2

[r] Revised.
[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] Includes lubricants, naphtha, and other petroleum solvents, and miscellaneous petroleum and coal products.
[4] Data may not add to totals shown because of independent rounding.

Sources: Interstate Commerce Commission, Bureau of Accounts, Freight Commodity Statistics, Class I Railroads in the United States for the Years Ended Dec. 31, 1968 and 1969. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 5. National Summaries, Calendar Years 1969 and 1970, table 2.

Table 49.—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
1967	73.2	12.1	11.2	3.5	100.0
1968	72.7	12.3	11.3	3.7	100.0
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

[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 50.—Miles of utility gas main, by type of gas and type of main [1]

Type of gas and type of main	1966	1967	1968	1969	1970
All types:					
Field and gathering	62,980	63,710	64,440	64,914	66,556
Transmission	216,980	225,360	234,450	248,071	252,621
Distribution	519,610	539,200	562,750	578,639	595,653
Total	799,570	828,270	861,640	891,624	914,830
Natural gas:					
Field and gathering	62,980	63,710	64,440	64,914	66,556
Transmission	216,410	224,790	233,940	247,559	252,609
Distribution	509,840	529,340	554,030	569,999	587,760
Total	789,230	817,840	852,410	882,472	906,925
Manufactured gas:					
Transmission	--	--	--	--	--
Distribution	1,180	1,140	1,070	914	545
Total	1,180	1,140	1,070	914	545
Mixed gas:					
Transmission	570	570	510	510	11
Distribution	7,800	7,950	6,980	7,105	6,831
Total	8,370	8,520	7,490	7,615	6,842
Liquefied petroleum gas:					
Transmission	--	--	(2)	2	1
Distribution	790	770	670	621	517
Total	790	770	670	623	518

[1] Excludes service pipe. Data not adjusted to common denominator equivalent. Mileage shown at end of each year.
[2] Less than 5 miles.

Source: American Gas Association. Gas Facts, a Statistical Record of the Gas Utility Industry in 1970, p. 53. For earlier years, see Historical Statistics of the Gas Industry.

Table 51.—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 52.—Research and development activity

(Millions)

	Total		Funds Expended			
			Company		Federal Government	
	1968	1969	1968	1969	1968	1969
Petroleum refining and extraction	$539	$572	$468	$524	$71	$47
Percent of all industries	3.1	3.1	5.3	5.3	0.8	0.5
Chemicals and allied products	$1,658	$1,752	$1,458	$1,560	$201	$192
Percent of all industries	9.5	9.5	16.4	15.8	2.3	2.2
All industries	$17,469	$18,474	$8,869	$9,856	$8,600	$8,619

Source: National Science Foundation. Research and Development in Industry 1969. NSF 71-18, April 1971, tables 2, 6, 8.

Table 53.—Federal obligated funds for metallurgy and materials research

(Thousands)

Federal agency	Fiscal year 1971 [e]			Fiscal year 1972 [e]		
	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	$23,357	$50,559	$73,916	$25,073	$57,051	$82,124
Atomic Energy Commission	11,950	19,000	30,950	11,220	19,100	30,320
National Aeronautics and Space Administration	10,940	10,238	21,178	10,835	6,798	17,633
Bureau of Mines	2,214	14,613	16,827	483	14,814	15,297
National Science Foundation	1,597	390	1,987	2,510	550	3,060
Department of Agriculture	--	--	--	--	--	--
Department of Commerce	1,605	408	2,013	1,604	408	2,012
Federal Highway Administration	1,181	4,953	6,134	1,383	5,798	7,181
Other	39	1,690	1,729	42	2,081	2,123
Total	52,883	101,851	154,734	53,150	106,600	159,750

[e] Estimate.

Source: National Science Foundation. Federal Funds for Research, Development, and Other Scientific Activities. NSF 71-35, v. 20, October 1971, tables C-24, C-25, C-43, C-44, C-62, C-63.

Table 54.—Bureau of Mines obligations for mining and mineral research and development

(Thousands)

Fiscal year	Applied research	Basic research	Development	Total
1968	$24,215	$4,893	$5,136	$34,244
1969	25,934	4,051	5,033	35,018
1970	27,646	6,248	12,563	46,457
1971	32,214	6,525	21,561	60,300
1972 [e]	32,719	7,858	29,712	70,289

[e] Estimate.

Table 55.—Bureau of Mines obligations for total research, by field of science

(Thousands)

	Fiscal year		
	1970	1971	1972 [e]
Engineering sciences	$24,040	$27,939	$28,706
Physical sciences	7,462	7,455	10,500
Mathematical sciences	571	763	520
Environmental sciences	1,821	2,582	851
Total	33,894	38,739	40,577

[e] Estimate.

Table 56.—Summary of government inventories of strategic and critical materials, December 31, 1971

	Acquisition cost	Market value [1]
Total inventories in storage:		
National stockpile	$4,124,387,600	$4,899,061,100
Supplemental stockpile	1,404,457,000	1,498,211,700
Defense Production Act	666,853,600	406,790,700
Commodity Credit Corporation	--	--
Total on hand	6,195,698,200	6,804,063,500
On order	--	--
Inventories within objective:		
Total on hand	3,527,227,700	4,154,443,300
Inventories excess to objective:		
Total on hand	2,668,470,500	2,649,620,200

[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 that 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: Executive Office of the President, Office of Emergency Preparedness. Stockpile Report to the Congress, July–December 1971, p. 2.

Table 57.—U.S. Government stockpile disposal of mineral commodities, 1971

Commodity	Sales commitments	
	Quantity	Sales value
NATIONAL AND SUPPLEMENTAL STOCKPILE INVENTORIES		
Aluminum ... short tons	1,520	$881,800
Aluminum oxide ... do	1,028	83,476
Asbestos, amosite ... do	1,798	346,796
Asbestos, chrysotile ... do	288	74,968
Asbestos, crocidolite ... do	6,051	1,300,035
Bauxite, Surinam ... long dry tons	2,466,438	26,229,228
Beryl ... short tons	261	108,950
Bismuth ... pounds	15,500	93,025
Cadmium ... do	1,000	2,300
Chromite, chemical ... short dry tons	−8,372	[1] −131,711
Chromite, metallurgical ... do	8,779	8,500
Chromite, refractory ... do	29,348	740,418
Cobalt ... pounds	926,515	1,991,168
Diamond stones ... carats	91,810	652,148
Fluorspar, acid grade ... short dry tons	112,643	8,294,876
Graphite, natural, Malagasy ... short tons	3,601	461,730
Lead ... do	9,584	2,124,315
Magnesium ... do	1,560	1,026,965
Manganese, battery-grade, natural ... short dry tons	486	21,870
Manganese, battery-grade, synthetic dioxide ... do	3,159	1,062,716
Manganese, metallurgical ... do	616,989	11,552,848
Mica, muscovite block ... pounds	2,624,374	360,000
Mica, muscovite film ... do	17,276	11,233
Mica, muscovite splittings ... do	1,000,800	463,277
Mica, phlogopite block ... do	14,642	5,009
Mica, phlogopite splittings ... do	211,191	73,052
Nickel ... do	20,000,000	28,375,000
Quartz crystals ... do	198,286	604,645
Rare earths ... short dry tons	1,498	760,502
Tin ... long tons	1,736	6,412,522
Tungsten ... pounds	1,024,008	3,885,458
Zinc ... short tons	2,107	667,077
Total	--	98,544,196
DEFENSE PRODUCTION ACT (DPA) INVENTORY		
Aluminum ... short tons	750	435,000
Chromite, metallurgical ... short dry tons	−899,950	[1] −6,450,000
Copper ... short tons	[2] 108,772	130,254,298
Manganese, metallurgical ... short dry tons	304,556	5,669,412
Mica, muscovite block ... pounds	311,097	215,665
Nickel ... do	2,439,518	3,244,559
Tungsten ... do	358,152	1,248,851
Total	--	134,617,785

See footnotes at end of table.

Table 57.—U.S. Government stockpile disposal of mineral commodities—Continued

Commodity	Sales commitments	
	Quantity	Sales value
OTHER		
Bauxite long dry tons	110,000	$500,000
Copper short tons	--	[3] −663
Mercury flasks	3,066	1,080,630
Silver fine troy ounces	--	[3] −45,906
Total	--	1,534,061
Grand total		234,696,042

[1] Negative sales figure represents adjustments of earlier disposal contracts.
[2] Represents that portion of copper made available to the U.S. mint for coinage purposes.
[3] Negative sales figures represent adjustment in earlier sales contracts for Treasury silver copper alloy. Copper value receipts shown represent difference in proceeds over and above asset value of $0.4215 per pound. Silver value receipts represent difference in that portion of total proceeds in excess of the U.S. monetary value of $1.2929 per ounce.

Source: Executive Office of the President, Office of Emergency Preparedness. Stockpile Report to the Congress. January–June 1971, pp. 16–17; July–December 1971, pp. 14–15.

Table 58.—United Nations indexes of world [1] mineral industry production

(1963 = 100)

Industry sector and geographic area	1969	1970	1971	1971 by quarters			
				1st	2nd	3rd	4th
EXTRACTIVE INDUSTRIES							
Metals:							
Non-Communist world	125	132	129	124	133	130	130
Industrialized countries [2]	121	131	131	126	137	130	132
United States and Canada	119	133	129	123	140	124	126
Europe	119	122	125	123	133	117	129
European Economic Community [3]	93	90	86	91	89	79	87
European Free Trade Association [4]	134	135	140	144	153	119	146
Australia and New Zealand	168	188	201	182	190	220	212
Less industrialized countries [5]	133	136	126	121	125	130	129
Latin America [6]	135	139	136	128	132	143	140
Asia [7]	125	139	147	139	147	149	153
Communist Europe [8]	172	187	200	202	198	200	197
World	139	145	145	141	147	146	145
Coal:							
Non-Communist world	91	90	88	95	92	84	80
Industrialized countries [2]	89	88	85	93	90	82	77
United States and Canada	117	124	117	134	133	123	80
Europe	77	74	73	78	73	67	72
European Economic Community [3]	79	77	75	81	74	70	77
European Free Trade Association [4]	71	66	65	71	70	57	62
Australia and New Zealand	172	184	181	160	195	161	208
Less industrialized countries [5]	121	123	121	120	121	118	124
Latin America [6]	136	141	139	NA	NA	NA	NA
Asia [7]	121	121	119	119	119	118	122
Communist Europe [8]	118	124	128	128	126	125	133
World	102	104	105	109	106	102	102
Crude petroleum and natural gas:							
Non-Communist world	152	165	170	172	171	168	172
Industrialized countries [2]	127	134	136	140	134	134	138
United States and Canada	125	130	130	133	129	129	130
Europe	154	179	200	214	188	176	220
European Economic Community [3]	152	170	182	196	172	165	197
European Free Trade Association [4]	146	207	265	298	240	199	322
Australia and New Zealand	NA	NA	NA	NA	NA	NA	NA
Less industrialized countries [5]	177	197	205	204	207	202	207
Latin America [6]	118	121	118	122	120	114	115
Asia [7]	174	192	216	206	220	218	223
Communist Europe [8]	163	175	187	192	190	184	182
World	155	167	174	176	175	171	175
Total extractive industry:							
Non-Communist world	132	140	141	142	143	139	141
Industrialized countries [2]	116	121	121	123	124	119	120
United States and Canada	123	128	126	129	130	126	122
Europe	102	105	108	110	108	101	111
European Economic Community [3]	108	112	114	118	112	108	121
European Free Trade Association [4]	88	87	89	93	94	79	89
Australia and New Zealand	167	190	207	183	204	213	228
Less industrialized countries [5]	164	179	183	181	184	181	184
Latin America [6]	123	126	123	124	124	122	122
Asia [7]	166	183	203	194	206	204	209
Communist Europe [8]	144	155	165	166	166	163	164
World	136	144	149	149	151	147	148

See footnotes at end of table.

Table 58.—United Nations indexes of world [1] mineral industry production—Continued

(1963 = 100)

Industry sector and geographic area	1969	1970	1971	1971 by quarters 1st	2nd	3rd	4th
PROCESSING INDUSTRIES							
Base metals:							
Non-Communist world	148	149	144	150	154	133	140
Industrialized countries [2]	148	148	142	149	153	130	137
United States and Canada	135	127	120	131	137	102	110
Europe	141	145	140	145	145	131	140
European Economic Community [3]	147	151	144	150	148	136	143
European Free Trade Association [4]	123	125	120	125	126	108	120
Australia and New Zealand	143	150	150	147	147	158	149
Less industrialized countries [5]	154	160	175	158	179	184	179
Latin America [6]	158	169	188	161	195	201	197
Asia [7]	152	150	161	161	160	163	158
Communist Europe [8]	154	164	174	176	173	173	173
World	150	154	153	158	160	145	150
Nonmetallic mineral products:							
Non-Communist world	138	141	147	132	153	152	151
Industrialized countries [2]	136	137	142	128	149	147	146
United States and Canada	124	118	122	111	128	126	124
Europe	139	146	152	132	161	157	157
European Economic Community [3]	134	141	145	120	154	153	151
European Free Trade Association [4]	136	139	145	137	153	143	146
Australia and New Zealand	148	152	154	139	158	159	158
Less industrialized countries [5]	158	174	188	169	190	197	195
Latin America [6]	152	170	187	171	183	194	201
Asia [7]	176	195	202	189	204	208	206
Communist Europe [8]	163	179	195	192	199	191	198
World	147	155	165	155	171	167	169
Chemicals, petroleum and coal products:							
Non-Communist world	175	183	194	187	194	192	201
Industrialized countries [2]	177	184	194	188	195	192	201
United States and Canada	170	171	179	170	180	182	185
Europe	179	193	203	202	205	194	211
European Economic Community [3]	185	200	211	209	212	202	220
European Free Trade Association [4]	161	172	178	179	182	168	182
Australia and New Zealand	160	172	194	170	199	206	200
Less industrialized countries [5]	158	174	188	179	183	192	198
Latin America [6]	161	180	195	NA	NA	NA	NA
Asia [7]	155	167	181	175	175	183	192
Communist Europe [8]	192	213	236	233	238	238	234
World	178	189	202	197	203	202	207
OVERALL INDUSTRIAL PRODUCTION							
Non-Communist world	148	152	156	155	156	152	160
Industrialized countries [2]	147	150	153	152	154	149	158
United States and Canada	144	140	141	140	141	140	142
Europe	140	148	152	152	153	142	160
European Economic Community [3]	142	151	155	156	156	145	164
European Free Trade Association [4]	131	136	138	139	140	127	145
Australia and New Zealand	147	155	163	154	164	170	164
Less industrialized countries [5]	155	166	177	171	177	177	181
Latin America [6]	148	158	169	NA	NA	NA	NA
Asia [7]	155	166	180	176	179	181	185
Communist Europe [8]	163	177	192	193	193	189	192
World	152	159	166	165	167	163	169

NA Not available.

[1] Excludes a number of countries of the Near East and Africa as well as People's Republic of China, North Korea, and North Vietnam.

[2] All countries having a per capita value added in manufacturing in 1958 equivalent to US$125 or more.

[3] Belgium, France, West Germany, Italy, Luxembourg, and the Netherlands.

[4] Austria, Denmark, Norway, Portugal, Sweden, Switzerland, and United Kingdom.

[5] Countries having a per capita value added in manufacturing in 1958 of less than US$125.

[6] Central and South America and the Caribbean Islands.

[7] Afghanistan, Brunei, Burma, Ceylon, Hong Kong, India, Indonesia, Iran, Republic of Korea, Malaysia (excluding Sabah), Mongolia, Pakistan, Philippines, Singapore, Taiwan, Thailand, and South Vietnam.

[8] Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the U.S.S.R.

Source: United Nations. Monthly Bulletin of Statistics. August 1972, pp. 10–23.

Table 59.—Comparisons of world and U.S. production and U.S. imports of principal minerals and mineral fuels in 1971

Mineral	World production (thousand short tons unless otherwise stated) p	U.S. production (percentage of world total)	U.S. imports (percentage of world production)	Total U.S. production and imports (percentage of world total) 1971	Total U.S. production and imports (percentage of world total) 1970 r
METALLIC ORES AND CONCENTRATES					
Bauxite ---- thousand long tons	61,981	3.2	19.9	23.1	26.1
Chromite	7,006	--	18.5	18.5	21.1
Copper (content of ore and concentrate)	6,665	22.8	2.4	25.2	30.3
Iron ore ---- thousand long tons	773,376	10.4	5.2	15.6	17.8
Lead (content of ore and concentrate)	3,752	15.4	2.4	17.8	16.5
Mercury ---- thousand 76-pound flasks	305,726	5.8	9.3	15.1	17.3
Molybdenum (content of ore and concentrate) ---- short tons	86,512	63.3	.5	63.8	62.6
Nickel (content of ore and concentrates)	706	2.4	20.1	22.5	24.8
Platinum group (Pt, Pd, etc.) ---- thousand troy ounces	4,077	.4	18.5	18.9	19.0
Silver ---- do	294,691	14.1	19.7	33.8	35.6
Titanium concentrates:					
Ilmenite [1]	3,721	18.4	5.0	23.4	27.8
Rutile [1]	416	--	51.6	51.6	52.9
Tungsten concentrate (60-percent tungsten dioxide) ---- short tons	40,364	8.5	.5	9.0	14.4
Zinc (content of ore and concentrate)	6,126	8.0	7.6	15.6	16.4
METALS, SMELTER BASIS					
Aluminum	11,339	34.6	6.2	40.8	41.7
Copper	6,736	22.3	2.4	24.7	26.3
Iron, pig	474,347	17.2	(2)	17.2	19.4
Lead	3,492	18.6	5.6	24.2	25.3
Magnesium	257	48.1	1.3	49.4	47.3
Steel ingots and castings	641,673	18.8	2.9	21.7	21.3
Tin ---- thousand long tons	227	NA	20.7	NA	NA
Uranium oxide [1] ---- short tons	24,582	52.5	3.9	56.4	56.3
Zinc	5,083	16.7	6.4	23.1	21.2
NONMETALS					
Asbestos	3,948	3.3	17.3	20.6	20.1
Cement ---- thousand barrels	3,460,674	12.0	.5	12.5	12.5
Diamond ---- thousand carats	42,189	--	41.7	41.7	41.4
Feldspar ---- thousand long tons	2,231	29.7	(2)	29.7	27.6
Fluorspar (marketable)	5,112	5.3	21.0	26.3	29.6
Gypsum	58,564	17.8	10.4	28.2	27.2
Mica (including scrap)	184	69.0	3.8	72.8	70.2
Nitrogen, agricultural [3 4]	45,357	25.2	2.0	27.2	27.7
Phosphate rock	96,468	40.3	(2)	40.3	41.3
Potash (K_2O equivalent)	22,119	11.7	12.5	24.2	26.1
Salt [4]	157,299	28.0	2.5	30.5	31.4
Sulfur, elemental ---- thousand long tons	22,516	42.5	6.3	48.8	51.6
MINERAL ENERGY RESOURCES					
Crude petroleum ---- thousand barrels	17,633,033	19.6	3.5	23.1	24.0
Natural gas ---- million cubic feet	43,846,430	51.3	2.1	53.4	60.0
Bituminous coal and lignite	3,110,435	17.8	(2)	17.8	19.5
Anthracite	198,508	4.4	--	4.4	4.9

p Preliminary. r Revised. NA Not available.
[1] World total exclusive of the U.S.S.R.
[2] Less than ½ unit.
[3] Year ended June 30, 1971.
[4] Including Puerto Rico.

Table 60.—Value of world export trade in major mineral commodity groups

(Million U.S. dollars)

Commodity group [1]	1966	1967	1968	1969	1970
Metals:					
All ores, concentrates, and scrap	r 4,760	r 5,030	5,590	r 6,340	7,880
Iron and steel	9,670	r 10,350	r 11,420	r 13,700	17,000
Nonferrous metals	r 8,010	r 8,020	r 9,450	r 10,860	12,020
Subtotal	22,440	23,400	26,460	r 30,900	36,900
Nonmetals (crude only)	r 1,890	2,010	2,180	2,260	2,410
Mineral fuels	r 18,710	r 20,890	r 23,030	r 24,860	28,700
Total	r 43,040	r 46,300	r 51,670	r 58,020	68,010
All commodities	r 202,260	r 213,760	r 238,080	r 271,440	311,390

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 Section 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 61.—Mineral commodity export price indexes

(1963 = 100)

Year and quarter	Metal Ores	Fuels	All crude minerals
1969	114	100	104
1970	122	105	109
1971:			
First quarter	125	120	121
Second quarter	125	128	128
Third quarter	125	131	129
Fourth quarter	127	131	130
Annual average	126	127	127

Source: United Nations. Monthly Bulletin of Statistics. New York, September 1972, p. 13.

Table 62.—Analysis of export price indexes

(1963 = 100)

Year and quarter	Developed areas		Developing areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1969	107	158	103	187
1970	122	167	104	191
1971:				
First quarter	142	149	112	158
Second quarter	145	155	120	168
Third quarter	146	151	122	160
Fourth quarter	147	148	122	154
Annual average	145	151	119	160

Source: United Nations. Monthly Bulletin of Statistics. New York, September 1972, p. 13.

Technologic Trends in the Mineral Industries (Metals and Nonmetals Except Fuels)

By John L. Morning[1]

The growth of the minerals industry (metals and nonmetals except fuels) slowed down in 1971, owing to the lag in the Nation's economy. Production of crude ore was about the same as in 1970, but owing to lower prices for some metal commodities total value of metal and nonmetal output decreased to $9.470 billion from $9.639 billion in 1970. During the decade from 1961 to 1970, output of crude ore for metals and nonmetals grew at an annual average rate of 2.8 percent; value of output grew nearly 5.1 percent annually.

Over 4 billion tons of material was handled in 1971 in producing over 2.6 billion tons of crude ore. Exploration and development activity decreased for the second year in a row, but activity was significantly increased at gold, zinc, barite, and gypsum mines.

Recent mining developments in the U.S. have been strongly influenced by mine health and safety requirements and environmental considerations, and future trends are expected to reflect the effort being devoted to improved health and safety and preservation of the environment. Design of new equipment for both surface and underground mining is reflected by the continuing emphasis on health and safety. Additional new safety features and more sophisticated safety equipment will continue to appear in the near future. In addition, disasters such as those at the Sunshine Mine in Idaho and along Buffalo Creek in West Virginia vividly illustrate the need for constant reexamination of mining technology. Such events attract worldwide attention and in the aftermath are likely to bring global improvements in procedures and equipment to avoid similar disasters.

Metallurgical trends have been controlled to a very large extent by environmental factors. Environmental and pollution problems have become increasingly important subjects of discussion at technical meetings, and it is becoming commonplace for producers to have a staff officer whose duties are concerned solely with these problems. Most primary base metal producers have implemented programs that will lead at least to partial compliance with both air quality and sulfur emission standards, and almost every smelter operator is either planning or already constructing new facilities as an approach to reducing metallurgical smelter emissions.

Materials Handled.—Producers of metal and nonmetal minerals (excluding fuels) handled 4,083 million tons of ore and waste in 1971, nearly the same quantity as in 1970, but 18 percent higher than in 1967 and 49 percent higher than in 1962. During the past 10 years, material handled has grown at a rate of 4 percent annually.

Crude ore output in 1971 totaled 2,613 million tons, off slightly from that of 1970. This compares with 2,073 million tons in 1962 and 2,413 million tons in 1967. Crude ore output has grown at 2.8 percent an-

[1] Supervisory physical scientist, Division of Ferrous Metals.

nually during the past 10 years. Copper and iron ore accounted for 84 percent of metal mine crude ore production, whereas phosphate rock, sand and gravel, and stone accounted for 94 percent of the nonmetal mine crude ore output. On a comparison basis, the percentages for the same commodities in 1962 were 74 percent and 93 percent, respectively, and in 1967, 79 percent and 92 percent, respectively.

Waste quantities mined to permit ore recovery more than doubled during the past decade. Waste handled in 1971 totaled 1,470 million tons compared with 666 million tons in 1962 and 1,028 million tons in 1967. Metal mines accounted for 70 percent and nonmetal for 30 percent of total waste handled. A high level of stripping in copper accounted for 41 percent of total waste handled, followed by phosphate rock, 19 percent, and iron ore, 13 percent. Stripping activities at uranium mines resulted in an increase of 66 percent in ore and waste handled compared with 1970 figures and accounted for 16 percent of total material handled at exploration and development activities.

Ten States, Arizona, California, Florida, Illinois, Michigan, Minnesota, New Mexico, Texas, Utah, and Wyoming, reported handling more than 100 million tons of material; this was one more than in 1970 and four more than in 1962. Four states reported handling between 90 and 100 million tons of material. Arizona and Florida continued to lead the nation in total material handled, as they have since 1965, and Florida and Minnesota led in output of crude ore production. Twenty-four States indicated an increase in crude ore production; 16 States registered increased waste material handled, and 23 States indicated an increase in total material handled compared with 1970 totals.

Magnitude of the Mining Industry.—A total of 15,000 mines reported crude ore production during the year. The data are not comparable with those of previous years, owing to combination reporting for some sand and gravel operations and elimination of brine and pumping operations. Of the total mines reporting production, clay mines totaled 1,398; sand and gravel operations, 7,110; crushed and broken stone operations, 4,715; dimension stone operations, 478; other nonmetal mines, 507; and metal mines, 792. In addition, there were 109 pumping, well, or pond operations.

Excluding clay, sand and gravel, and stone mines, metal and nonmetal mines (table 6) reporting production totaled 1,299, 61 percent of which were metal mines. Crude ore production ranged from less than one ton of ore to over 35 million tons.[2] Seventeen mines produced over 10 million tons of ore each; seven were copper, five iron ore, four phosphate rock, and one molybdenum.

The Utah Copper mine of Kennecott Copper Corp. retained its leading rank in output of crude ore and total material handled for metal mines. The Hoyt Lake mine of the Pickands Mather & Co. gained second place for output of ore, replacing the Peter Mitchell mine of Reserve Mining Co., which dropped to third place. The Hoyt Lake mine was the leading producer of crude ore in 1967 and 1968, while the Peter Mitchell mine was the leader in 1966. The Twin Buttes mine of The Anaconda Co. and the Sierrita mine of Duval Sierrita Corp. were second and third respectively, for total material handled.

Phosphate rock mines dominated the listing of large nonmetallic mines in terms of crude ore output and total material handled. The Suwanee mine of Occidental Petroleum Corp. moved into first place in 1971 from second place in 1970 and third place in 1969 for output of crude ore. The Payne Creek mine of Continental Oil Co. and the Noralyn mine of International Minerals & Chemical Co. were second and third, respectively. The Noralyn mine was the leader in output of ore in 1966 and 1969. In terms of total material handled, the Payne Creek mine was the leader, the Fort Meade mine of Mobil Oil Corp. retained its second ranking of 1970, and the Kingsford mine of International Minerals & Chemical Co. dropped from first place in 1970 to third place in 1971.

The 25 leading metal mines produced nearly 355 million tons of crude ore, 63 percent of the total output of crude ore from metal mines. The same mines also handled over 1,054 million tons of material which represented 67 percent of total material handled.

The 25 leading nonmetal mines produced over 137 million tons of crude ore and 426 million tons of total material handled. This represented 7 and 17 percent, respectively,

[2] Kennecott Copper Corp. Annual report, 1971, p. 24.

of total crude ore and total material handled at nonmetal mines.

The Freeport, Tex. plant of The Dow Chemical Co. was the leader in treating raw materials from lakes, ponds, seas, or wells. In addition to the Freeport plant, 18 operations treated over 1 million tons of material.

Value of Principal Mineral Products.—The measurement of value used in table 3 is the same as used throughout the Minerals Yearbook. When possible, the measurement is mine output, the form in which the minerals are extracted from the ground. For some minerals, the value of the products from beneficiation is used. Values for some metals are assigned according to average selling price of refined metal.

Value patterns are normally mixed, but on an average they increase, reflecting the trend in the nation's economy. In 1971, the average value of a ton of metal ore decreased for the first time since 1961, the first year these data were published. Unit values for copper, lead, mercury, and silver contributed to the decline in average value. Changes in unit values for nonmetals were mixed as the average value of a ton of ore decreased slightly. Among the nonmetals, phosphate rock contributed to the decrease in average value.

Byproducts contributed to the value of salable products of various mineral commodities. The value of byproducts was more significant for metal ores, of which they contributed 9 percent of total value. This percentage level returns the contribution of byproducts to ore value to about the level of the early 1960's. For the past three years, byproducts accounted for only 7 percent of total value. Byproducts raised the value of ores of lode gold 14 percent; lead, 42 percent; silver, 26 percent; uranium, 14 percent; and zinc, 24 percent. Among the nonmetals, byproducts increased total value of fluorspar 14 percent; lithium minerals, 22 percent; salt, 14 percent; and sodium carbonate, 13 percent.

Comparison of Production From Surface and Underground Mines.—Surface mining accounted for 94 percent of crude ore production and 96 percent of total material handled in 1971. Although there is little variation in the year-to-year ratio of production from surface and underground mines, the long-term trend indicates an increasing percentage of crude ore production by surface methods. This is especially notable for metal mine operations, as the nonmetal ratio is dominated by the large-volume commodities, sand and gravel and stone, which are primarily mined by surface methods.

At metal mines, surface mines in 1971 accounted for 86 percent of crude ore output and 85 percent of total material handled; underground mines accounted for the remainder. In 1962, underground metal mines accounted for 18 percent of crude ore production and 10 percent of total material handled, while in 1967, underground mines accounted for 17 percent of crude ore production and 8 percent of total material handled. Over the past decade, as crude ore production rose 33 percent at metal mines, surface mining grew at a faster rate than did underground mining.

Crude nonmetal material output and material handled at nonmetal underground mines were 4 and 3 percent, respectively, of total crude ore production and material handled, a relationship that has held since 1965.

Ratio of Ore Treated to Marketable Product.—The ratio of ore treated to marketable product varies with the mineral commodity and depends on grade of ore treated and the type of valuable mineral content. For some metal commodities, such as copper and iron ore, the trend in the past decade has been to higher ratios, indicating the treatment of lower grade ores. In the case of copper, the average grade of ore has declined, while in the iron ore industry new technology has allowed upgrading of various ore types to higher iron content iron ore pellets. The 10-year trend for lead indicates a decreasing ratio as new mines with higher grade ore deposits were phased into operation in the late 1960's. Other metal commodities such as bauxite and titanium have indicated a relatively constant ratio during the decade. Ratios for most nonmetal commodities indicate no discernable trend in ratio during the past decade. For many of these commodities the ratio is 1 to 1. A notable exception is that of barite, which has a trend of a lower ratio for the decade. New mines in Nevada and Alaska with higher grade deposits accounted for the lower ratio.

Two metal commodities, antimony and lead, and three nonmetal commodities, potassium salts, natural sodium carbonate, and wollastonite were mined entirely by underground methods. Ten metal commodities and 20 nonmetal commodities were mined entirely by surface methods.

Underground mining accounted for substantial percentages of crude ore production in six States: Colorado, 36 percent; New Mexico, 33 percent; Missouri, 26 percent; Wyoming, 21 percent; Louisiana, 17 percent; and Tennessee, 16 percent. Eighteen States reported no underground activity.

Exploration and Development.—Exploration and development work decreased for the second year in a row, but the mining industry was actively engaged in exploration, delineating existing ore bodies, and development of known ore reserves. The data presented are comparable with those of 1969, but do not include data from sand and gravel, stone, and clay mines reported in previous years. For metal mines, a surge of activity was noted for gold and zinc mines as activity at uranium mines dropped significantly. Ninety-seven percent of all exploration and development work occurred at metal mines. Notable increases in activity for nonmetal mines occurred in barite and gypsum, while activity decreased slightly in phosphate rock.

Six States reported over 1 million feet of exploration and development work. Wyoming led with 22 percent of the total, followed by Utah, 17 percent; Texas, 15 percent; and New Mexico, 14 percent. Exploration and development work significantly increased in Utah and New Mexico as a result of a high activity for copper, gold, and uranium. Rotary drilling accounted for 56 percent of all activity, decreasing from 73 percent in 1970. Percussion drilling more than doubled from that of 1970, rising to nearly 7.8 million feet. Other types of exploration and development methods to increase were drifting and crosscutting, trenching, and other methods. (See table 13.)

Stripping activities in phosphate rock accounted for 42 percent of the total material produced by exploration and development work. Other commodities that contributed significant material produced by stripping were copper, 22 percent; uranium, 16 percent; and iron ore, 14 percent. Copper accounted for the largest quantity of shaft and winze sinking, and raising tonnage while uranium accounted for the largest quantity of drifting and crosscutting, and trenching tonnage. Florida was the only State to produce over 100 millions tons of material from exploration and development work, accounting for 37 percent of total material produced.

Explosives.—Explosive statistics for the year of review are released too late for incorporation in this chapter. The apparent consumption of industrial explosives and breaking agents in the United States totaled 2,393 million pounds during 1970, an increase of 8 percent over that of 1969. The minerals industry accounted for 79 percent of the total explosive consumption. Coal mining led with 40 percent, followed by metal mining with 20 percent, and quarrying and nonmetal mining with 19 percent. All other uses, including construction and seismographic work, accounted for the balance.

Of the nearly 1.9 billion pounds of explosives used in the minerals industry, coal mining accounted for 51 percent, metal mining 25 percent, and quarrying and nonmetal mining 24 percent. Over 76 percent of the explosives consumed was primarily processed or unprocessed ammonium nitrate, the use of which continues to grow. Of the total ammonium nitrate used in the minerals industry, coal mining accounted for 61 percent, quarrying and nonmetal mining 20 percent, and metal mining 19 percent. The use of permissible high explosives continued to decline and the use of black powder was nearly phased out.

The five top-ranking States in order of total explosives and blasting agents consumed were as follows: Kentucky, Pennsylvania, Ohio, West Virginia, and Arizona. The total consumed in these States was 968 million pounds or 40 percent of all explosives and blasting agents used in 1970. In 1965, the ranking States of Pennsylvania, Kentucky, Ohio, Minnesota and Texas consumed 651 million pounds or 35 percent of all industrial explosives and blasting agents. In 1971, nine States consumed over 100 million pounds of explosives.

Leading States in the use of explosives and blasting agents for coal mining were Kentucky and Indiana; for metal mining, Arizona and Minnesota; and for quarrying and nonmetal mining, Pennsylvania and Illinois.

Data presented in tables 17 and 18 were prepared using definitions of explosives and blasting agents classified in 1967 as follows:

Fixed high explosives—Permissibles—Grades approved by the U.S. Bureau of Mines for use in a prescribed manner in underground coal mines.

Other high explosives—All high explosives except permissibles and those water gels and slurries containing high explosives. Prior to 1967, some rigidly cartridged and water gels and slurries were included in this category but now are included in either rigidly cartridged or water gels and slurries under blasting agents.

Blasting agents—Rigidly cartridged blasting agents—All blasting agents packaged in metal cans, rigid plastic containers and fiber drums of sufficient strength that no outside box is required. These were included formerly under other fixed high explosives and/or processed ammonium nitrate.

Water gels and slurries—All water gels or slurries, packaged or in bulk, made by addition of more than 5 percent water to high explosives or blasting agents. Products in this category were included formerly in other fixed high explosives and/or processed ammonium nitrate.

Other processed blasting agents and unprocessed ammonium nitrate—Ammonium nitrate-fuel mixtures sold in bulk or packaged in nonrigid containers which require an outside box for shipment and all prilled or grained (unprocessed) ammonium nitrate. Previously, this category was divided into (1) processed ammonium nitrate, which included some rigidly cartridged blasting agents and water gels and slurries, and (2) unprocessed ammonium nitrate.

Black blasting powder—Generally a mixture of sodium nitrate, sulfur, and charcoal in granular or pellet form.

More detailed explosive information is published in the Annual Explosive issue of Mineral Industry Surveys prepared by the Bureau of Mines.

Table 1.—Material handled at surface and underground mines, by commodity, in 1971 [1]

(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] 2,709	[3] 11,974	[3] 14,683	W	W	W	2,709	11,974	14,683
Copper	222,450	599,599	822,050	26,002	915	26,917	248,453	600,514	848,967
Gold:									
Lode	1,877	10,689	12,565	1,985	348	2,333	3,861	11,037	14,898
Placer	1,600	557	2,157	(4)	4	4	1,600	561	2,161
Iron ore	206,412	190,693	397,105	12,678	1,598	14,276	219,091	192,290	411,381
Lead	(4)	212	213	9,962	477	10,438	9,962	689	10,651
Mercury	156	283	439	120	20	139	276	303	578
Silver	29	48	77	710	285	995	739	333	1,072
Titanium: Ilmenite	21,525	2,206	23,731	--	--	--	21,525	2,206	23,731
Tungsten	22	(4)	22	641	44	685	663	44	707
Uranium	2,929	132,529	135,457	3,127	947	4,074	6,056	133,476	139,532
Zinc	156	663	819	9,007	1,372	10,379	9,163	2,035	11,198
Other [5]	19,994	67,663	87,658	15,532	251	15,783	35,527	67,915	103,443
Total metals [2]	480,000	1,017,000	1,497,000	80,000	6,000	86,000	560,000	1,023,000	1,583,000
NONMETALS									
Abrasives [6]	215	15	230	44	--	44	259	15	274
Asbestos	[3] 2,373	[3] 2,119	[3] 4,493	W	W	W	2,373	2,119	4,493
Barite	3,785	2,688	6,473	114	14	128	3,899	2,703	6,602
Clays	53,871	e 47,000	100,871	1,114	e 16	1,130	54,985	47,016	102,001
Diatomite	551	2,608	3,160	--	--	--	551	2,608	3,160
Feldspar	[3] 1,701	360	[3] 2,061	W	--	W	1,701	360	2,061
Fluorspar	59	(4)	59	691	9	700	749	9	759
Gypsum	8,022	12,307	20,329	2,298	67	2,365	10,319	12,375	22,694
Mica	692	432	1,123	(4)	(4)	(4)	692	432	1,123
Perlite	[3] 495	--	[3] 495	W	--	W	495	--	495
Phosphate rock	132,911	273,889	406,800	322	(4)	322	133,233	273,889	407,122
Potassium salts	--	--	--	16,117	4,514	20,631	16,117	4,514	20,631
Pumice	3,341	151	3,492	--	--	--	3,341	151	3,492
Salt	720	2	721	14,661	144	14,805	15,381	146	15,526
Sand and gravel	919,608	--	919,608	--	--	--	919,608	--	919,608
Sodium carbonate (natural)	--	--	--	4,514	178	4,692	4,514	178	4,692
Stone:									
Crushed and broken	841,353	e 73,200	914,553	31,916	e 230	32,146	873,269	73,430	946,699
Dimension	e 3,600	e 1,900	e 5,500	14	--	14	3,614	1,900	5,514
Talc, soapstone, and pyrophyllite	624	988	1,612	448	18	465	1,072	1,005	2,077
Other [7]	6,276	24,450	30,726	75	--	75	6,351	24,450	30,801
Total nonmetals [2]	1,980,000	442,000	2,422,000	73,000	5,000	78,000	2,053,000	447,000	2,500,000
Grand total	2,460,000	1,459,000	3,919,000	153,000	11,000	164,000	2,613,000	1,470,000	4,083,000

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Excludes material from wells, ponds, or pumping operations.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes underground; Bureau of Mines not at liberty to publish separately.
[4] Less than ½ unit.
[5] Antimony, beryllium, magnesium, manganese, molybdenum, nickel, platinum-group metals, rare-earth metals, tin, and vanadium.
[6] Emery, garnet, and tripoli.
[7] Aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, pyrites, vermiculite, wollastonite, and zeolite.

Table 2.—Material handled at surface and underground mines (including sand and gravel and stone), by State, in 1971 [1]

(Thousand short tons)

State	Surface			Underground			All mines [2]		
	Crude ore	Waste	Total [2]	Crude ore	Waste	Total [2]	Crude ore	Waste	Total
Alabama	29,909	4,638	34,547	W	--	W	29,909	4,638	34,547
Alaska	29,906	639	30,544	57	33	90	29,962	672	30,635
Arizona	162,059	334,814	496,873	16,259	601	16,861	178,318	335,416	513,733
Arkansas	32,401	12,662	45,063	721	16	737	33,122	12,678	45,800
California	179,519	64,374	243,893	2,196	132	2,329	181,715	64,506	246,221
Colorado	31,787	109	31,895	17,571	987	18,559	49,358	1,096	50,454
Connecticut	14,484	22	14,507	--	--	--	14,484	22	14,507
Delaware	2,219	--	2,219	--	--	--	2,219	--	2,219
Florida	200,669	242,120	442,789	--	--	--	200,669	242,120	442,789
Georgia	44,693	90	44,783	512	--	512	45,204	90	45,295
Hawaii	7,177	33	7,210	--	--	--	7,177	33	7,210
Idaho	18,951	12,764	31,714	1,651	373	2,024	20,601	13,137	33,738
Illinois	106,832	(3)	106,832	2,781	--	2,781	109,613	(3)	109,613
Indiana	51,893	--	51,893	974	33	1,007	52,867	33	52,900
Iowa	44,517	3,447	47,964	1,780	--	1,780	46,297	3,447	49,744
Kansas	25,201	--	25,201	2,940	37	2,978	28,141	37	28,178
Kentucky	37,734	--	37,734	4,487	--	4,487	42,221	--	42,221
Louisiana	30,272	--	30,272	6,017	--	6,017	36,289	--	36,289
Maine	9,623	662	10,285	W	W	W	9,623	662	10,285
Maryland	27,474	--	27,474	W	--	W	27,474	--	27,474
Massachusetts	25,342	--	25,342	--	--	--	25,342	--	25,342
Michigan	128,759	17,264	146,024	11,458	220	11,679	140,218	17,484	157,702
Minnesota	196,489	110,258	306,746	--	--	--	196,489	110,258	306,746
Mississippi	14,415	--	14,415	--	--	--	14,415	--	14,415
Missouri	51,877	2,217	54,094	18,547	771	19,318	70,424	2,988	73,412
Montana	38,020	58,742	96,763	687	309	996	38,707	59,051	97,758
Nebraska	16,966	--	16,966	W	--	W	16,966	--	16,966
Nevada	34,231	64,496	98,727	31	39	70	34,262	64,535	98,797
New Hampshire	8,871	--	8,871	--	--	--	8,871	--	8,871
New Jersey	34,370	381	34,751	W	W	W	34,370	381	34,751
New Mexico	37,922	140,650	178,572	18,926	4,804	23,729	56,848	145,454	202,302
New York	67,486	2,534	70,020	5,872	121	5,992	73,358	2,654	76,012
North Carolina	54,903	8,085	62,988	96	--	96	54,999	8,085	63,085
North Dakota	8,334	--	8,334	--	--	--	8,334	--	8,334
Ohio	89,478	--	89,478	6,745	--	6,745	96,223	--	96,223
Oklahoma	25,739	10,638	36,377	W	--	W	25,739	10,638	36,377
Oregon	36,972	602	37,573	3	2	5	36,974	604	37,578
Pennsylvania	83,873	1,259	85,132	5,986	824	6,810	89,859	2,083	91,941
Rhode Island	2,559	--	2,559	--	--	--	2,559	--	2,559
South Carolina	21,641	231	21,872	--	--	--	21,641	231	21,872
South Dakota	19,439	2,807	22,245	W	W	W	19,439	2,807	22,245
Tennessee	43,922	3,698	47,620	8,162	630	8,792	52,084	4,328	56,413
Texas	90,710	9,409	100,119	675	4	678	91,385	9,413	100,798
Utah	54,040	93,709	147,749	1,056	186	1,242	55,097	93,895	148,991
Vermont	7,206	590	7,796	177	9	187	7,383	599	7,982
Virginia	48,138	83	48,220	2,495	483	2,978	50,633	565	51,198
Washington	35,448	898	36,345	327	7	333	35,774	904	36,678
West Virginia	16,373	--	16,373	1,075	--	1,075	17,448	--	17,448

Wisconsin	56,388	4,368	60,756	535	--	535	56,923	4,368	61,291
Wyoming	20,715	128,716	149,431	5,533	335	5,868	26,248	129,051	155,299
Undistributed	1,957	121,217	123,174	5,934	503	6,437	7,891	121,720	129,611
Total [2]	2,460,000	1,459,000	3,919,000	153,000	11,000	164,000	2,613,000	1,470,000	4,083,000

W Withheld to avoid disclosing individual company confidential data, included with "Undistributed."
[1] Material from wells, ponds, or pumping operations not included in State totals.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.
[4] Includes estimated data in table 1.

Table 3.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States, in 1971

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total
METALS									
Bauxite	[1] $9.97	$0.42	[1] $10.39	W	--	W	$9.97	$0.42	$10.39
Copper	6.02	.40	6.42	$9.65	$0.79	$10.44	6.41	.44	6.85
Gold:									
Lode	7.63	.11	7.74	12.95	2.85	15.80	10.48	1.44	11.92
Placer	.42	--	.42	--	--	--	.42	--	.42
Iron ore	3.87	.02	3.89	8.44	.02	8.46	4.11	.02	4.13
Lead	47.23	50.20	97.43	14.41	6.03	20.44	14.41	6.04	20.45
Mercury	17.72	--	17.72	19.85	--	19.85	18.65	--	18.65
Silver	2.58	4.28	6.86	33.29	8.46	41.75	32.08	8.30	40.38
Titanium: Ilmenite	.71	.23	.94	--	--	--	.71	.23	.94
Tungsten	8.50	--	8.50	23.31	2.00	25.31	22.88	1.95	24.83
Uranium	22.80	--	22.80	23.53	6.74	30.27	23.14	3.16	26.30
Zinc	14.09	19.98	34.07	12.96	2.93	15.89	12.98	3.18	16.16
Average value [2]	4.92	.28	5.20	10.68	1.85	12.53	5.74	.50	6.24
NONMETALS									
Asbestos	[1] 5.13	.01	[1] 5.14	W	--	W	5.13	.01	5.14
Barite	3.26	.04	3.30	10.09	--	10.09	3.46	.04	3.50
Clays	4.87	--	4.87	3.48	--	3.48	4.84	--	4.84
Diatomite	63.44	--	63.44	--	--	--	63.44	--	63.44
Feldspar	5.62	.19	5.81	7.59	--	7.59	5.62	.19	5.81
Fluorspar	12.62	--	12.62	23.91	3.48	27.39	23.04	3.21	26.25
Gypsum	3.42	--	3.42	4.90	--	4.90	3.75	--	3.75
Mica (scrap)	[1] 6.80	.57	[1] 7.37	W	--	W	6.80	.57	7.37
Perlite	[1] 21.78	--	[1] 21.78	W	--	W	21.78	--	21.78
Phosphate rock	1.52	.05	1.57	6.84	--	6.84	1.53	.05	1.58
Potassium salts	--	--	--	5.38	.06	5.44	5.38	.06	5.44
Pumice	1.53	--	1.53	--	--	--	1.53	--	1.53
Salt	9.88	.46	10.34	6.25	.95	7.20	6.43	.92	7.35
Sand and gravel	1.25	--	1.25	--	--	--	1.25	--	1.25
Sodium carbonate (natural)	W	W	W	[3] 8.84	[3] 1.18	[3] 10.02	8.84	1.18	10.02
Stone:									
Crushed and broken	1.71	.01	1.72	1.75	--	1.75	1.71	.01	1.72
Dimension	56.61	--	56.61	63.58	--	63.58	56.67	--	56.67
Talc, soapstone, pyrophyllite	6.34	--	6.34	8.20	--	8.20	7.12	--	7.12
Average value [2]	1.70	.01	1.71	4.51	.23	4.74	1.80	.02	1.82
Average value—metals and nonmetals [2]	2.26	.06	2.32	7.74	1.08	8.82	2.57	.12	2.69
Average value—nonmetals, (excluding stone, sand and gravel) [2]	3.18	.08	3.26	6.72	.41	7.13	3.72	.13	3.85
Average value—metals and nonmetals (excluding stone, sand and gravel) [2]	4.00	.20	4.20	9.35	1.37	10.72	4.72	.36	5.08

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground; Bureau of Mines not at liberty to publish separately.
[2] Including unpublished data.
[3] Includes surface; Bureau of Mines not at liberty to publish separately.

Table 4.—Crude ore and total material handled at surface and underground mines, by commodity, in 1971

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	--	100	75	25
Bauxite	[1] 100	W	[1] 100	W
Beryllium	100	--	100	--
Copper	90	10	97	3
Gold:				
Lode	46	54	84	16
Placer	100	--	100	--
Iron ore	94	6	96	4
Lead	--	100	2	98
Magnesium	100	--	100	--
Manganiferrous ore	100	--	100	--
Mercury	55	45	76	24
Molybdenum	32	68	82	18
Nickel	100	--	100	--
Platinum-group metals	100	--	100	--
Rare-earth metals	100	--	100	--
Silver	2	98	7	93
Tin	100	--	100	--
Titanium: Ilmenite	100	--	100	--
Tungsten	3	97	3	97
Uranium	49	51	97	3
Vanadium	100	--	100	--
Zinc	2	98	7	93
Total metals	86	14	85	15
NONMETALS				
Abrasives:				
Emery	100	--	100	--
Garnet	100	--	100	--
Tripoli	41	59	48	52
Aplite	100	--	100	--
Asbestos	99	1	99	1
Barite	97	3	98	2
Boron minerals	100	--	100	--
Clays	98	2	98	2
Diatomite	100	--	100	--
Feldspar	100	--	100	--
Fluorspar	8	92	8	92
Graphite	100	--	100	--
Greensand marl	100	--	100	--
Gypsum	78	22	90	10
Iron oxide pigments (crude)	100	--	100	--
Kyanite	100	--	100	--
Lithium minerals	100	--	100	--
Magnesite	100	--	100	--
Mica	100	--	100	--
Millstones	100	--	100	--
Olivine	100	--	100	--
Perlite	99	1	99	1
Phosphate rock	100	--	100	--
Potassium salts	--	100	--	100
Pumice	100	--	100	--
Salt	4	96	5	95
Sand and gravel	100	--	100	--
Sodium carbonate (natural)	--	100	--	100
Stone:				
Crushed and broken	96	4	96	4
Dimension	99	1	99	1
Talc, soapstone, pyrophyllite	58	42	78	22
Vermiculite	100	--	100	--
Wollastonite	--	100	2	98
Zeolite	100	--	100	--
Total nonmetals	96	4	97	3
Grand total	94	6	96	4

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

Table 5.—Crude ore and total material handled at surface and underground mines, by State, in 1971

(Percent)

	Crude ore		Total material	
	Surface	Underground	Surface	Underground
STATE				
Alabama	97	3	98	2
Alaska	100	--	100	--
Arizona	91	9	97	3
Arkansas	98	2	98	2
California	99	1	99	1
Colorado	64	36	63	37
Connecticut	100	--	100	--
Delaware	100	--	100	--
Florida	100	--	100	--
Georgia	99	1	99	1
Hawaii	100	--	100	--
Idaho	92	8	94	6
Illinois	98	2	98	2
Indiana	98	2	98	2
Iowa	96	4	96	4
Kansas	90	10	89	11
Kentucky	89	11	89	11
Louisiana	83	17	83	17
Maine	100	--	100	--
Maryland	93	7	93	7
Massachusetts	100	--	100	--
Michigan	92	8	93	7
Minnesota	100	--	100	--
Mississippi	100	--	100	--
Missouri	74	26	74	26
Montana	98	2	99	1
Nebraska	97	3	97	3
Nevada	100	--	100	--
New Hampshire	100	--	100	--
New Jersey	100	--	100	--
New Mexico	67	33	88	12
New York	92	8	92	8
North Carolina	100	--	100	--
North Dakota	100	--	100	--
Ohio	93	7	93	7
Oklahoma	98	2	99	1
Oregon	100	--	100	--
Pennsylvania	93	7	93	7
Rhode Island	100	--	100	--
South Carolina	100	--	100	--
South Dakota	92	8	92	8
Tennessee	84	16	84	16
Texas	100	--	100	--
Utah	98	2	99	1
Vermont	98	2	98	2
Virginia	95	5	94	6
Washington	99	1	99	1
West Virginia	94	6	94	6
Wisconsin	99	1	99	1
Wyoming	79	21	96	4
Total	94	6	96	4

Table 6.—Number of domestic metal and nonmetal mines in 1971, 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	23	--	8	11	4	--	--
Copper	84	25	5	10	16	21	7
Gold:							
Lode	30	22	3	1	3	1	--
Placer	37	20	6	10	--	1	--
Iron ore	75	--	7	11	23	29	5
Lead	45	19	7	3	11	5	--
Mercury	62	37	18	7	--	--	--
Silver	42	25	10	5	2	--	--
Titanium: Ilmenite	6	--	--	--	1	5	--
Tungsten	66	59	5	1	1	--	--
Uranium	245	37	132	58	18	--	--
Zinc	52	10	5	14	23	--	--
Other [2]	25	10	1	4	4	5	1
Total metals	792	264	207	135	106	67	13
NONMETALS							
Abrasives [3]	14	3	7	3	1	--	--
Asbestos	9	3	--	1	5	--	--
Barite	35	1	4	18	12	--	--
Boron minerals	2	--	--	1	--	1	--
Diatomite	11	2	1	7	1	--	--
Feldspar	40	2	22	12	4	--	--
Fluorspar	21	4	10	5	2	--	--
Gypsum	65	2	6	18	39	--	--
Mica	20	8	5	5	2	--	--
Perlite	14	2	5	5	2	--	--
Phosphate rock	55	1	9	8	17	16	4
Potassium salts	8	--	--	--	1	7	--
Pumice	107	18	36	45	8	--	--
Salt	20	--	3	2	9	6	--
Sodium carbonate (natural)	3	--	--	--	1	2	--
Talc, soapstone, pyrophyllite	55	7	22	25	1	--	--
Vermiculite	3	--	1	--	2	--	--
Other [4]	25	10	3	5	7	--	--
Total nonmetals	[5] 507	63	134	160	114	32	4
Grand total	1,299	327	341	295	220	99	17

[1] Excludes wells, ponds, or pumping operations.
[2] Antimony, beryllium, magnesium, manganiferrous ore, molybdenum, nickel, platinum-group metals, rare-earth metals, tin, and vanadium.
[3] Emery, garnet, and tripoli.
[4] Aplite, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, wollastonite, and zeolite.
[5] In addition, there were 1,398 clay mines, 7,110 sand and gravel operations, 4,715 crushed and broken stone operations, and 478 dimension stone operations, but specific data on these operations are not available.

Table 7.—Twenty-five leading metal and nonmetal [1] mines in the United States in 1971, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Hoyt Lake	Minn	Pickands Mather & Co	Iron ore	Do.
Peter Mitchell	do	Reserve Mining Co	do	Do.
Sierrita	Ariz	Duval Sierrita Corp	Copper	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Pima	Ariz	Pima Mining Co	Copper	Do.
Morenci	do	Phelps Dodge Corp	do	Do.
San Manuel	do	Magma Copper Co	do	Caving.
Ray Pit	do	Kennecott Copper Corp	do	Open pit.
Climax	Colo	American Metal Climax, Inc	Molybdenum	Caving.
Berkeley Pit	Mont	The Anaconda Company	Copper	Open pit.
Empire	Mich	Cleveland-Cliffs Iron Co	Iron ore	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	do	Do.
Yerington	Nev	The Anaconda Company	Copper	Do.
New Cornelia	Ariz	Phelps Dodge Corp	do	Do.
Butler	Minn	The Hanna Mining Co	Iron ore	Do.
Republic	Mich	Cleveland-Cliffs Iron Co	do	Do.
Tyrone	N. Mex	Phelps Dodge Corp	Copper	Do.
National Steel	Minn	The Hanna Mining Co	Iron ore	Do.
Twin Buttes	Ariz	The Anaconda Company	Copper	Do.
Chino	N. Mex	Kennecott Copper Corp	do	Do.
Questa	do	Molydenum Corp. of America	Molybdenum	Do.
Thunderbird	do	Eveleth Taconite Co	Iron ore	Do.
White Pine	Mich	White Pine Copper Co	Copper	Open stopes.
Inspiration	Ariz	Inspiration Consolidated Copper Co.	do	Open pit.
		NONMETALS		
Suwannee	Fla	Occidental Petroleum Corp	Phosphate rock	Open pit.
Payne Creek	do	Continental Oil Co	do	Do.
Noralyn	do	International Minerals & Chemical Co.	do	Do.
Kingsford	do	do	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Haynsworth	do	Brewster Phosphate	do	Do.
Palmetto	do	Continental Oil Co	do	Do.
Rockland	do	U.S.S. Agri-Chemicals, Inc	do	Do.
Clear Spring	do	International Minerals & Chemical Co.	do	Do.
Saddle Creek	do	Continental Oil Co	do	Do.
Silver City	do	Swift Agricultural Chemicals Corp.	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Tampa Agricultural Chemical Operation.	do	Cities Service Co	do	Do.
Tenoroc	do	Borden, Inc	do	Do.
Lee Creek	N.C	Texas Gulf Inc	do	Do.
Watson	Fla	Swift Agricultural Chemicals Corp.	do	Do.
International	N. Mex	International Minerals & Chemical Co.	Potassium salts	Open stopes.
Retsof	N.Y	International Salt Co	Salt	Do.
PCA	N. Mex	Potash Co. of America	Potassium salts	Do.
Hobbs	do	Kerr-McGee Chemical Corp	do	Do.
Carlsbad	do	AMAX Chemical Corp	do	Do.
Boron	Calif	United States Borax & Chemical Corp.	Boron minerals	Open pit.
Bartow	Fla	U.S.S. Agri-Chemicals, Inc	Phosphate rock	Do.
Westvaco	Wyo	FMC Corp	Sodium compounds	Stoping.
St. Mary	La	Cargill, Inc	Salt	Open stopes.

[1] Brines and materials from wells excepted.

Table 8.—Twenty-five leading metal and nonmetal [1] mines in the United States in 1971, 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	The Anaconda Company	do	Do.
Sierrita	do	Duval Sierrita Corp	do	Do.
Berkeley Pit	Mont	The Anaconda Company	do	Do.
Questa	N. Mex	Molybdenum Corp. of America.	Molybdenum	Do.
Hoyt Lake	Minn	Pickands Mather & Co	Iron ore	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Do.
Peter Mitchell	Minn	Reserve Mining Co	do	Do.
Tyrone	N. Mex	Phelps Dodge Corp	Copper	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Pima	Ariz	Pima Mining Co	Copper	Do.
Ray Pit	do	Kennecott Copper Corp	do	Do.
Ruth	Nev	do	do	Do.
Lucky Mc	Wyo	Utah International Inc	Uranium	Do.
New Cornelia	Ariz	Phelps Dodge Corp	Copper	Do.
Chino	N. Mex	Kennecott Copper Corp	do	Do.
Mission	Ariz	American Smelting and Refining Co.	do	Do.
Shirley Basin (Sec. 27, 28, 29; T28N).	Wyo	Utah International, Inc	Uranium	Do.
Yerington	Nev	The Anaconda Company	Copper	Do.
Highland	Wyo	Humble Oil & Refining Co	Uranium	Do.
Inspiration	Ariz	Inspiration Consolidated Copper Co.	Copper	Do.
Shirley Basin (Sec. 10 and 15; T27N).	Wyo	Getty Oil Co	Uranium	Do.
Metcalf	Ariz	Phelps Dodge Corp	Copper	Do.
Sherman	Minn	United States Steel Corp	Iron ore	Do.
NONMETALS				
Payne Creek	Fla	Continental Oil Co	Phosphate rock	Open pit.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Kingsford	do	International Minerals & Chemical Co.	do	Do.
Haynesworth	do	Brewster Phosphates	do	Do.
Noralyn	do	International Minerals & Chemical Co.	do	Do.
Rockland	do	U.S.S. Agri-Chemicals, Inc	do	Do.
Suwannee	do	Occidental Petroleum Corp	do	Do.
Palmetto	do	Continental Oil Co	do	Do.
Boron	Calif	United States Borax & Chemical Corp.	Boron minerals	Do.
Saddle Creek	Fla	Continental Oil Co	Phosphate rock	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Tenoroc	do	Borden, Inc	do	Do.
Tampa Agricultural Chemical Operations.	do	Cities Service Co	do	Do.
Silver City	do	Swift Agricultural Chemicals Corp.	do	Do.
Clear Spring	do	International Minerals & Chemical Co.	do	Do.
Lee Creek	N.C	Texas Gulf Inc	do	Do.
Bartow	Fla	U.S.S. Agri-Chemicals, Inc	do	Do.
Watson	do	Swift Agricultural Chemicals Corp.	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
International	N. Mex	International Minerals & Chemical Co.	Potassium salts	Open stopes.
Leefe	Wyo	Stauffer Chemical Co	Phosphate rock	Open pit.
Nichols	Fla	Mobil Oil Corp	do	Do.
Henry	Idaho	Monsanto Co	do	Do.
Zonolite	Mont	W. R. Grace & Co	Vermiculite	Do.
Retsof	N.Y	International Salt Co	Salt	Open stopes.

[1] Brines and materials from wells excepted.

Table 9.—Fifteen leading plants in the United States that produced nonmetallics and other materials from lakes, ponds, seas, or wells, in order of output of raw materials

Plant	State	Operator	Commodity
Freeport	Tex	The Dow Chemical Co	Magnesium chloride.
Cape May	N.J	Northwest Magnesite Co	Magnesium compounds.
Port St. Joe	Fla	Basic Magnesia, Inc	Do.
Pascagoula	Miss	Corchem, Inc	Do.
Silver Peak	Nev	Foote Mineral Co	Lithium.
South San Francisco	Calif	Merck & Co., Inc	Magnesium compounds.
Moss Landing	do	Kaiser Aluminum & Chemical Corp	Do.
Iberville	La	The Dow Chemical Co	Salt brine.
Plaquemine	do	Allied Chemical Corp	Do.
Tully	N.Y	do	Do.
Great Salt Lake	Utah	Great Salt Lake Minerals & Chemical Corp	Potassium salts.
Wyandotte	Mich	BASF Wyandotte Corp	Salt brine.
Diamond Shamrock Corp	Ohio	Diamond Shamrock Chemical Co	Do.
Grand Isle	La	Freeport Minerals Co	Frasch sulfur.
Grand Ecaille	do	do	Do.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States, by commodity in 1971

Commodity	Unit of marketable product	Surface: Ore treated (thousand short tons)	Surface: Marketable product, units	Surface: Ratio of units of ore to units of marketable product	Underground: Ore treated (thousand short tons)	Underground: Marketable product, units	Underground: Ratio of units of ore to units of marketable product	Total: Ore treated (thousand short tons)[1]	Total: Marketable product, units[1]	Total: Ratio of units of ore to units of marketable product
METALS										
Bauxite	thousand long tons	[2] 2,862	[2] 1,988	1.4:1	W	W	W	2,862	1,988	1.4:1
Copper	thousand short tons	216,320	1,252	172.8:1	26,061	242	107.8:1	242,381	1,494	162.2:1
Gold:										
Lode	thousand troy ounces	1,727	319	5.4:1	1,996	627	3.2:1	3,723	946	3.9:1
Placer	do	1,600	16	99.2:1	--	--	--	1,600	16	99.2:1
Iron ore	thousand long tons	206,351	69,418	3.0:1	11,512	7,544	1.5:1	217,864	76,962	2.8:1
Lead	thousand short tons	1	(3)	6.0:1	9,944	519	19.2:1	9,945	519	19.2:1
Mercury	thousand flasks	155	9	16.5:1	120	8	14.7:1	274	17	15.7:1
Silver	thousand troy ounces	29	48	0.6:1	704	15,155	0.1:1	733	15,204	0.1:1
Titanium: Ilmenite	thousand short tons	21,641	714	30.3:1	--	--	--	21,641	714	30.3:1
Tungsten	do	19	(3)	343.7:1	647	6	116.8:1	666	6	119.1:1
Uranium	do	3,496	6	543.9:1	3,075	6	527.0:1	6,570	12	535.9:1
Zinc	do	134	6	22.9:1	8,983	362	24.8:1	9,117	368	24.8:1
NONMETALS										
Asbestos	do	[2] 2,373	[2] 131	[2] 18.1:1	W	W	W	2,373	131	18.1:1
Barite	do	3,787	775	4.9:1	114	51	2.2:1	3,901	825	4.7:1
Clays	do	54,312	52,569	1.0:1	1,114	897	1.2:1	55,426	53,466	1.0:1
Diatomite	do	542	535	1.0:1	--	--	--	542	535	1.0:1
Feldspar	thousand long tons	[2] 1,700	[2] 636	[2] 2.7:1	W	W	W	1,700	636	2.7:1
Fluorspar	thousand short tons	58	21	2.8:1	691	251	2.8:1	749	272	2.8:1
Garnet	do	176	17	10.3:1	--	--	--	176	17	10.3:1
Gypsum	do	8,022	7,950	1.0:1	2,298	2,369	1.0:1	10,319	10,319	1.0:1
Mica (scrap)	do	128	102	1.3:1	W	W	W	128	102	1.3:1
Perlite	do	[2] 432	[2] 432	[2] 1.0:1	W	W	W	432	432	1.0:1
Phosphate rock	do	132,981	38,652	3.4:1	322	234	1.4:1	133,303	38,886	3.4:1
Potassium salts	do	--	--	--	16,117	2,291	7.0:1	16,117	2,291	7.0:1
Pumice	do	3,316	3,316	1.0:1	--	--	--	3,316	3,316	1.0:1
Salt	do	728	586	1.2:1	13,845	13,146	1.0:1	14,573	13,732	1.1:1
Sand and gravel	do	919,608	919,608	1.0:1	--	--	--	919,608	919,608	1.0:1
Sodium carbonate (natural)	do	W	W	W	[4] 6,409	[4] 2,737	[4] 2.3:1	6,409	2,737	2.3:1
Stone:										
Crushed and broken	do	849,095	847,356	1.0:1	31,994	25,455	1.3:1	881,089	872,812	1.0:1
Dimension	do	[e] 3,600	1,634	2.2:1	14	14	1.0:1	3,614	1,648	2.2:1
Talc, soapstone, pyrophyllite	do	624	591	1.1:1	448	446	1.0:1	1,072	1,037	1.0:1
Tripoli	do	[2] 75	[2] 75	[2] 1.0:1	W	W	W	75	75	1.0:1

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.
[2] Includes underground; Bureau of Mines not at liberty to publish separately.
[3] Less than ½ unit.
[4] Includes surface; Bureau of Mines not at liberty to publish separately.

Table 11.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States, by commodity, in 1971

Commodity	Unit of marketable product	Surface			Underground			Total		
		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)[1]	Marketable product, units[1]	Ratio of units of material handled to units of marketable product
METALS										
Bauxite	thousand long tons	[2] 14,683	[2] 1,988	[2] 7.4:1	W	W	W	14,683	1,988	7.4:1
Copper	thousand short tons	822,050	1,252	643.2:1	26,917	242	110.1:1	848,967	1,494	556.9:1
Gold:										
Lode	thousand troy ounces	12,565	319	39.3:1	2,333	627	3.7:1	14,898	946	15.7:1
Placer	do	2,157	16	128.2:1	4	--	--	2,161	16	128.2:1
Iron ore	thousand long tons	397,105	69,418	5.7:1	14,276	7,544	1.5:1	411,381	76,962	5.3:1
Lead	thousand short tons	213	(3)	6.1:1	10,438	19	545.5:1	10,651	19	540.8:1
Mercury	thousand flasks	439	9	46.6:1	139	8	17.1:1	578	17	32.9:1
Silver	thousand troy ounces	77	48	0.8:1	995	15,155	0.1:1	1,072	15,204	0.1:1
Titanium: Ilmenite	thousand short tons	23,731	714	33.3:1	--	--	--	23,731	714	33.3:1
Uranium	short tons	135,457	6,427	18.0:1	4,074	5,834	0.7:1	139,532	12,261	9.8:1
Zinc	thousand short tons	819	6	139.5:1	10,379	362	28.7:1	11,198	368	30.5:1
NONMETALS										
Asbestos	do	[2] 4,493	[2] 131	[2] 34.3:1	W	W	W	4,493	131	34.3:1
Barite	do	6,473	775	8.4:1	128	51	2.5:1	6,602	825	8.0:1
Clays	do	100,871	52,569	1.9:1	1,130	897	1.3:1	102,001	53,466	1.9:1
Diatomite	do	3,160	535	5.9:1	--	--	--	3,160	535	5.9:1
Feldspar	thousand long tons	[2] 2,061	[2] 636	[2] 3.2:1	W	W	W	2,061	636	3.2:1
Fluorspar	thousand short tons	59	21	2.8:1	700	251	2.8:1	759	272	2.8:1
Gypsum	do	20,329	7,950	2.6:1	2,365	2,369	1.0:1	22,694	10,319	2.2:1
Mica (scrap)	do	[2] 987	[2] 102	[2] 9.7:1	W	W	W	987	102	9.7:1
Perlite	do	[2] 495	[2] 432	[2] 1.1:1	W	W	W	495	432	1.1:1
Phosphate rock	do	406,800	38,652	10.5:1	322	234	1.4:1	407,122	38,886	10.5:1
Potassium salts	do	--	--	--	20,631	2,291	9.0:1	20,631	2,291	9.0:1
Pumice	do	3,492	3,316	1.1:1	--	--	--	3,492	3,316	1.1:1
Salt	do	721	586	1.2:1	14,805	13,146	1.1:1	15,526	13,732	1.1:1
Sand and gravel	do	919,608	919,608	1.0:1	--	--	--	919,608	919,608	1.0:1
Sodium carbonate (natural)	do	--	W	--	4,692	[4] 2,737	1.8:1	4,962	2,737	1.7:1
Stone:										
Crushed and broken	do	914,553	847,356	1.1:1	32,146	25,455	1.3:1	946,699	872,812	1.1:1
Dimension	do	[e] 5,500	1,634	3.4:1	14	14	1.0:1	5,514	1,648	3.3:1
Talc, soapstone, pyrophyllite	do	1,612	591	2.7:1	465	446	1.0:1	2,077	1,037	2.0:1
Tripoli	do	[2] 84	[2] 75	1.1:1	W	W	W	84	75	1.1:1

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.
[2] Includes underground data; Bureau of Mines not at liberty to publish separately.
[3] Less than ½ unit.
[4] Includes surface data; Bureau of Mines not at liberty to publish separately.

Table 12.—Mining methods used in open-pit mining, by commodity, in 1971

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting [1]	Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting [1]
METALS			NONMETALS—Continued		
Bauxite	82	18	Boron minerals	100	--
Beryllium	--	100	Clays	--	100
Copper	91	9	Diatomite	--	100
Gold:			Feldspar	65	35
Lode	100	--	Fluorspar	97	3
Placer	--	100	Graphite	100	--
Iron ore	86	14	Greensand marl	--	100
Lead	69	31	Gypsum	93	7
Manganiferrous ore	73	27	Iron oxide pigments (crude)	--	100
Mercury	63	37	Kyanite	100	--
Molybdenum	100	--	Magnesite	100	--
Nickel	15	85	Mica	17	83
Platinum-group metals	--	100	Millstones	97	3
Rare-earth metals	100	--	Olivine	43	57
Silver	51	49	Perlite	51	49
Tin	--	100	Phosphate rock	1	99
Titanium: Ilmenite	16	84	Pumice	1	99
Tungsten	34	66	Salt	4	96
Uranium	16	84	Sand and gravel	--	100
Vanadium	20	80	Stone:		
Zinc	94	6	Crushed and broken	3	97
NONMETALS			Dimension	--	100
Abrasives:			Talc, soapstone, pyrophyllite	54	46
Abrasive stone	32	68	Vermiculite	70	30
Emery	100	--	Zeolite	--	100
Garnet	98	2			
Tripoli	100	--	Total	33	67
Aplite	29	71			
Asbestos	80	20			
Barite	8	92			

[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

Method	Metals: Feet	Metals: Percent of total	Nonmetals: Feet	Nonmetals: Percent of total	Total: Feet	Total: Percent of total
		1970				
Shaft and winze sinking	29,943	0.1	2,628	0.3	32,571	0.1
Raising	188,720	.7	7,521	1.0	196,241	.7
Drifting and crosscutting	787,994	2.8	21,537	2.7	809,531	2.8
Diamond drilling	2,318,116	8.3	130,095	16.4	2,448,211	8.5
Churn drilling	125,492	.4	16,753	2.1	142,245	.5
Rotary drilling	20,619,313	73.7	390,212	49.2	21,009,525	73.0
Percussion drilling	3,067,783	11.0	186,848	23.6	3,254,631	11.3
Trenching	66,853	.2	16,242	2.0	83,095	.3
Other	769,480	2.8	21,262	2.7	790,742	2.8
Total	27,973,694	100.0	793,098	100.0	28,766,792	100.0
		1971				
Shaft and winze sinking	19,129	.1	1,770	.2	20,899	.1
Raising	160,376	.6	4,321	.5	164,697	.6
Drifting and crosscutting	888,712	3.3	22,857	2.8	911,569	3.3
Diamond drilling	1,892,858	7.1	141,941	17.3	2,034,799	7.4
Churn drilling	121,483	.4	4,720	.6	126,203	.5
Rotary drilling	15,130,310	56.5	283,603	34.6	15,413,913	55.8
Percussion drilling	7,470,551	27.9	327,252	40.0	7,797,803	28.2
Trenching	117,310	.4	5,254	.6	122,564	.4
Other	988,313	3.7	27,584	3.4	1,015,897	3.7
Total	26,789,042	100.0	819,302	100.0	27,608,344	100.0

Table 14.—Exploration and development by method and selected metals and nonmetals, in 1971

(Feet)

Commodity	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
METALS										
Copper	6,289	69,706	148,317	1,657	809,071	18,125	175,048	118,066	1,190	1,347,469
Gold	2,120	10,150	34,947	5,210	44,993	2,030	519,190	3,849,928	3,071	4,471,639
Iron ore	--	10,777	96,507	680	102,446	5,000	11,583	26,459	309	253,761
Lead	1,590	16,068	60,417	33,041	263,360	26,968	30,460	838,426	91,424	1,361,754
Mercury	975	676	3,272	1,200	375	--	33,000	32,111	--	71,609
Silver	2,651	9,712	27,501	6,878	55,924	85	4,430	204,767	85	312,033
Tungsten	360	1,471	6,147	6,525	21,523	--	120	12,500	10,000	58,646
Uranium	1,986	15,777	361,234	40,442	271,629	1,400	13,669,085	1,068,187	841,291	16,271,031
Zinc	2,062	25,015	75,879	18,597	230,161	--	392	1,315,147	16,558	1,683,811
Other [1]	1,096	1,024	74,491	3,080	93,376	67,875	687,002	4,960	24,385	957,289
Total	19,129	160,376	888,712	117,310	1,892,858	121,483	15,130,310	7,470,551	988,313	26,789,042
NONMETALS										
Asbestos	--	210	1,150	--	900	--	--	400	--	2,660
Barite	--	668	3,733	4,954	--	4,720	3,965	110,047	7,370	135,457
Fluorspar	496	2,281	5,531	--	76,843	--	1,771	--	--	86,922
Gypsum	368	--	9,514	--	11,500	--	59,888	166,515	--	247,785
Phosphate rock	--	216	--	--	3,886	--	191,313	--	--	195,415
Talc, soapstone, pyrophyllite	871	946	2,679	--	12,300	--	--	40,000	--	56,796
Other [2]	35	--	250	300	36,512	--	26,666	10,290	20,214	94,267
Total	1,770	4,321	22,857	5,254	141,941	4,720	283,603	327,252	27,584	819,302
Grand total	20,899	164,697	911,569	122,564	2,034,799	126,203	15,413,913	7,797,803	1,015,897	27,608,344

[1] Antimony, bauxite, beryllium, manganese ore, molybdenum, nickel, titanium (ilmenite), and vanadium.
[2] Abrasive stone, boron minerals, clays, diatomite, feldspar, mica (scrap), pumice, salt, tripoli, wollastonite, and zeolite.

Table 15.—Exploration and development by method and State, in 1971

(Feet)

State	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
Alabama	--	--	--	--	19,887	72,875	617,953	--	10,120	720,835
Alaska	--	1,030	3,030	1,100	14,838	85	--	--	--	20,083
Arizona	6,685	61,179	129,830	1,823	399,091	14,685	101,562	75,380	7,574	797,809
Arkansas	536	668	15,483	--	5,638	--	55,449	--	8,885	86,659
California	721	3,099	10,062	3,335	33,837	30	6,900	48,752	8,594	115,330
Colorado	1,848	16,742	132,063	3,180	386,614	--	532,845	172,842	340,271	1,586,405
Florida	--	--	--	--	--	--	48,256	--	--	48,256
Georgia	--	--	--	--	--	4,720	3,965	--	--	8,685
Idaho	1,780	15,518	49,465	3,680	74,589	--	152,300	2,156,587	500	2,454,419
Illinois	226	436	934	--	68,775	--	1,236	--	--	71,607
Indiana	368	--	--	--	--	--	--	--	--	368
Iowa	--	--	--	--	7,500	--	840	--	--	8,340
Kentucky	--	--	--	--	--	--	--	3,000	--	3,000
Louisiana	--	--	--	--	7,200	--	--	--	--	7,200
Maine	--	--	357	--	17,588	--	--	--	--	17,945
Michigan	--	--	28,611	--	24,767	--	--	--	--	53,378
Minnesota	--	--	--	--	171,987	--	1,174	5,515	--	178,676
Missouri	802	3,513	73,163	30,450	223,110	26,548	29,188	--	91,860	478,634
Montana	291	5,215	12,825	2,144	69,412	2,020	66,099	43,160	85	201,251
Nevada	1,167	705	3,646	10,070	53,858	400	557,223	302,976	10,250	940,295
New Jersey	--	1,635	826	--	--	--	--	--	15,500	17,961
New Mexico	473	15,325	288,436	915	96,809	3,440	2,264,209	826,378	473,002	3,968,987
New York	71	13,344	24,046	--	28,669	--	--	--	--	66,130
North Carolina	--	--	500	--	10,000	--	--	7,300	--	17,800
Oklahoma	--	--	--	300	--	--	42,050	--	--	42,350
Oregon	--	80	160	800	--	--	59,000	--	1,500	61,540
Pennsylvania	533	5,625	14,178	--	1,197	--	--	33,318	--	54,851
South Dakota	1,610	8,983	29,483	--	42,655	--	162,455	490	725	246,401
Tennessee	252	3,583	30,159	15,807	113,749	--	3,500	126,836	--	293,886
Texas	69	--	560	--	--	--	4,007,262	--	1,766	4,009,657
Utah	2,507	3,179	28,087	7,930	72,328	1,400	578,695	3,979,661	3,780	4,677,567
Vermont	800	200	560	--	800	--	--	--	--	2,360
Virginia	--	2,886	7,536	--	25,988	--	25,648	2,720	--	64,778
Washington	60	1,000	5,758	1,030	39,202	--	420	--	14,278	61,748
Wisconsin	--	--	--	--	15,407	--	683	--	--	16,090
Wyoming	100	752	21,811	40,000	9,304	--	6,095,001	12,888	27,207	6,207,063
Total	20,899	164,697	911,569	122,564	2,034,799	126,203	15,413,913	7,797,803	1,015,897	27,608,344

Table 16.—Total material (ore and waste) produced by exploration and development in the United States, by commodity and State, in 1971

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Stripping	Total[1]
COMMODITY						
METALS						
Bauxite	1	--	91	--	11,973	12,065
Copper	122	193	1,168	10	141,592	143,085
Gold:						
Lode	10	41	125	19	4,836	5,032
Placer	1	--	1	10	89	100
Iron ore	--	132	1,354	5	91,690	93,181
Lead	10	51	428	59	201	751
Mercury	7	1	9	2	263	282
Silver	25	47	145	25	41	283
Tungsten	1	4	36	6	(2)	47
Uranium	9	32	1,403	215	106,161	107,819
Zinc	15	67	570	169	--	821
Other[3]	1	6	412	81	1,750	2,249
Total metals[1]	202	573	5,742	601	358,597	365,715
NONMETALS						
Barite		2	18	18	146	183
Fluorspar	4	6	42	--	9	61
Gypsum	4	--	79	--	10,849	10,932
Phosphate rock	--	1	--	--	273,372	273,373
Talc, soapstone, pyrophyllite	5	2	11	--	944	963
Other[4]	(2)	(2)	4	1	6,564	6,569
Total nonmetals[1]	13	11	155	19	291,887	292,084
Grand total[1]	215	584	5,897	619	650,484	657,799
STATE						
Alabama	--	--	--	--	3,548	3,548
Alaska	--	3	27	9	95	134
Arizona	124	140	1,066	11	52,155	53,495
Arkansas	1	2	108	--	12,637	12,749
California	2	9	51	7	4,808	4,876
Colorado	7	52	712	77	33	880
Florida	--	--	--	--	241,606	241,606
Georgia	--	--	--	--	86	86
Idaho	27	66	267	21	12,760	13,141
Illinois	2	3	8	--	(2)	13
Indiana	4	--	--	--	--	4
Iowa	--	--	--	--	3,447	3,447
Kansas	--	--	--	--	34	34
Michigan	--	--	72	--	13,434	13,506
Minnesota	--	--	--	--	75,078	75,078
Missouri	4	11	947	63	--	1,026
Montana	1	39	70	4	441	555
Nevada	8	3	10	28	41,627	41,677
New Jersey	--	2	3	--	381	385
New Mexico	2	38	1,088	2	54,954	56,083
New York	1	25	133	--	--	159
North Carolina	--	--	2	--	7,162	7,164
Oregon	--	(2)	3	1	--	4
Pennsylvania	5	118	550	--	1,250	1,922
South Dakota	9	32	107	--	2,803	2,951
Tennessee	(2)	16	360	167	3,698	4,242
Texas	(2)	--	1	--	6,583	6,585
Utah	12	19	147	15	4,396	4,588
Vermont	5	1	3	--	590	598
Virginia	--	3	70	--	49	123
Washington	(2)	4	17	2	728	751
Wyoming	(2)	1	70	213	95,450	95,735
Other[5]	--	--	4	1	10,650	10,655
Total[1]	215	584	5,897	619	650,484	657,799

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.
[3] Antimony, beryllium, manganese ore, molybdenum, nickel, rare-earth metals, titanium (ilmenite), and vanadium.
[4] Abrasive stone, aplite, asbestos, boron minerals, clays, diatomite, feldspar, graphite, iron oxide pigments (crude), mica (scrap), pumice, tripoli, wollastonite, and zeolite.
[5] Connecticut, Hawaii, Maine, and Oklahoma.

Table 17.—U.S. consumption of industrial explosives

(Thousand pounds)

Year	Kind of explosive								
	Fixed high explosives		Blasting agents			Black blasting powder		Liquid oxygen	
	Permissibles	Other high explosives	Rigidly-cartridged	Water gels and slurries	Other blasting agents processed and unprocessed ammonium nitrate	Granular	Pellets		Grand total [1]
1967	68,770	304,566	66,413	167,018	1,287,506	242	182	10,017	1,904,714
1968	64,130	288,114	40,732	206,518	1,347,817	257	170	--	1,947,737
1969	60,364	286,464	33,281	221,535	1,624,564	209	61	--	2,226,477
1970	56,269	285,841	37,430	214,856	1,799,012	79	4	--	2,393,491

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

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				
1967	65,284	161	2,238	67,683
1968	60,943	267	1,394	62,604
1969	57,528	58	1,193	58,779
1970	53,185	47	1,122	54,354
OTHER HIGH EXPLOSIVES				
1967	18,713	36,235	107,494	162,442
1968	14,409	41,009	98,315	153,733
1969	14,359	41,272	103,557	159,188
1970	16,764	41,299	112,006	170,069
BLASTING AGENTS, RIGIDLY CARTRIDGED				
1967	8,093	1,696	10,488	20,277
1968	7,966	3,142	12,185	23,293
1969	6,962	2,210	12,404	21,576
1970	8,651	2,293	15,176	26,120
BLASTING AGENTS, WATER GELS AND SLURRIES				
1967	4,136	123,250	28,036	155,422
1968	7,107	151,164	34,163	192,434
1969	9,583	162,359	35,517	207,459
1970	8,910	161,682	31,113	201,705
BLASTING AGENTS, AMMONIUM NITRATE [1]				
1967	555,303	166,250	261,145	982,698
1968	593,741	207,859	251,832	1,053,432
1969	731,679	264,892	286,003	1,282,574
1970	874,821	274,187	295,965	1,444,973
PELLET BLACK BLASTING POWDER				
1967	32	1	23	56
1968	--	--	11	11
1969	2	--	21	23
1970	--	--	4	4
GRANULAR BLACK BLASTING POWDER				
1967	3	3	101	107
1968	--	3	98	101
1969	1	--	94	95
1970	--	--	38	38
TOTAL EXPLOSIVES				
1967	r [2] 661,581	327,596	409,525	r [2] 1,398,702
1968	684,166	403,444	397,998	1,485,608
1969	820,114	470,791	438,789	1,729,694
1970	962,331	479,508	455,424	1,897,263

r Revised.

[1] Includes other processed blasting agents and unprocessed ammonium nitrate.

[2] Includes 10,017,000 pounds liquid oxygen.

Statistical Summary

By Staff, Office of Technical Data Services

This chapter summarizes mineral production in the United States, its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico. Tables showing the principal minerals exported from and imported into the United States, and comparing world and U.S. mineral production also are included. More detailed data are contained in the commodity chapters of volume I and the State chapters of volume II.

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 in the form in which they are first extracted from the ground, but customarily includes for some minerals the product of auxiliary processing operations at or near mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. The quantities of gold, silver, copper, lead, zinc, and tin are recorded on a mine basis (as the recoverable content of ore sold or treated). The values assigned to these quantities, however, 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 metal.

The weight or volume units shown are those customarily used in the particular industries producing the commodities. Values shown are in current dollars. No adjustments of the values have been 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 groups
(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total [2]
1967	$16,195	$5,200	r $2,327	r $23,723
1968	16,820	r 5,449	r 2,698	r 24,966
1969	17,965	5,624	r 3,333	26,921
1970	r 20,152	5,711	r 3,928	r 29,791
1971	21,258	6,068	3,406	30,732

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	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
MINERAL FUELS								
Asphalt and related bitumens (native): Bituminous limestone and sandstone and gilsonite ... short tons	1,797,219	$8,179	1,918,748	$8,561	1,980,562	$8,879	1,668,928	$8,291
Carbon dioxide, natural [e] ... thousand cubic feet	1,118,027	176	1,194,836	144	1,109,530	191	1,271,995	216
Coal:								
Bituminous and lignite [2] ... thousand short tons	545,245	2,546,340	560,505	2,795,509	602,932	3,772,662	552,192	3,901,496
Pennsylvania anthracite ... do	11,461	97,245	10,473	100,769	9,729	105,341	8,727	103,469
Helium:								
Crude ... million cubic feet	3,788	44,700	3,993	46,843	r 3,953	r 46,820	3,988	47,856
High purity ... do	1,066	28,355	760	21,599	647	17,405	577	14,539
Natural gas ... do	19,322,493	3,168,698	20,698,240	3,455,615	21,920,642	3,745,680	22,493,012	4,096,550
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	199,049	571,679	201,784	603,084	206,305	603,024	200,181	616,657
LP gases ... do	351,262	552,335	378,457	498,927	399,611	672,088	417,634	769,397
Peat ... thousand short tons	619	7,230	566	7,055	526	5,986	600	7,011
Petroleum (crude) ... thousand 42-gallon barrels	3,329,042	9,794,826	3,371,751	10,426,680	3,517,450	11,173,726	3,453,914	11,692,998
Total mineral fuels	XX	16,820,000	XX	17,965,000	XX	r 20,152,000	XX	21,258,000
NONMETALS (EXCEPT FUELS)								
Abrasive stones [3] ... short tons	3,141	629	3,311	600	r 3,055	r 635	2,349	563
Asbestos ... do	120,690	10,406	125,936	10,648	125,314	10,696	130,882	12,174
Barite ... thousand short tons	927	13,706	1,077	15,753	854	12,800	825	13,491
Boron minerals ... do	963	76,535	1,020	81,261	1,041	86,827	1,047	89,856
Bromine ... thousand pounds	362,452	86,787	391,883	87,990	349,748	60,560	355,946	61,750
Calcium-magnesium chloride ... short tons	W	W	W	W	632,500	15,225	W	W
Cement:								
Portland ... thousand 376-pound barrels	388,525	1,227,942	400,883	1,284,600	381,001	1,268,718	403,621	1,421,388
Masonry ... thousand 280-pound barrels	23,167	66,259	23,253	69,106	21,275	67,537	23,860	84,556
Natural and slag ... thousand 376-pound barrels	86	332	W	W	W	W	W	W
Clays ... thousand short tons	57,348	246,938	58,694	264,415	54,853	267,912	56,666	274,431
Diatomite ... short tons	W	W	598,482	36,485	597,636	32,649	535,318	34,392
Feldspar ... long tons	667,679	8,265	673,985	8,869	648,276	9,638	663,223	9,969
Fluorspar ... short tons	252,411	11,656	182,567	8,411	269,221	13,923	272,071	17,263
Garnet (abrasive) ... do	22,136	1,922	20,458	1,874	18,837	1,936	18,984	1,934
Gem stones [e]	NA	2,497	NA	2,390	NA	2,396	NA	2,589
Gypsum ... thousand short tons	10,018	36,775	9,905	38,354	9,436	35,132	10,418	39,057
Lime ... do	18,637	249,639	20,209	280,736	19,747	286,155	19,591	308,100
Magnesium compounds from sea water and brine (except for metal) ... short tons, MgO equivalent	525,210	43,449	618,762	53,046	707,874	62,434	668,649	62,322

Mica:								
Scrap ... thousand short tons	125	3,014	133	2,893	119	2,527	127	2,917
Sheet ... pounds	15,000	W	W	3	--	--	17,005	7
Perlite ... short tons	427,574	4,221	471,454	5,100	456,134	4,904	432,208	4,941
Phosphate rock ... thousand short tons	41,251	250,692	37,725	208,689	38,739	203,218	38,886	203,828
Potassium salts ... thousand short tons, K_2O equivalent	2,722	75,664	2,804	73,572	2,729	98,123	2,587	100,527
Pumice ... thousand short tons	3,530	5,570	3,609	5,050	r 3,036	r 4,671	3,316	5,064
Pyrites ... thousand long tons	872	W	W	W	W	W	808	7,137
Salt ... thousand short tons	41,274	272,275	44,245	287,680	r 45,896	r 304,759	44,077	303,687
Sand and gravel ... do	917,468	1,020,107	937,169	1,069,667	943,941	1,115,705	919,593	1,148,969
Sodium carbonate (natural) ... do	2,043	42,104	2,513	50,922	2,688	56,320	2,878	60,774
Sodium sulfate (natural) ... do	700	12,729	672	12,427	602	10,932	688	11,008
Stone [4] ... do	819,597	1,317,911	862,895	1,424,694	874,512	1,474,917	875,716	1,601,391
Sulfur:								
Frasch process mines ... thousand long tons	6,645	268,146	6,551	176,659	6,419	151,779	6,756	118,245
Other mines ... do	3	46	--	--	--	--	--	--
Talc, soapstone, and pyrophyllite ... short tons	958,262	6,656	1,029,238	7,508	1,027,929	7,773	1,037,297	7,634
Tripoli ... do	85,534	796	84,673	734	68,105	520	75,134	569
Vermiculite ... thousand short tons	290	5,684	310	6,805	285	6,501	301	7,198
Value of items that cannot be disclosed: Aplite, brucite, emery, graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values of nonmetal items indicated by symbol W	XX	79,309	XX	46,941	XX	r 33,373	XX	50,289
Total nonmetals	XX	r 5,449,000	XX	5,624,000	XX	r 5,711,000	XX	6,068,000
METALS								
Antimony ore and concentrate short tons, antimony content	856	W	938	W	1,130	W	1,025	933
Bauxite ... thousand long tons, dried equivalent	1,665	23,752	1,843	25,725	2,082	30,070	1,988	28,543
Beryllium concentrate ... short tons, gross weight	168	81	W	W	W	W	W	W
Copper (recoverable content of ores, etc.) ... short tons	1,204,621	1,008,195	1,544,579	1,468,400	1,719,657	1,984,484	1,522,183	1,583,071
Gold (recoverable content of ores, etc.) [5] ... troy ounces	1,478,292	58,038	1,733,176	71,944	1,743,322	63,439	1,495,108	61,673
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	81,934	836,433	89,854	929,293	87,176	941,739	77,106	891,002
Lead (recoverable content of ores, etc.) ... short tons	359,156	94,903	509,013	151,635	571,767	178,609	578,550	159,679
Manganese ore (35 percent or more Mn) short tons, gross weight	11,378	W	5,630	157	4,737	W	142	W
Manganiferous ore (5 to 35 percent Mn) ... do	244,590	W	430,637	W	368,302	W	198,334	W
Mercury ... 76-pound flasks	28,874	15,464	29,640	14,969	r 27,296	r 11,130	17,627	5,154
Molybdenum (content of concentrate) ... thousand pounds	93,245	151,000	103,009	173,819	110,381	190,077	97,882	164,917
Nickel (content of ore and concentrate) ... short tons	17,294	W	17,056	W	15,933	W	17,036	W
Rare-earth metal concentrates ... do	W	W	W	W	W	W	17,194	7,538
Silver (recoverable content of ores, etc.) thousand troy ounces	32,729	70,191	41,906	75,040	r 45,006	r 79,697	41,564	64,258
Titanium concentrate, ilmenite ... short tons, gross weight	960,118	19,484	893,034	18,636	920,964	18,626	713,549	15,403
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	r 9,501	r 20,293	r 8,312	r 18,770	r 9,785	r 23,790	7,173	20,184
Uranium (recoverable content U_3O_8) ... thousand pounds	24,139	182,698	23,748	142,161	24,682	149,464	24,520	152,029
Vanadium (recoverable in ore and concentrate) ... short tons	6,483	23,143	5,577	26,334	5,319	34,923	5,252	37,690
Zinc (recoverable content of ores, etc.) ... do	529,446	142,950	553,124	161,512	534,136	163,650	502,543	161,820

See footnotes at end of table.

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

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
METALS—Continued								
Value of items that cannot be disclosed: Cobalt, columbium-tantalum concentrate (1969), magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), tin (content of concentrates), titanium concentrate (rutile 1968), zircon concentrates, and value of metal items indicated by symbol W	XX	51,030	XX	54,180	XX	58,430	XX	51,690
Total metals	XX	r 2,698,000	XX	r 3,333,000	XX	r 3,928,000	XX	3,406,000
Grand total mineral production	XX	r 24,966,000	XX	r 26,921,000	XX	r 29,791,000	XX	30,732,000

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.

[5] Based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through March 15, 1968; and Engelhard selling quotations Mar. 20, 1968 through 1971.

Table 3.—Minerals produced in the United States and principal producing States in 1971

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	Mo., Nev., Ark., Ga	Alaska, Calif., Tenn.
Bauxite	Ark., Ala., Ga.	
Beryllium concentrate	Utah, S. Dak., Colo.	
Boron minerals	Calif.	
Bromine	Ark., Mich., Calif.	
Brucite	Nev.	
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., Wisc., 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., Utah, Va., Wash., Wyo.
Cobalt	Pa.	
Copper (mine)	Ariz., Utah, N. Mex., Nev	Calif., Colo., Idaho, Maine, Mich., Mo., Mont., N.C., Okla., Oreg., Pa., Tenn., Wash.
Diatomite	Calif., Nev., Wash., Ariz	Oreg.
Emery	N.Y., Oreg.	
Feldspar	N.C., Calif., Conn., S.C	Ariz., Colo., Ga., S. Dak., Va., Wyo.
Fluorspar	Ill., Colo., Ky., Mont	Ariz., Idaho, Nev., N. Mex., Utah.
Garnet, abrasive	N.Y., Idaho.	
Gold (mine)	S. Dak., Nev., Utah, Ariz	Alaska, Calif., Colo., Idaho., Mont., N. Mex., N.C., Oreg., Pa., Tenn., Wash.
Graphite	Tex.	
Gypsum	Mich., Calif., Tex., Iowa	Ariz., Ark., Colo., Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah, Va., Wash., Wyo.
Helium	Kans., Tex., Okla., Ariz	N. Mex.
Iodine	Mich.	
Iron Ore	Minn., Mich., Calif., Mo	Ala., Ariz., Colo., Ga., Idaho, Mont., Nev., N. Mex., N.Y., N.C., Pa., Tex., Utah, Wisc., Wyo.
Kyanite	Va., Ga., Fla.	
Lead (mine)	Mo., Idaho, Utah, Colo	Ariz., Calif., Ill., Mont., Nev., N. Mex., N.Y., N.C., Va., Wash., Wisc.
Lime	Ohio, Pa., Mo., Tex	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., Tex., N.J	Fla., Miss., Utah.
Manganese ore	Mont.	
Manganiferous ore	Minn., N. Mex., Utah.	
Manganiferous residuum	N.J.	
Marl, greensand	N.J., Md.	
Mercury	Calif., Nev., Tex., Idaho	Alaska, Ark., N.Y., Oreg.
Mica, scrap	N.C., Ala., Ga., S.C	Ariz., Colo., Conn., N. Mex., Pa., S. Dak.
Mica, sheet	N.C., Colo.	
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.
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., Fla., Ind	Calif., Colo., Ga., Idaho, Iowa, Maine, Md., Mass., Minn., Mont., N.J., N. Mex., N.Y., N. Dak., Ohio, Pa., S.C., Vt., Wash., Wis.
Perlite	N. Mex., Ariz., Calif., Nev	Colo., Idaho.

Table 3.—Minerals produced in the United States and principal producing States in 1971—Continued

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

Table 4.—Value of mineral production in the United States and principal minerals produced in 1971

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$291,492	23	.95	Coal, cement, stone, petroleum.
Alaska	333,923	21	1.09	Petroleum, sand and gravel, natural gas, coal.
Arizona	981,020	8	3.19	Copper, molybdenum, cement, sand and gravel.
Arkansas	253,219	27	.82	Petroleum, bromine, stone, natural gas.
California	1,920,648	3	6.25	Petroleum, natural gas, cement, sand and gravel.
Colorado	392,721	18	1.28	Petroleum, molybdenum, coal, sand and gravel.
Connecticut	27,961	46	.09	Stone, sand and gravel, feldspar, lime.
Delaware	2,241	50	.01	Sand and gravel, clays, gem stones.
Florida	343,731	20	1.12	Phosphate rock, stone, cement, sand and gravel.
Georgia	229,397	29	.75	Clays, stone, cement, sand and gravel.
Hawaii	28,107	45	.09	Stone, cement, sand and gravel, pumice.
Idaho	112,280	33	.37	Silver, lead, phosphate rock, zinc, sand and gravel.
Illinois	700,819	11	2.28	Coal, petroleum, stone, sand and gravel.
Indiana	281,565	25	.92	Coal, cement, stone, sand and gravel.
Iowa	127,821	31	.42	Cement, stone, sand and gravel, coal.
Kansas	589,444	15	1.92	Petroleum, natural gas, natural gas liquids, helium.
Kentucky	925,885	9	3.01	Coal, stone, petroleum, natural gas.
Louisiana	5,553,009	2	18.07	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	21,898	47	.07	Cement, sand and gravel, stone, copper.
Maryland	99,429	35	.32	Stone, cement, sand and gravel, coal.
Massachusetts	50,199	43	.16	Stone, sand and gravel, lime, clays.
Michigan	640,636	13	2.08	Iron ore, cement, sand and gravel, copper.
Minnesota	608,776	14	1.98	Iron ore, sand and gravel, stone, cement.
Mississippi	262,393	26	.85	Petroleum, natural gas, sand and gravel, clays.
Missouri	400,089	17	1.30	Lead, cement, stone, iron ore.
Montana	285,073	24	.93	Petroleum, copper, sand and gravel, stone.
Nebraska	74,079	40	.24	Petroleum, cement, sand and gravel, stone.
Nevada	164,774	30	.54	Copper, gold, sand and gravel, diatomite, cement.
New Hampshire	10,284	48	.03	Sand and gravel, stone, gem stones, clays.
New Jersey	93,575	37	.30	Sand and gravel, stone, zinc, magnesium compounds.
New Mexico	1,046,284	7	3.40	Petroleum, natural gas, copper, potassium salts.
New York	298,835	22	.97	Cement, stone, salt, sand and gravel.
North Carolina	112,451	32	.37	Stone, sand and gravel, cement, phosphate rock.
North Dakota	99,901	34	.33	Petroleum, coal, sand and gravel, natural gas.
Ohio	652,151	12	2.12	Coal, stone, lime, cement.
Oklahoma	1,189,516	5	3.87	Petroleum, natural gas, natural gas liquids, stone.
Oregon	77,885	39	.25	Sand and gravel, stone, cement, nickel.
Pennsylvania	1,149,107	6	3.74	Coal, cement, stone, sand and gravel.
Rhode Island	4,299	49	.01	Sand and gravel, stone, gem stones.
South Carolina	66,888	41	.22	Cement, stone, clays, sand and gravel.
South Dakota	62,988	42	.20	Gold, sand and gravel, stone, cement.
Tennessee	239,662	28	.78	Coal, stone, cement, zinc.
Texas	6,807,955	1	22.15	Petroleum, natural gas, natural gas liquids, cement.
Utah	525,700	16	1.71	Copper, petroleum, coal, molybdenum.
Vermont	36,284	44	.12	Stone, asbestos, sand and gravel, talc.
Virginia	385,161	19	1.25	Coal, stone, sand and gravel, cement.
Washington	94,601	36	.31	Sand and gravel, cement, stone, coal.
West Virginia	1,273,960	4	4.15	Coal, natural gas, stone, sand and gravel.
Wisconsin	84,036	38	.27	Sand and gravel, stone, iron ore, cement.
Wyoming	717,937	10	2.34	Petroleum, natural gas, sodium carbonate, uranium.
Total	30,732,000	--	100.00	

Table 5.—Mineral production [1] in the United States, by State

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
ALABAMA								
Cement: [2]								
Masonry ... thousand 280-pound barrels	2,523	$7,309	2,600	$8,520	2,402	$7,601	2,493	$8,657
Portland ... thousand 376-pound barrels	15,514	48,147	16,527	51,251	16,053	51,114	12,149	42,281
Clays ... thousand short tons	2,793	6,995	3,097	7,083	2,748	8,213	[3] 2,915	[3] 6,913
Coal (bituminous) ... do	16,440	115,815	17,456	130,405	20,560	166,308	17,944	146,180
Iron ore (usable) ... thousand long tons, gross weight	1,151	6,730	1,125	6,435	W	W	415	2,773
Lime ... thousand short tons	773	8,933	747	9,870	749	10,286	761	11,454
Natural gas ... million cubic feet	230	30	180	24	627	87	355	54
Petroleum (crude) ... thousand 42-gallon barrels	7,635	20,385	7,701	20,793	7,263	20,627	7,832	23,496
Sand and gravel ... thousand short tons	8,140	9,130	8,323	9,427	6,725	8,144	6,674	7,513
Stone ... do	20,643	33,847	19,854	37,512	[4] 19,982	37,166	17,773	34,413
Value of items that cannot be disclosed: Asphalt (native), bauxite, cement (slag), natural gas liquids (1969–71), mica (scrap), phosphate rock (1969–70), salt, stone (dimension) (1970–71), talc and values indicated by symbol W	XX	2,300	XX	3,416	XX	13,699	XX	7,758
Total	XX	259,621	XX	284,736	XX	323,245	XX	291,492
ALASKA								
Antimony ore and concentrate ... short tons, antimony content	3	W	12	13	63	109	--	--
Barite ... thousand short tons	91	W	W	W	134	835	102	1,075
Coal (bituminous) ... do	750	4,502	667	4,366	549	4,059	698	5,710
Gold (recoverable content of ores, etc.) [5] ... troy ounces	21,262	835	21,227	881	34,776	1,265	13,012	537
Lead (recoverable content of ores, etc.) ... short tons	W	W	2	1	--	--	--	--
Natural gas ... million cubic feet	17,343	4,388	50,864	12,665	111,576	27,448	121,618	28,945
Petroleum (crude) ... thousand 42-gallon barrels	66,204	186,695	73,953	214,464	83,616	251,684	79,494	257,562
Sand and gravel ... thousand short tons	18,013	20,366	16,205	18,615	25,825	41,092	23,617	32,806
Silver (recoverable content of ores, etc.) thousand troy ounces	4	8	2	4	2	4	1	1
Stone ... thousand short tons	W	W	1,954	3,902	6,470	10,014	2,658	5,066
Tin ... long tons	W	W	W	W	W	W	17	47
Value of items that cannot be disclosed: Copper (1968), gem stones, LP gases (1969–71), platinum-group metals, uranium (1971), and values indicated by symbol W	XX	4,923	XX	2,865	XX	1,761	XX	2,174
Total	XX	221,717	XX	257,776	XX	338,271	XX	333,923

ARIZONA								
Clays……thousand short tons	77	347	120	394	199	454	[3] 119	[3] 84
Coal (bituminous)……do	--	--	--	--	132	W	1,146	W
Copper……short tons	627,961	525,566	801,363	761,840	917,918	1,059,277	820,171	852,978
Diatomite……do	W	W	725	W	W	W	W	W
Gem stones	NA	149	NA	153	NA	155	NA	160
Gold (recoverable content of ores, etc.) [5]……troy ounces	95,999	3,769	110,878	4,603	109,853	3,998	94,038	3,879
Gypsum……thousand short tons	W	W	83	424	98	358	W	W
Helium, high purity……million cubic feet	65	1,600	56	1,126	62	1,186	W	W
Iron ore (usable)……thousand long tons, gross weight	16	124	18	136	W	W	15,859	W
Lead (recoverable content of ores, etc.)……short tons	1,704	450	217	65	285	89	859	237
Lime……thousand short tons	260	4,561	283	5,074	309	4,523	296	4,474
Mercury……76-pound flasks	192	103	W	W	--	--	--	--
Molybdenum (content of concentrate)……thousand pounds	12,127	19,207	12,699	20,947	15,672	26,700	22,684	39,872
Natural gas (marketed)……million cubic feet	881	142	1,136	199	1,101	188	868	153
Petroleum (crude)……thousand 42-gallon barrels	3,370	9,606	2,433	7,056	1,784	5,281	1,236	3,918
Pumice……thousand short tons	1,033	974	910	814	824	627	949	625
Sand and gravel……do	13,981	14,423	16,744	18,224	17,822	19,804	19,791	24,391
Silver (recoverable content of ores, etc.) thousand troy ounces	4,958	10,633	6,141	10,997	7,330	12,981	6,170	9,538
Stone……thousand short tons	3,293	6,239	2,827	5,812	3,511	7,094	2,873	5,848
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	1	3	1	2	W	W	W	W
Uranium (recoverable content U_3O_8)……thousand pounds	295	1,923	W	W	--	--	--	--
Zinc (recoverable content of ores, etc.)……short tons	5,441	1,469	9,039	2,639	9,618	2,947	7,761	2,499
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite, 1971), feldspar, fluorspar (1971), mica (scrap), perlite, pyrites, vanadium (1968–69), vermiculite (1968–69) and values indicated by symbol W	XX	16,253	XX	18,957	XX	21,105	XX	32,364
Total	XX	617,541	XX	859,462	XX	1,166,767	XX	981,020
ARKANSAS								
Barite……thousand short tons	166	3,839	210	4,616	168	3,721	W	W
Bauxite……thousand long tons, dried equivalent	1,582	23,058	1,755	24,706	1,869	26,293	1,781	24,979
Bromine and bromine in compounds……thousand pounds	95,499	20,790	145,100	28,287	W	W	W	W
Clays……thousand short tons	919	2,134	992	2,426	1,014	2,902	[3] 936	[3] 1,499
Coal (bituminous)……do	211	1,576	228	1,802	268	2,225	276	2,848
Gem stones	NA	30	NA	24	NA	25	NA	30
Lime……thousand short tons	206	3,058	184	2,748	186	2,680	157	2,313
Natural gas……million cubic feet	156,627	24,456	169,257	26,743	181,351	29,560	172,154	29,426
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	753	2,192	692	2,049	643	1,824	517	1,686
LP gases……do	1,435	2,899	1,279	2,098	1,205	2,482	1,035	2,650
Petroleum (crude)……do	19,464	53,137	18,049	51,079	18,035	51,760	18,263	56,805
Sand and gravel……thousand short tons	12,997	14,643	12,674	14,949	13,301	16,036	11,630	15,603
Stone……do	16,322	22,256	16,463	23,134	15,284	22,786	17,116	35,677
Value of items that cannot be disclosed: Abrasive stones, cement, clays, gypsum, mercury (1970–71), soapstone, tripoli, vanadium (1971), and values indicated by symbol W	XX	24,655	XX	23,465	XX	63,331	XX	79,703
Total	XX	198,723	XX	208,126	XX	225,625	XX	253,219

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
CALIFORNIA								
Antimony ore and concentrate short tons, antimony content	--	--	--	--	4	$10	--	--
Asbestos short tons	75,592	$6,139	75,828	$5,956	78,966	6,332	87,144	$7,806
Boron minerals thousand short tons	963	76,535	1,020	81,261	1,041	86,827	1,047	89,856
Cement thousand 376-pound barrels	47,595	151,961	50,610	170,612	49,499	173,126	48,493	169,921
Clays thousand short tons	2,755	6,630	2,993	7,443	2,824	6,506	[3] 2,822	[3] 7,103
Copper (recoverable content of ores, etc.) short tons	1,182	989	1,129	1,073	2,308	2,663	515	536
Gem stones	NA	200	NA	200	NA	200	NA	205
Gold (recoverable content of ores, etc.) [5] troy ounces	15,682	616	7,904	328	4,999	182	2,966	122
Gypsum thousand short tons	1,360	3,603	1,210	3,339	1,132	3,271	1,352	3,884
Lead (recoverable content of ores, etc.) short tons	4,001	1,057	2,518	750	1,772	553	2,284	630
Lime thousand short tons	568	9,301	585	9,666	572	9,911	630	10,846
Magnesium compounds from seawater and bitterns (partly estimated) short tons, MgO equivalent	81,622	7,229	76,220	7,143	73,726	7,489	152,918	16,836
Mercury 76-pound flasks	21,417	11,470	18,480	9,333	18,593	7,582	13,233	3,869
Natural gas million cubic feet	714,893	221,077	677,689	207,440	649,117	208,367	612,629	199,717
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	13,403	42,963	12,954	39,944	11,993	38,478	11,045	35,545
LP gases do	8,589	18,749	8,238	17,646	7,051	16,006	6,755	16,482
Peat thousand short tons	W	W	11	106	10	W	12	W
Perlite do	8,806	80	11,419	105	W	W	W	W
Petroleum (crude) thousand 42-gallon barrels	375,496	883,644	375,291	920,060	372,191	945,365	358,484	975,076
Pumice thousand short tons	776	1,312	866	1,229	r 499	r 832	699	1,179
Salt do	1,901	W	1,895	W	1,656	r 15,053	1,887	21,142
Sand and gravel do	124,655	153,360	124,718	155,883	140,259	174,221	115,468	157,683
Silver (recoverable content of ores, etc.) thousand troy ounces	598	1,282	492	881	451	799	444	686
Stone thousand short tons	36,125	52,671	38,033	57,757	46,399	66,950	43,336	86,255
Sulfur ore long tons	3,125	46	--	--	--	--	--	--
Talc, soapstone, and pyrophyllite short tons	165,396	2,075	145,158	2,329	184,660	2,545	153,227	2,084
Zinc (recoverable content of ores, etc.) [7] do	3,525	952	3,327	971	3,514	1,077	3,003	967
Value of items that cannot be disclosed: Barite, bromine, calcium-magnesium chloride, carbon dioxide, coal (lignite), diatomite, feldspar, iron ore, lithium minerals, scrap mica (1968), molybdenum, phosphate rock (1968–70), platinum-group metals (crude) (1968), potassium salts, rare-earth metal concentrates, sodium carbonates and sulfates, tungsten concentrate, wollastonite, and values indicated by symbol W	XX	r 146,009	XX	r 143,208	XX	r 125,337	XX	112,218
Total	XX	r 1,799,950	XX	r 1,844,663	XX	r 1,899,682	XX	1,920,648

COLORADO								
Beryllium concentrate ... short tons	W	W	46	W	W	W	W	W
Carbon dioxide, natural ... thousand cubic feet	200,657	34	175,787	30	W	W	W	W
Clays ... thousand short tons	616	1,222	732	1,619	[3] 637	[3] 1,503	625	1,334
Coal (bituminous) ... do	5,558	26,785	5,530	29,121	6,025	35,243	5,337	33,813
Copper (recoverable content of ores, etc.) ... short tons	3,451	2,888	3,598	3,421	3,749	4,326	3,938	4,096
Feldspar ... long tons	W	W	358	3	426	3	510	4
Gem stones	NA	121	NA	122	NA	120	NA	125
Gold (recoverable content of ores, etc.) [5] ... troy ounces	22,638	889	25,777	1,070	37,114	1,351	42,031	1,734
Gypsum ... thousand short tons	98	354	94	339	W	W	W	W
Lead (recoverable content of ores, etc.) ... short tons	19,778	5,226	21,767	6,484	21,855	6,827	25,746	7,106
Lime ... thousand short tons	125	2,375	127	2,449	119	1,613	193	3,039
Mica, sheet ... pounds	--	--	--	--	--	--	8,300	4
Molybdenum (content of concentrate) ... thousand pounds	61,684	100,296	62,411	105,346	W	W	W	W
Natural gas ... million cubic feet	121,424	16,392	118,754	17,219	105,804	15,553	108,537	16,932
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	1,289	3,248	1,076	2,798	745	1,937	929	2,462
LP gases ... do	1,987	3,338	1,782	2,762	1,542	2,529	1,653	3,190
Peat ... thousand short tons	28	250	26	160	34	210	28	156
Petroleum (crude) ... thousand 42-gallon barrels	31,937	94,215	28,294	88,277	24,723	78,619	27,391	92,855
Pumice ... thousand short tons	28	234	42	232	50	268	62	W
Pyrites ... thousand long tons	23	97	24	120	W	W	W	W
Sand and gravel ... thousand short tons	23,131	26,608	19,877	27,266	22,261	24,190	27,000	30,155
Silver (recoverable content of ores, etc.) thousand troy ounces	1,646	3,351	2,599	4,653	2,933	5,194	3,390	5,241
Stone ... thousand short tons	2,471	5,201	2,245	5,079	3,552	8,076	3,785	7,933
Tin (content of concentrate) ... long tons	33	64	44	119	W	W	W	W
Tungsten concentrate ... short tons, 60-percent WO_3 basis	1,893	4,413	1,941	4,440	W	W	W	W
Uranium (recoverable content U_3O_8) ... thousand pounds	2,706	20,009	2,736	16,935	2,727	15,832	2,536	15,725
Vanadium (recoverable in ore and concentrate) ... short tons	3,492	12,468	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.) [7] ... do	50,258	13,570	53,715	15,685	56,694	17,370	61,181	19,700
Value of items that cannot be disclosed: Cement, fluorspar, iron ore, scrap mica (1970–71), perlite, rare-earth metal concentrates (1968–69), salt, and values indicated by symbol W	XX	15,630	XX	32,745	XX	r 169,060	XX	147,117
Total	XX	359,458	XX	368,494	XX	r 389,824	XX	392,721
CONNECTICUT								
Clays ... thousand short tons	195	325	197	341	171	386	174	322
Gem stones	NA	8	NA	8	A	8	NA	15
Mica, scrap ... thousand short tons	W	W	W	W	W	W	3	W
Sand and gravel ... do	8,752	9,321	8,857	10,359	6,765	9,202	6,921	10,262
Stone ... do	6,383	12,729	7,562	15,325	8,338	16,915	7,193	15,649
Value of items that cannot be disclosed: Feldspar, lime, and scrap mica	XX	1,493	XX	1,734	XX	1,872	XX	1,713
Total	XX	23,876	XX	27,767	XX	28,383	XX	27,961

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
DELAWARE								
Clays ...thousand short tons	12	$12	11	$11	11	$11	14	$8
Gem stones	NA	1	NA	1	NA	1	NA	2
Sand and gravel ...thousand short tons	1,596	1,483	2,257	2,074	1,565	1,603	2,205	2,231
Stone ...do	200	500	--	--	--	--	--	--
Total	XX	1,996	XX	2,086	XX	1,615	XX	2,241
FLORIDA								
Cement:								
Masonry ...thousand 280-pound barrels	W	W	W	W	W	W	1,283	4,877
Portland ...thousand 376-pound barrels	W	W	W	W	W	W	11,581	48,970
Clays ...thousand short tons	808	11,699	907	13,627	872	12,661	[3] 993	12,834
Lime ...do	125	2,059	182	2,712	167	2,810	159	2,958
Natural gas ...million cubic feet	108	16	50	8	--	--	903	270
Peat ...thousand short tons	41	277	55	359	46	304	57	412
Petroleum (crude) ...thousand 42-gallon barrels	1,474	W	1,731	W	2,999	W	5,347	W
Sand and gravel ...thousand short tons	7,765	7,967	14,409	13,988	12,482	12,254	23,228	18,836
Stone [4] ...do	36,692	46,563	42,332	56,611	43,089	61,302	42,816	64,332
Value of items that cannot be disclosed: Kaolin (1971), kyanite, magnesium compounds, natural gas liquids, phosphate rock, rare-earth metal concentrates (1968), staurolite, stone (dimension limestone 1968–70), titanium concentrate, zircon concentrate, and values indicated by symbol W	XX	236,042	XX	208,071	XX	210,711	XX	190,242
Total	XX	304,623	XX	295,376	XX	300,042	XX	343,731
GEORGIA								
Barite ...thousand short tons	140	2,874	124	3,116	W	W	W	W
Cement:								
Masonry ...thousand 280-pound barrels	W	W	W	W	W	W	448	1,470
Portland ...thousand 376-pound barrels	W	W	W	W	W	W	6,458	22,470
Clays ...thousand short tons	5,111	88,632	5,670	98,462	5,684	110,149	[3] 5,791	[3] 119,096
Iron ore (usable) ...thousand long tons, gross weight	192	1,119	241	1,338	243	1,467	W	W
Peat ...thousand short tons	W	W	W	W	W	W	1	13
Sand and gravel ...do	3,803	4,314	3,824	4,709	3,667	4,437	3,697	5,310
Stone ...do	26,903	56,177	27,755	59,451	26,635	59,200	30,669	69,897
Talc ...short tons	45,600	288	47,790	301	45,900	289	53,000	334
Value of items that cannot be disclosed: Bauxite, fire clay (1971), feldspar, kyanite, scrap mica, rare-earth metal concentrates, titanium concentrate, zircon concentrates, and values indicated by symbol W	XX	19,686	XX	23,525	XX	27,683	XX	10,807
Total	XX	173,090	XX	190,902	XX	203,225	XX	229,397

HAWAII								
Cement:								
Masonry thousand 280-pound barrels	--	--	--	--	77	366	79	431
Portland thousand 376-pound barrels	1,841	9,254	2,075	10,544	2,105	9,968	1,993	10,196
Clays thousand short tons	3	4	2	9	2	11	W	W
Lime do	8	268	9	287	9	338	8	228
Pumice, pumicite, and volcanic ash do	408	724	403	783	350	933	289	779
Sand and gravel do	546	1,653	552	1,816	514	1,679	836	1,967
Stone do	5,211	11,273	6,534	16,059	[4] r 6,332	15,538	[4] 6,056	14,357
Value of items that cannot be disclosed: Gem stones, salt, and value of items indicated by symbol W	XX	49	XX	41	XX	132	XX	149
Total	XX	23,225	XX	29,539	XX	28,965	XX	28,107
IDAHO								
Antimony ore and concentrate short tons, antimony content	853	W	922	W	993	W	857	817
Clays [3] thousand short tons	12	14	23	51	13	28	W	W
Copper (recoverable content of ores, etc.) short tons	3,525	2,950	3,332	3,168	3,612	4,168	3,776	3,927
Gem stones	NA	200	NA	90	NA	90	NA	100
Gold (recoverable content of ores, etc.) [5] troy ounces	3,277	127	3,403	141	3,128	114	3,596	148
Gypsum thousand short tons	3	13	--	--	--	--	--	--
Lead (recoverable content of ores, etc.) short tons	54,790	14,478	65,597	19,541	61,211	19,121	66,610	18,384
Mercury 76-pound flasks	W	W	1,012	511	1,038	423	1,057	309
Peat thousand short tons	W	W	1	W	W	W	W	W
Phosphate rock do	3,879	22,721	W	W	W	W	W	W
Pumice do	135	259	21	62	r 53	r 94	W	W
Sand and gravel do	8,224	9,133	8,555	7,583	12,953	10,022	11,279	11,437
Silver (recoverable content of ores, etc.) thousand troy ounces	15,959	34,225	18,930	33,897	19,115	33,849	19,140	29,590
Stone thousand short tons	2,195	5,209	3,750	6,426	[4] 4,240	[4] 6,368	4,149	6,118
Tungsten concentrate short tons, 60-percent WO_3 basis	W	W	27	63	W	W	25	66
Zinc (recoverable content of ores, etc.) [7] short tons	57,248	15,457	55,900	16,323	41,052	12,578	45,078	14,515
Value of items that cannot be disclosed: Cement, clays, (fire clay and kaolin), fluorspar (1971), abrasive garnet, iron ore, lime, perlite, stone (dimension 1970), vanadium, and values indicated by symbol W	XX	9,467	XX	30,453	XX	32,904	XX	26,869
Total	XX	114,253	XX	118,309	XX	119,759	XX	112,280
ILLINOIS								
Cement:								
Portland thousand 376-pound barrels	9,372	32,475	8,720	29,996	7,946	25,252	7,578	25,975
Masonry thousand 280-pound barrels	602	2,097	603	2,137	508	1,874	522	2,336
Clays [3] thousand short tons	2,327	4,813	1,863	4,321	1,676	3,862	1,788	4,294
Coal (bituminous) do	62,441	250,685	64,722	279,712	65,119	320,705	58,402	318,878
Fluorspar short tons	188,325	9,134	88,480	4,676	148,208	8,637	138,051	9,883
Lead (recoverable content of ores, etc.) do	1,467	388	791	236	1,532	479	1,238	342
Natural gas million cubic feet	4,380	552	3,800	536	4,850	761	498	88
Peat thousand short tons	62	867	67	958	63	711	72	W
Petroleum (crude) thousand 42-gallon barrels	56,391	173,120	50,724	161,302	43,747	141,994	39,084	135,621
Sand and gravel thousand short tons	45,609	52,943	44,138	56,688	43,926	60,155	45,364	59,397
Stone do	55,858	80,188	54,857	81,318	55,776	86,502	61,991	106,084

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
ILLINOIS—Continued								
Zinc (recoverable content of ores, etc.) [7] ....short tons..	18,182	$4,909	13,765	$4,019	16,797	$5,146	12,706	$4,091
Value of items that cannot be disclosed: Clay (fuller's earth, 1968–70), gem stones, lime, natural gas liquids, silver (1971), and tripoli	XX	35,372	XX	33,916	XX	32,619	XX	33,830
Total	XX	647,543	XX	659,815	XX	688,697	XX	700,819
INDIANA								
Abrasive stones....short tons..	5	16	5	17	W	W	W	W
Cement [2] ....thousand 376-pound barrels..	14,774	48,096	14,497	45,264	12,432	41,810	W	W
Clays....thousand short tons..	1,550	2,355	1,483	2,264	1,335	2,139	[3] 1,324	[3] 2,304
Coal (bituminous)....do....	18,486	71,680	20,086	82,902	22,263	102,371	21,396	110,796
Natural gas....million cubic feet..	234	55	171	40	153	36	537	132
Peat....thousand short tons..	39	557	38	515	W	W	50	W
Petroleum (crude)....thousand 42-gallon barrels..	8,692	26,511	7,841	25,013	7,487	23,958	6,658	22,770
Sand and gravel....thousand short tons..	25,774	26,160	26,218	27,438	23,476	25,796	24,982	29,094
Stone....do....	26,307	46,790	25,559	45,400	25,818	45,215	26,233	48,218
Value of items that cannot be disclosed: Cement (masonry), gypsum, lime, and values indicated by symbol W	XX	13,166	XX	13,018	XX	14,461	XX	68,251
Total	XX	235,386	XX	241,871	XX	255,786	XX	281,565
IOWA								
Cement:								
Portland....thousand 376-pound barrels..	13,900	47,275	14,084	47,265	12,744	45,432	12,726	47,925
Masonry....thousand 280-pound barrels..	624	1,986	606	1,912	520	1,758	473	1,719
Clays....thousand short tons..	1,264	1,747	1,199	1,660	1,181	1,823	[3] 1,028	[3] 1,702
Coal (bituminous)....do....	876	3,289	903	3,392	987	4,059	989	4,609
Gypsum....do....	1,351	5,838	1,169	5,274	1,136	4,223	1,154	4,460
Sand and gravel....do....	16,332	15,192	18,391	17,867	21,058	20,642	18,279	20,530
Stone....do....	26,150	40,397	26,233	40,895	25,305	41,119	[4] 25,389	[4] 44,977
Value of items that cannot be disclosed: Clay (fire, 1971), gem stones, lime, peat, and dimension stone (1971)	XX	1,573	XX	1,665	XX	1,766	XX	1,899
Total	XX	117,297	XX	119,930	XX	120,822	XX	127,821
KANSAS								
Cement: [2]								
Portland....thousand 376-pound barrels..	9,680	29,898	9,764	29,365	9,197	28,177	9,208	29,961
Masonry....thousand 280-pound barrels..	383	1,177	348	1,023	328	1,029	355	1,232
Clays....thousand short tons..	932	1,433	[3] 797	[3] 1,070	[3] 713	[3] 946	879	1,151
Coal (bituminous)....do....	1,268	6,526	1,313	7,108	1,627	9,102	1,151	6,579

Helium:								
Crude ... million cubic feet	2,750	33,600	2,669	32,667	r 2,550	r 30,600	2,510	30,120
High purity ... do	292	7,300	330	7,578	354	8,137	342	7,182
Lead (recoverable content of ores, etc.) ... short tons	1,227	324	395	118	80	25	--	--
Lime ... thousand short tons	W	W	7	W	6	W	8	W
Natural gas ... million cubic feet	835,555	115,307	883,156	122,759	899,955	125,994	885,144	127,267
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	4,824	10,977	4,855	11,848	6,549	14,617	5,387	12,253
LP gases ... do	15,748	25,827	19,574	26,229	20,814	30,597	23,215	39,001
Petroleum (crude) ... do	94,505	285,405	88,716	283,891	84,853	277,469	78,532	276,433
Pumice ... thousand short tons	11	10	W	W	W	W	W	W
Salt [6] ... do	1,128	15,520	1,270	17,090	1,230	18,206	1,240	18,712
Sand and gravel ... do	12,427	10,559	12,029	10,061	12,968	12,351	11,862	11,351
Stone ... do	14,372	20,650	15,828	22,645	15,161	22,406	[4] 14,908	23,697
Zinc (recoverable content of ores, etc.) [7] ... short tons	3,012	813	1,900	555	1,186	364	--	--
Value of items that cannot be disclosed: Natural cement (1968–69), clays (fire 1969–70), gypsum, salt (brine), and values indicated by symbol W	XX	3,311	XX	3,808	XX	r 3,969	XX	4,505
Total	XX	568,637	XX	577,815	XX	r 583,989	XX	589,444
KENTUCKY								
Clays [3] ... thousand short tons	1,219	1,952	1,232	2,076	1,020	1,793	956	1,377
Coal (bituminous) ... do	101,156	395,039	109,049	450,950	125,305	711,163	119,389	774,735
Fluorspar ... short tons	17,050	878	W	W	W	W	W	W
Natural gas ... million cubic feet	89,024	22,256	81,304	20,407	77,892	19,161	72,723	18,253
Petroleum (crude) ... thousand 42-gallon barrels	14,036	41,125	12,924	40,194	11,575	36,461	10,692	35,925
Sand and gravel ... thousand short tons	7,478	8,081	8,364	9,628	8,760	10,474	8,202	11,061
Stone ... do	30,105	43,266	[4] 30,158	[4] 44,644	[4] 29,310	[4] r 45,208	32,514	52,296
Zinc (recoverable content of ores, etc.) [7] ... short tons	W	W	W	W	4,189	1,283	5,268	1,696
Value of items that cannot be disclosed: Native asphalt (1968), cement, ball clay, lead (1968), lime (1971), natural gas liquids, stone (quartzite, 1969–71), and values indicated by symbol W	XX	22,266	XX	23,148	XX	r 21,922	XX	30,542
Total	XX	534,863	XX	591,047	XX	847,465	XX	925,885
LOUISIANA								
Clays ... thousand short tons	863	1,163	1,078	2,943	1,080	1,575	1,073	1,606
Lime ... do	781	10,159	822	10,750	1,025	12,811	960	17,625
Natural gas ... million cubic feet	6,416,015	1,212,627	7,227,826	1,387,743	7,788,276	1,503,137	8,081,907	1,632,545
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	49,928	156,903	53,565	171,434	56,526	174,632	54,424	173,425
LP gases ... do	57,165	91,464	71,867	96,302	80,385	138,262	90,271	166,099
Petroleum (crude) ... do	817,426	2,570,641	844,603	2,791,269	906,907	3,061,558	935,243	3,359,710
Salt ... thousand short tons	10,908	53,854	12,435	61,102	13,584	64,854	13,352	67,950
Sand and gravel ... do	20,411	26,504	18,131	21,895	18,155	22,363	19,228	24,492
Stone [4] ... do	9,387	11,785	9,237	11,892	9,183	11,945	9,688	14,139
Sulfur (Frasch process) ... thousand long tons	4,074	162,664	3,999	108,299	3,618	89,489	3,681	W
Value of items that cannot be disclosed: Cement, gypsum, miscellaneous stone, and value indicated by symbol W	XX	23,246	XX	21,697	XX	21,695	XX	95,413
Total	XX	4,321,010	XX	4,685,326	XX	5,102,321	XX	5,553,009

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
MAINE								
Clays [3] thousand short tons	42	$65	42	$56	41	$55	42	$56
Copper short tons	W	W	W	W	2,703	3,120	2,510	2,610
Gem stones	NA	35	NA	35	NA	35	NA	40
Sand and gravel thousand short tons	11,866	5,978	11,275	6,026	12,971	6,888	8,292	5,881
Silver thousand troy ounces	W	W	W	W	63	112	41	64
Stone thousand short tons	1,187	3,205	1,101	3,798	W	W	1,133	2,913
Zinc [7] short tons	W	W	W	W	9,114	2,792	5,850	1,884
Value of items that cannot be disclosed: Beryllium (1969–70), cement, clays, feldspar (1968–70), peat, and values indicated by symbol W	XX	8,527	XX	10,273	XX	10,778	XX	8,450
Total	XX	17,810	XX	20,188	XX	23,780	XX	21,898
MARYLAND								
Clays [3] thousand short tons	[5] 1,078	[5] 1,252	[5] 1,152	[5] 1,369	[5] 1,129	[5] 1,433	[5] 1,027	[5] 1,558
Coal (bituminous) do	1,447	5,318	1,368	5,261	1,615	8,083	1,644	10,274
Gem stones	NA	3	NA	3	NA	3	NA	8
Natural gas million cubic feet	864	221	978	248	813	202	214	52
Peat thousand short tons	6	94	4	78	4	47	3	39
Sand and gravel do	11,719	17,157	14,230	21,226	12,951	20,434	12,842	23,201
Stone do	13,344	26,606	15,067	30,504	16,015	32,783	15,912	34,770
Value of items that cannot be disclosed: Cement, selected clays, diatomite (1969), lime, greensand marl, potassium salts (1968–70), and talc and soapstone	XX	21,193	XX	24,794	XX	25,231	XX	29,527
Total	XX	71,844	XX	83,483	XX	88,216	XX	99,429
MASSACHUSETTS								
Clays thousand short tons	257	314	332	624	284	582	186	377
Gem stones	NA	2	NA	2	NA	2	NA	W
Lime thousand short tons	198	3,380	199	3,718	W	W	W	W
Peat do	W	W	W	W	W	W	2	32
Sand and gravel do	17,799	20,106	19,456	22,950	17,925	22,244	17,343	23,058
Stone do	6,917	19,501	7,847	22,521	8,136	24,349	7,816	23,582
Value of items that cannot be disclosed: Nonmetals and values indicated by symbol W	XX	37	XX	28	XX	3,183	XX	3,150
Total	XX	43,340	XX	49,843	XX	50,360	XX	50,199

MICHIGAN								
Cement:								
Portland thousand 376-pound barrels	31,375	99,158	30,373	98,425	29,813	101,019	32,489	104,665
Masonry thousand 280-pound barrels	2,006	5,527	1,904	5,473	1,519	5,253	1,704	5,872
Clays thousand short tons	2,599	2,906	2,667	3,037	2,480	2,887	2,458	3,366
Copper (recoverable content of ores, etc.) short tons	74,805	62,607	75,226	71,516	67,543	77,945	56,005	58,245
Gypsum thousand short tons	1,405	5,196	1,327	5,384	1,312	5,061	1,433	5,585
Iron ore (usable) thousand long tons, gross weight	12,699	148,890	14,058	169,756	13,100	168,958	11,833	159,854
Lime thousand short tons	1,630	19,870	1,589	20,372	1,538	21,355	1,444	20,549
Magnesium compounds from sea water and brine (except for metal) short tons, MgO equivalent	266,406	25,087	321,191	30,343	411,911	38,050	272,918	27,777
Natural gas million cubic feet	40,480	10,160	36,163	9,294	38,851	10,373	25,662	6,776
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	1,066	3,177	921	2,481	599	1,611	553	1,513
LP gases do	1,384	3,432	1,197	2,561	1,176	2,764	975	2,623
Peat thousand short tons	238	2,919	186	2,724	167	1,896	202	2,497
Petroleum (crude) thousand 42-gallon barrels	12,974	38,287	12,213	37,494	11,693	36,246	11,893	38,859
Salt thousand short tons	4,893	44,481	4,819	45,961	4,899	49,963	4,458	49,007
Sand and gravel do	56,663	54,979	58,092	58,968	53,092	54,646	56,613	62,898
Silver (recoverable content of ores, etc.) thousand troy ounces	473	1,014	1,009	1,807	892	1,579	670	1,036
Stone thousand short tons	37,279	41,092	39,186	43,572	41,687	49,501	40,705	49,240
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine, and potassium salts (1968–70)	XX	58,293	XX	58,818	XX	41,622	XX	40,274
Total	XX	627,075	XX	667,986	XX	670,729	XX	640,636
MINNESOTA								
Clays thousand short tons	[3] 240	[3] 359	[3] 275	[3] 412	227	335	223	335
Iron ore (usable) thousand long tons, gross weight	51,275	508,814	56,957	570,446	54,791	571,488	49,054	547,607
Manganiferous ore (5 to 35 percent Mn) short tons, gross weight	191,846	W	381,491	W	321,436	W	169,732	W
Peat thousand short tons	6	96	12	249	r 14	335	W	W
Sand and gravel do	44,674	36,414	48,121	40,191	46,851	38,802	44,916	37,645
Stone do	4,427	13,045	5,035	14,253	4,579	r 12,311	5,838	14,346
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1968–69), gem stones, lime, and values indicated by symbol W	XX	8,699	XX	10,085	XX	9,735	XX	8,843
Total	XX	567,427	XX	635,636	XX	633,006	XX	608,776
MISSISSIPPI								
Clays thousand short tons	1,693	9,075	1,703	8,660	1,553	8,062	2,278	8,501
Natural gas million cubic feet	135,051	22,601	131,234	23,097	126,031	23,190	118,805	24,830
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	459	1,277	565	1,572	544	1,465	W	W
LP gases do	518	958	538	799	428	964	W	W
Petroleum (crude) do	58,708	164,396	64,283	187,514	65,119	194,706	64,066	201,808
Sand and gravel thousand short tons	11,980	12,669	11,484	12,263	10,859	11,950	11,289	13,526
Stone do	747	833	W	W	W	W	848	938

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
MISSISSIPPI—Continued								
Value of items that cannot be disclosed: Cement, lime, magnesium compounds, and values indicated by symbol W	XX	$9,146	XX	$9,279	XX	$9,636	XX	$12,790
Total	XX	220,955	XX	243,184	XX	249,973	XX	262,393
MISSOURI								
Barite thousand short tons	284	4,102	304	4,220	230	3,555	232	3,606
Cement:								
Portland thousand 376-pound barrels	20,081	71,206	21,325	74,368	21,224	64,261	24,017	77,568
Masonry thousand 280-pound barrels	405	1,312	427	1,319	402	1,234	518	1,629
Clays thousand short tons	2,433	6,158	[3] 2,251	[3] 6,405	[3] 2,128	[3] 6,480	[3] 2,354	[3] 7,454
Coal (bituminous) do	3,205	13,460	3,301	14,283	4,447	19,526	4,036	19,670
Copper (recoverable content of ores, etc.) short tons	5,494	4,598	12,664	12,039	12,134	14,003	8,445	8,783
Iron ore (usable) thousand long tons, gross weight	1,648	23,585	2,622	35,826	2,612	38,100	2,727	W
Lead (recoverable content of ores, etc.) short tons	212,611	56,180	355,452	105,889	421,764	131,751	429,634	118,579
Natural gas million cubic feet	107	14	126	17	87	21	22	5
Petroleum (crude) thousand 42-gallon barrels	W	W	67	W	66	W	66	W
Sand and gravel thousand short tons	10,649	14,204	10,940	14,574	12,446	15,379	10,327	15,109
Silver (recoverable content of ores, etc.) thousand troy ounces	341	731	1,442	2,582	1,817	3,218	1,661	2,568
Stone thousand short tons	38,988	58,743	41,977	63,251	39,726	[4] 57,285	41,099	[4] 64,772
Zinc (recoverable content of ores, etc.) [7] short tons	12,301	3,321	41,099	12,001	50,721	15,540	48,215	15,525
Value of items that cannot be disclosed: Native asphalt, lime, and values indicated by symbol W	XX	18,624	XX	20,458	XX	22,643	XX	64,821
Total	XX	276,238	XX	367,232	XX	392,996	XX	400,089
MONTANA								
Antimony short tons	--	--	--	--	W	W	135	81
Clays thousand short tons	30	34	34	63	[3] 41	[3] 71	[3] 264	[3] 1,712
Coal (bituminous and lignite) do	519	1,214	1,030	2,199	3,447	6,394	7,064	12,817
Copper (recoverable content of ores, etc.) short tons	69,480	58,151	103,314	98,219	120,412	138,955	88,581	92,125
Gem stones	NA	109	NA	109	NA	109	NA	114
Gold (recoverable content of ores, etc.) [5] troy ounces	13,385	525	24,189	1,004	22,456	817	15,613	644
Iron ore (usable) thousand long tons, gross weight	12	W	13	W	14	W	14	W
Lead (recoverable content of ores, etc.) short tons	1,870	494	1,753	522	996	311	615	169
Lime thousand short tons	179	2,005	255	2,737	208	W	199	2,416
Manganese ore and concentrate (35 percent or more Mn) short tons, gross weight	4,649	213	775	26	512	W	142	W
Manganiferous ore (5 to 35 percent Mn) do	2,063	22	--	--	--	--	--	--
Natural gas million cubic feet	19,313	1,757	41,229	4,205	42,705	4,399	32,720	3,959
Petroleum (crude) thousand 42-gallon barrels	48,460	124,488	43,954	118,359	37,879	105,403	34,599	104,128
Pumice thousand short tons	93	327	134	102	--	--	--	--

Sand and gravel do	8,762	7,754	16,595	14,383	19,275	20,249	15,781	25,207
Silver (recoverable content of ores, etc.) thousand troy ounces	2,133	4,574	3,429	6,141	4,304	7,622	2,748	4,248
Stone thousand short tons	3,314	4,878	7,667	10,579	[4] 6,501	[4] 6,896	W	W
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	W	W	W	W	9	23	W	W
Zinc (recoverable content of ores, etc.) [7] short tons	3,778	1,020	6,143	1,794	1,457	446	361	116
Value of items that cannot be disclosed: Cement, clays (bentonite 1968–70 and fire clay 1971), fluorspar, gypsum, natural gas liquids, peat, phosphate rock, stone (dimension, 1970), talc, vermiculite and values indicated by symbol W	XX	20,566	XX	22,189	XX	21,321	XX	37,337
Total	XX	228,131	XX	282,631	XX	313,016	XX	285,073
NEBRASKA								
Clays thousand short tons	148	206	149	223	90	147	69	82
Gem stones	NA	4	NA	5	NA	5	NA	10
Lime thousand short tons	28	W	35	W	27	W	29	W
Natural gas (marketed) million cubic feet	8,129	1,423	6,989	1,209	5,991	1,024	3,496	612
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	153	456	128	387	W	W	W	W
LP gases do	451	911	408	738	365	858	W	W
Petroleum (crude) do	13,183	36,781	12,106	36,075	11,451	35,384	10,062	34,010
Sand and gravel thousand short tons	12,742	12,946	12,758	13,592	12,232	12,974	13,224	13,626
Stone do	4,416	7,435	4,665	9,494	4,265	7,378	4,174	7,892
Value of items that cannot be disclosed: Cement, pumice, and values indicated by symbol W	XX	14,446	XX	16,307	XX	14,887	XX	17,847
Total	XX	74,608	XX	78,030	XX	72,657	XX	74,079
NEVADA								
Antimony ore and concentrate short tons, antimony content	--	--	W	W	W	W	W	W
Barite thousand short tons	216	1,511	320	2,275	192	1,455	192	1,490
Copper (recoverable content of ores, etc.) short tons	77,213	64,623	104,924	99,749	106,688	123,118	96,928	100,806
Gem stones	NA	100	NA	100	NA	100	NA	105
Gold (recoverable content of ores, etc.) [5] troy ounces	317,382	12,460	456,294	18,941	480,144	17,472	374,878	15,464
Gypsum thousand short tons	552	1,534	521	1,550	451	1,457	695	2,372
Iron ore (usable) thousand long tons, gross weight	569	2,917	W	W	575	W	W	W
Lead (recoverable content of ores, etc.) short tons	863	228	1,420	423	364	114	111	30
Mercury 76-pound flasks	4,780	2,560	8,165	4,124	r 4,909	r 2,001	1,589	465
Perlite short tons	9,315	79	8,998	77	8,470	73	9,600	114
Petroleum (crude) thousand 42-gallon barrels	271	W	223	W	149	W	113	W
Pumice thousand short tons	62	144	83	188	80	191	112	232
Sand and gravel do	7,812	10,442	8,447	10,834	8,574	9,819	9,379	12,225
Silver (recoverable content of ores, etc.) thousand troy ounces	645	1,384	884	1,583	718	1,271	601	930
Stone thousand short tons	1,325	2,041	1,494	2,433	1,860	2,722	2,531	3,800
Talc and soapstone short tons	3,029	38	6,434	81	W	W	--	--
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	25	58	34	69	122	306	33	88
Zinc (recoverable content of ores, etc.) [7] short tons	2,104	568	941	275	127	39	71	23

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
NEVADA—Continued								
Value of items that cannot be disclosed: Brucite, cement, clays, diatomite, fluorspar, lime, lithium minerals, magnesite, molybdenum, pyrites (1969–71), salt, and values indicated by symbol W	XX	$119,354	XX	$125,594	XX	$126,207	XX	$126,630
Total	XX	120,041	XX	168,296	XX	r 186,345	XX	164,774
NEW HAMPSHIRE								
Clays ... thousand short tons	41	41	44	40	40	32	37	34
Gem stones	W	W	W	W	W	W	NA	40
Sand and gravel ... thousand short tons	7,742	5,698	6,310	5,149	6,529	4,753	8,404	6,777
Stone ... do	383	3,377	320	2,888	W	r 845	429	3,433
Value of items that cannot be disclosed: Feldspar (1968–69), mica scrap (1969–70), and values indicated by symbol W	XX	50	XX	43	XX	r 3,100	--	--
Total	XX	9,166	XX	8,120	XX	8,730	XX	10,284
NEW JERSEY								
Clays ... thousand short tons	373	1,008	327	1,123	262	990	201	864
Gem stones	NA	10	NA	10	NA	10	NA	15
Peat ... thousand short tons	56	621	46	551	45	557	46	526
Sand and gravel ... do	20,306	33,570	20,325	33,977	16,732	31,571	18,511	38,279
Stone ... do	13,151	30,343	15,162	34,034	[4] 15,160	[4] 40,567	[4] 13,469	[4] 36,057
Zinc (recoverable content of ores, etc.) [7] ... short tons	25,668	6,930	25,076	7,322	28,683	8,788	29,977	9,653
Value of items that cannot be disclosed: Lime, magnesium compounds, manganiferous residuum, greensand marl, stone, dimension (1970–71), and titanium concentrate	XX	4,984	XX	6,122	XX	6,798	XX	8,181
Total	XX	77,466	XX	83,139	XX	89,281	XX	93,575
NEW MEXICO								
Carbon dioxide, natural ... thousand cubic feet	749,364	52	902,186	69	W	W	W	W
Clays ... thousand short tons	66	89	70	89	67	91	[3] 76	[3] 114
Coal (bituminous) ... do	3,429	13,507	4,471	16,376	7,361	21,249	8,175	26,657
Copper (recoverable content of ores, etc.) ... short tons	90,769	75,968	119,956	114,040	166,278	191,885	157,419	163,715
Feldspar ... long tons	98	W	W	W	--	--	--	--
Gem stones	NA	59	NA	60	NA	60	NA	65
Gold (recoverable content of ores, etc.) [5] ... troy ounces	6,630	260	8,952	372	8,719	317	10,681	441
Gypsum ... thousand short tons	146	549	141	526	W	W	W	W
Helium:								
Crude ... million cubic feet	--	--	--	--	1	18	--	--
High purity ... do	39	1,355	13	260	(8)	6	W	W
Iron ore (usable) ... thousand long tons, gross weight	17	113	W	W	W	W	W	W

Lead (recoverable content of ores, etc.) short tons	1,363	360	2,368	705	3,550	1,109	2,971	820
Lime thousand short tons	27	377	37	W	37	W	35	W
Manganese ore (35 percent or more Mn) short tons, gross weight	6,729	W	4,855	131	4,225	W	--	
Manganiferous ore (5 to 35 percent Mn) do	50,681	379	49,146	340	46,166	W	28,490	-- W
Natural gas million cubic feet	1,164,182	156,000	1,138,133	155,924	1,138,980	162,874	1,167,577	175,137
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	8,868	23,104	9,053	24,388	9,606	25,548	9,952	28,465
LP gases do	23,802	34,989	24,920	30,402	25,999	37,179	27,082	43,331
Peat thousand short tons	(8)	4	(8)	4	(8)	7	1	W
Perlite do	365,481	3,706	397,987	4,493	382,456	4,321	385,746	4,559
Petroleum (crude) thousand 42-gallon barrels	128,550	378,708	129,227	404,441	128,184	410,320	118,412	402,602
Potassium salts thousand short tons, K_2O equivalent	2,289	63,406	2,327	62,034	2,390	85,877	2,291	86,689
Pumice thousand short tons	243	527	226	415	203	442	287	601
Salt do	W	W	W	W	W	W	146	1,130
Sand and gravel do	12,262	12,396	8,574	10,422	10,666	10,516	8,869	7,975
Silver (recoverable content of ores, etc.) thousand troy ounces	225	482	466	834	782	1,385	782	1,210
Stone thousand short tons	2,226	3,527	2,826	3,286	[4] 3,100	[4] 4,030	[4] 2,913	[4] 5,337
Uranium (recoverable content U_3O_8) thousand pounds	12,282	95,144	11,811	69,887	11,574	69,970	10,567	65,517
Zinc (recoverable content of ores, etc) [7] short tons	18,686	5,045	24,308	7,098	16,601	5,086	13,959	4,495
Value of items that cannot be disclosed: Beryllium (1968–69), cement, fluorspar, mica scrap, molybdenum, stone (other dimension (1970–71), tin (1969), vanadium, and other values indicated by symbol W	XX	23,669	XX	29,150	XX	28,068	XX	27,424
Total	XX	893,775	XX	935,746	XX	1,060,358	XX	1,046,284
NEW YORK								
Clays thousand short tons	1,675	1,790	1,623	1,783	1,707	1,897	[3] 1,588	[3] 1,742
Gem stones	NA	10	NA	10	NA	10	NA	15
Gypsum thousand short tons	570	2,925	492	2,945	425	2,737	415	2,376
Lead (recoverable content of ores, etc.) short tons	1,396	369	1,686	502	1,280	400	877	242
Lime thousand short tons	1,086	10,154	1,055	10,224	W	W	W	W
Mercury 76-pound flasks	--	--	280	141	28	11	W	W
Natural gas million cubic feet	4,632	1,390	4,861	1,458	3,358	1,017	2,202	661
Peat thousand short tons	15	153	14	178	15	145	15	196
Petroleum (crude) thousand 42-gallon barrels	1,532	7,093	1,256	5,683	1,194	5,397	1,126	5,292
Salt thousand short tons	5,218	42,488	5,582	45,561	5,990	47,254	5,303	43,601
Sand and gravel do	43,439	45,812	39,806	42,518	35,537	38,839	23,221	28,328
Silver (recoverable content of ores, etc.) thousand troy ounces	28	59	32	57	24	42	18	28
Stone thousand short tons	35,441	63,510	37,561	66,839	37,616	68,118	37,778	73,418
Zinc (recoverable content of ores, etc.) [7] short tons	66,194	17,872	58,728	17,149	58,577	17,947	63,420	20,421
Value of items that cannot be disclosed: Cement, emery, abrasive garnet, iron ore, talc, titanium concentrate, wollastonite, and values indicated by symbol W	XX	106,011	XX	107,432	XX	115,750	XX	122,515
Total	XX	299,636	XX	302,480	XX	299,564	XX	298,835
NORTH CAROLINA								
Clays [3] thousand short tons	3,310	2,148	3,342	2,610	3,318	3,102	3,503	3,802
Feldspar long tons	316,862	4,340	338,149	4,615	345,186	5,173	351,617	4,681
Gem stones	NA	20	NA	20	NA	20	NA	30

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
NORTH CAROLINA—Continued								
Mica:								
Scrap ... thousand short tons	69	$1,640	67	$1,513	64	$1,457	67	$1,770
Sheet ... pounds	15,000	W	W	3	--	--	8,705	3
Sand and gravel ... thousand short tons	10,771	11,178	10,562	11,437	12,772	13,277	14,240	14,690
Stone ... do	24,543	42,429	26,812	47,829	30,363	54,121	30,917	58,026
Talc and pyrophyllite ... short tons	100,030	520	105,728	586	92,639	544	85,289	522
Value of items that cannot be disclosed: Asbestos, barite (1968), cement, clay (kaolin), copper (1971), gold (1971), iron ore (1969–71), lead (1971), lithium minerals, olivine, phosphate rock, silver (1971), tungsten (1970–71), zinc (1971), and values indicated by symbol W	XX	20,544	XX	21,843	XX	20,671	XX	28,927
Total	XX	82,819	XX	90,456	XX	98,365	XX	112,451
NORTH DAKOTA								
Coal (lignite) ... thousand short tons	4,487	7,986	4,704	8,696	5,639	11,009	6,075	11,580
Gem stones	NA	1	NA	1	NA	1	NA	2
Natural gas ... million cubic feet	41,023	6,769	33,587	5,441	34,889	5,722	33,864	5,655
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	558	1,479	508	1,346	504	1,376	W	W
LP gases ... do	2,156	3,622	1,951	2,868	1,840	2,944	W	W
Petroleum (crude) ... do	25,040	66,106	22,703	63,568	21,998	67,107	21,653	70,805
Sand and gravel ... thousand short tons	10,839	10,159	7,039	7,274	8,090	6,336	8,196	6,210
Stone ... do	165	326	72	99	103	126	W	W
Value of items that cannot be disclosed: Clays, lime, peat (1968, 1970–71), salt, uranium (1968), and values indicated by symbol W	XX	1,588	XX	1,755	XX	1,426	XX	5,649
Total	XX	98,036	XX	91,048	XX	96,047	XX	99,901
OHIO								
Cement:								
Portland ... thousand 376-pound barrels	15,222	49,814	15,100	50,071	11,752	39,997	15,411	54,338
Masonry ... thousand 280-pound barrels	1,063	3,155	1,123	3,527	867	3,116	1,016	3,811
Clays ... thousand short tons	4,750	15,216	4,587	11,693	3,920	10,100	3,973	11,380
Coal (bituminous) ... do	48,323	191,427	51,242	210,082	55,351	262,390	51,431	269,601
Gem stones	NA	3	NA	3	NA	3	NA	8
Lime ... thousand short tons	3,701	49,367	4,159	60,975	3,951	61,197	4,007	65,258
Natural gas ... million cubic feet	42,673	10,540	49,793	12,837	52,113	14,123	79,903	27,007
Peat ... thousand short tons	7	94	11	116	6	95	6	84
Petroleum (crude) ... thousand 42-gallon barrels	11,204	35,722	10,972	36,098	9,864	32,914	8,286	29,801
Salt ... thousand short tons	5,713	43,172	5,844	43,519	5,329	47,498	5,709	46,651
Sand and gravel ... do	46,734	57,671	50,029	64,552	42,069	57,506	40,797	54,044
Stone ... do	[4] 48,054	[4] 78,772	51,792	86,570	47,244	81,506	46,891	88,372

Value of items that cannot be disclosed: Abrasive stone, gypsum, and dimension stone (1968)	XX	1,945	XX	1,815	XX	1,721	XX	1,796
Total	XX	536,898	XX	581,858	XX	612,166	XX	652,151
OKLAHOMA								
Clays [3] thousand short tons	726	967	802	1,182	769	1,120	845	1,255
Coal (bituminous) do	1,089	6,401	1,838	10,662	2,427	15,211	2,234	15,004
Gypsum do	931	2,565	980	3,912	874	2,616	1,022	3,073
Helium:								
High purity million cubic feet	309	8,700	221	7,717	149	5,214	123	4,305
Crude do	--	--	133	1,123	245	r 2,940	270	3,240
Lead (recoverable content of ores, etc.) short tons	2,387	631	605	180	797	249	--	--
Natural gas million cubic feet	1,390,884	197,506	1,523,715	233,128	1,594,943	248,811	1,684,260	273,945
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	13,905	38,829	14,621	38,931	14,813	39,933	14,197	40,856
LP gases do	25,497	39,520	27,304	34,403	28,029	52,975	27,540	56,732
Petroleum (crude) do	223,623	668,202	224,729	701,155	223,574	712,419	213,313	725,611
Salt thousand short tons	7	44	9	51	13	78	W	W
Sand and gravel do	5,041	6,288	5,262	7,156	5,675	7,258	5,713	8,259
Stone do	17,290	21,950	18,799	23,650	18,177	23,701	19,449	27,125
Zinc (recoverable content of ores, etc.) [7] short tons	6,921	1,869	2,744	801	2,650	812	W	W
Value of items that cannot be disclosed: Cement, clay (bentonite), copper, lime, pumice, silver, tripoli, and values indicated by symbol W)	XX	23,360	XX	26,758	XX	24,935	XX	30,111
Total	XX	1,016,832	XX	1,090,809	XX	r 1,138,272	XX	1,189,516
OREGON								
Clays thousand short tons	[3] 213	[3] 284	[3] 215	[3] 321	[3] 134	[3] 180	157	255
Copper short tons	W	W	W	W	W	W	3	3
Diatomite do	120	W	85	W	500	5	70	1
Gem stones	NA	750	NA	750	NA	750	NA	755
Gold (recoverable content of ores, etc.) [5] troy ounces	23	1	875	36	256	9	244	10
Lead short tons	--	--	(8)	(8)	(8)	(8)	--	--
Lime thousand short tons	120	2,407	115	2,337	96	1,777	106	1,989
Mercury 76-pound flasks	938	502	43	22	274	112	W	W
Nickel (content of ore and concentrate) short tons	17,294	W	17,056	W	15,933	W	17,036	W
Peat thousand short tons	(8)	11	--	--	--	--	--	--
Pumice do	725	977	875	1,139	r 939	r 1,221	868	1,239
Sand and gravel do	18,260	21,457	15,740	20,491	17,532	25,978	20,230	28,707
Silver (recoverable content of ores, etc.) thousand troy ounces	(8)	1	5	9	4	6	4	6
Stone thousand short tons	14,312	21,168	11,662	18,897	13,439	20,948	13,794	26,708
Talc and soapstone short tons	3	1	W	W	W	W	W	W
Value of items that cannot be disclosed: Bauxite (1970), cement, clay (fire clay (1968–70)), copper (1968–70), tungsten (1971), and values indicated by symbol W	XX	16,890	XX	16,162	XX	r 17,095	XX	18,212
Total	XX	64,449	XX	60,164	XX	r 68,081	XX	77,885

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
PENNSYLVANIA								
Cement:								
Portland----thousand 376-pound barrels--	43,018	$123,176	44,893	$126,941	40,909	$121,100	41,753	$140,460
Masonry----thousand 280-pound barrels--	3,151	8,706	3,085	8,504	2,804	8,324	2,994	11,247
Clays [3]----thousand short tons--	3,034	17,679	2,727	19,637	2,665	15,845	2,325	8,940
Coal:								
Anthracite----do----	11,461	97,245	10,473	100,770	9,729	105,341	8,727	103,469
Bituminous----do----	76,200	408,982	78,631	461,579	80,491	585,057	72,835	620,196
Copper (recoverable content of ores, etc.)----short tons--	4,850	4,059	3,382	3,215	2,539	2,930	3,349	3,483
Gem stones----	NA	4	NA	4	NA	4	NA	9
Lime----thousand short tons--	1,702	24,272	2,008	28,952	1,887	29,279	1,760	30,008
Mica, scrap----do----	W	W	W	W	1	60	W	W
Natural gas----million cubic feet--	87,987	24,460	79,134	21,841	76,841	21,439	76,451	20,770
Natural gas liquids:								
Natural gasoline----thousand 42-gallon barrels--	27	73	22	61	19	50	W	W
LP gases----do----	37	95	35	78	34	87	W	W
Peat----thousand short tons--	36	385	35	407	44	517	38	461
Petroleum (crude)----thousand 42-gallon barrels--	4,160	18,698	4,448	20,086	4,093	18,500	3,798	17,699
Sand and gravel----thousand short tons--	18,101	31,076	18,105	31,451	18,504	33,915	19,668	36,162
Stone----do----	62,812	108,151	66,992	117,726	r 66,119	120,187	64,467	118,469
Zinc (recoverable content of ores, etc.) [7]----short tons--	30,382	8,203	33,035	9,646	29,554	9,055	27,438	8,835
Value of items that cannot be disclosed: Clay (kaolin), cobalt, gold, iron ore, pyrites, pyrophyllite (1968–70), silver, tripoli, and values indicated by symbol W----	XX	28,780	XX	25,470	XX	24,053	XX	28,899
Total----	XX	904,044	XX	976,368	XX	1,095,743	XX	1,149,107
RHODE ISLAND								
Sand and gravel----thousand short tons--	2,291	2,546	2,480	3,015	2,387	2,913	2,252	3,052
Stone----do----	W	W	W	1,417	W	W	3	422
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W----	XX	1,676	XX	1	XX	1,473	XX	825
Total----	XX	4,222	XX	4,433	XX	4,386	XX	4,299
SOUTH CAROLINA								
Clays----thousand short tons--	1,936	8,923	2,444	10,911	1,974	9,878	[3] 2,049	[3] 10,201
Sand and gravel----do----	5,662	8,074	5,692	8,229	5,864	7,766	6,438	9,119
Stone----do----	8,942	13,717	8,846	13,506	9,710	[4] 14,734	11,047	17,852
Value of items that cannot be disclosed: Cement, feldspar, kyanite (1968–69), scrap mica, peat, pyrites (1968–69), stone, and vermiculite----	XX	21,144	XX	23,218	XX	23,987	XX	29,716
Total----	XX	51,858	XX	55,864	XX	56,365	XX	66,888
SOUTH DAKOTA								
Beryllium concentrate----short tons, gross weight--	75	35	46	23	W	W	W	W
Cement:								
Portland----thousand 376-pound barrels--	1,826	6,228	1,556	5,715	W	W	W	W
Masonry----thousand 280-pound barrels--	54	180	49	181	W	W	W	W

Clays thousand short tons	226	1,119	187	1,171	165	946	[3] 150	[3] 128
Feldspar long tons	39,077	264	29,434	194	17,211	114	22,000	539
Gem stones	NA	34	NA	36	NA	35	NA	40
Gold (recoverable content of ores, etc.) [5] troy ounces	593,052	23,283	593,146	24,621	578,716	21,059	513,427	21,179
Gypsum thousand short tons	16	65	11	46	15	61	21	83
Lead (recoverable content of ores, etc.) short tons	--	--	1	(8)	3	1	--	--
Mica (scrap) thousand short tons	W	W	(8)	20	(8)	34	W	W
Petroleum (crude) thousand 42-gallon barrels	187	401	158	362	160	374	233	604
Sand and gravel thousand short tons	11,558	11,578	11,158	10,807	16,556	16,656	16,727	18,392
Silver (recoverable content of ores, etc.) thousand troy ounces	138	295	124	223	120	212	107	165
Stone thousand short tons	1,860	9,687	2,092	10,839	1,979	13,375	2,199	8,874
Zinc (recoverable content of ores, etc.)[7] short tons	--	--	--	--	1	(8)	--	--
Value of items that cannot be disclosed: Columbium-tantalum concentrates (1969), lime, lithium minerals (1968–69), tin (1969), uranium, vanadium (1970), and values indicated by symbol W	XX	917	XX	683	XX	8,709	XX	12,984
Total	XX	54,086	XX	54,921	XX	61,576	XX	62,988
TENNESSEE								
Barite thousand short tons	21	362	16	295	19	286	21	342
Cement:								
Portland thousand 376-pound barrels	8,488	27,691	9,159	29,403	8,878	29,832	9,110	33,733
Masonry thousand 280-pound barrels	1,370	3,836	1,331	3,587	969	2,749	1,135	3,649
Clays [3] thousand short tons	1,562	5,772	1,719	7,064	1,401	7,123	1,537	6,595
Coal (bituminous) do	8,148	29,647	8,082	30,682	8,237	40,372	9,271	59,368
Copper (recoverable content of ores, etc.) short tons	14,196	11,881	15,353	14,596	15,535	17,928	13,916	14,473
Gold (recoverable content of ores, etc.) [5] troy ounces	140	5	126	5	124	5	192	8
Natural gas million cubic feet	48	9	57	11	64	13	89	20
Petroleum (crude) thousand 42-gallon barrels	6	W	32	W	309	W	398	W
Phosphate rock thousand short tons	3,149	23,628	W	W	r 3,073	r 15,005	2,571	12,151
Sand and gravel do	7,344	11,140	6,175	9,709	6,715	10,639	8,018	11,845
Silver (recoverable content of ores, etc.) thousand troy ounces	90	192	79	141	95	168	131	203
Stone [4] thousand short tons	32,083	43,854	33,265	46,192	35,374	50,013	32,369	48,665
Zinc (recoverable content of ores, etc.)[7] short tons	124,039	33,491	124,532	36,363	118,260	36,233	119,295	38,413
Value of items that cannot be disclosed: Clay (fuller's earth), lime, pyrites, stone (crushed sandstone 1968), and values indicated by symbol W	XX	9,826	XX	27,402	XX	r 10,099	XX	10,197
Total	XX	201,334	XX	205,450	XX	220,465	XX	239,662
TEXAS								
Cement:								
Portland thousand 376-pound barrels	34,499	107,532	36,037	117,989	33,967	122,960	38,287	140,206
Masonry thousand 280-pound barrels	1,059	3,371	1,110	3,873	1,007	3,769	1,209	4,514
Clays thousand short tons	4,687	8,860	4,407	8,664	4,148	9,587	4,615	10,432
Gem stones	NA	150	NA	150	NA	150	NA	155
Gypsum thousand short tons	1,039	3,616	1,314	4,398	1,220	4,252	1,303	4,806
Helium:								
Crude million cubic feet	1,039	11,100	1,190	13,053	r 1,157	13,262	1,208	14,496
High purity do	362	9,400	141	4,917	82	2,862	50	1,750
Lime thousand short tons	1,564	21,154	1,633	22,107	1,673	24,427	1,612	24,583

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
TEXAS—Continued								
Natural gas ... million cubic feet	7,495,414	$1,011,881	7,853,199	$1,075,888	8,357,716	$1,203,511	8,550,705	$1,376,664
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	97,075	269,182	96,628	289,042	97,511	284,871	96,286	299,981
LP gases ... do	189,162	278,068	194,599	237,411	204,177	334,850	210,435	380,887
Petroleum (crude) ... do	1,133,380	3,450,707	1,151,775	3,696,328	1,249,697	4,104,005	1,222,926	4,261,775
Pumice ... thousand short tons	W	W	W	W	W	W	4	4
Salt ... do	8,534	42,663	9,261	43,012	10,184	45,000	9,217	40,838
Sand and gravel ... do	31,843	41,546	29,972	39,756	31,438	46,362	32,788	51,814
Stone ... do	48,480	58,006	46,638	64,986	45,557	64,422	41,168	[4] 62,144
Sulfur (Frasch process) ... thousand long tons	2,571	105,482	2,552	68,360	2,801	62,290	3,075	W
Talc and soapstone ... short tons	125,880	517	163,812	668	171,420	878	193,830	1,024
Value of items that cannot be disclosed: Native asphalt, bromine (1968–69), coal (lignite), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, sodium sulfate, uranium, vermiculite (1968–69), and values indicated by symbol W	XX	82,596	XX	79,368	XX	r 74,541	XX	131,882
Total	XX	5,505,831	XX	5,769,970	XX	r 6,401,999	XX	6,807,955
UTAH								
Carbon dioxide, natural ... thousand cubic feet	57,747	4	64,839	5	60,754	4	55,178	4
Clays [3] ... thousand short tons	160	476	179	1,286	189	1,237	198	1,064
Coal (bituminous) ... do	4,316	24,893	4,657	29,396	4,733	34,472	4,626	34,082
Copper (recoverable content of ores, etc.) ... short tons	228,245	191,027	296,699	282,066	295,738	341,282	263,451	273,989
Fluorspar ... do	8,762	213	6,667	207	19,214	595	10,947	341
Gem stones	NA	83	NA	85	NA	85	NA	90
Gold (recoverable content of ores, etc.) [5] ... troy ounces	334,419	13,129	433,385	17,990	408,029	14,848	368,996	15,221
Iron ore (usable) ... thousand long tons, gross weight	1,764	11,281	1,921	12,552	1,990	13,837	1,681	11,886
Lead (recoverable content of ores, etc.) ... short tons	45,205	11,945	41,332	12,313	45,377	14,175	38,270	10,562
Lime ... thousand short tons	174	3,439	191	3,947	186	3,756	172	3,569
Manganiferous ore (5 to 35 percent Mn) ... short tons	--	--	--	--	700	W	112	W
Natural gas ... million cubic feet	46,151	7,292	46,733	7,197	42,781	6,460	42,418	7,084
Petroleum (crude) ... thousand 42-gallon barrels	23,504	62,826	23,295	65,320	23,370	65,603	23,630	71,886
Pumice ... thousand short tons	8	19	10	21	W	18	6	10
Salt ... do	405	3,756	481	4,439	r 450	r 4,192	614	5,213
Sand and gravel ... do	10,293	9,364	19,151	16,042	12,010	10,439	10,505	10,190
Silver (recoverable content of ores, etc.) ... thousand troy ounces	5,121	10,982	5,954	10,661	6,030	10,678	5,294	8,185
Stone ... thousand short tons	1,953	4,312	2,582	4,434	1,650	4,320	2,556	5,335
Tungsten concentrates ... short tons, 60-percent WO_3 basis	W	W	3	6	W	W	W	W
Uranium (recoverable content U_3O_8) ... thousand pounds	1,712	13,175	1,140	6,824	1,635	10,023	1,445	8,959
Vanadium (recoverable in ore and concentrate) ... short tons	563	2,010	W	W	257	W	226	W
Zinc (recoverable content of ores, etc.) [7] ... do	33,153	8,951	34,902	10,191	34,688	10,628	25,701	8,276

Value of items that cannot be disclosed: Asphalt (gilsonite), cement, clay (kaolin (1968)), gypsum, magnesium compounds, molybdenum, natural gas liquids, perlite (1969–70), phosphate rock, potassium salts, pyrites (1968), sodium sulfate (1971), and values indicated by symbol W	XX	44,774	XX	57,507	XX	55,899	XX	49,754
Total	XX	423,951	XX	542,489	XX	r 602,551	XX	525,700
VERMONT								
Lime ... short tons	W	W	1,500	25	--	--	--	--
Peat ... thousand short tons	W	W	(8)	4	(8)	$6	W	W
Sand and gravel ... do	3,587	2,806	3,336	3,028	4,046	4,122	3,761	3,518
Stone ... do	2,536	21,401	2,151	19,810	1,514	19,088	2,498	28,135
Value of items that cannot be disclosed: Asbestos, clays (1968–70), gem stones, lime, talc, and values indicated by symbol W	XX	4,508	XX	4,892	XX	4,627	XX	4,631
Total	XX	28,715	XX	27,759	XX	27,843	XX	36,284
VIRGINIA								
Clays ... thousand short tons	1,462	$1,714	1,677	$1,504	1,633	$1,672	1,710	$1,800
Coal (bituminous) ... do	36,966	178,946	35,555	192,802	35,016	246,181	30,628	254,870
Gem stones	NA	7	NA	7	NA	7	NA	12
Lead (recoverable content of ores, etc.) ... short tons	3,573	944	3,358	1,000	3,356	1,048	3,386	934
Lime ... thousand short tons	919	11,138	1,072	13,653	1,046	14,090	759	11,049
Natural gas ... million cubic feet	3,389	1,013	2,846	845	2,805	864	2,619	822
Petroleum (crude) ... thousand 42-gallon barrels	3	W	1	W	1	W	1	W
Sand and gravel ... thousand short tons	10,859	13,644	12,140	15,954	11,126	15,229	12,796	20,201
Soapstone ... short tons	3,928	10	4,600	12	3,760	9	3,704	8
Stone ... thousand short tons	31,217	53,533	33,461	58,713	35,415	60,477	34,643	63,482
Zinc (recoverable content of ores, etc.) [7] ... short tons	19,257	5,199	18,704	5,462	18,063	5,534	16,829	5,419
Value of items that cannot be disclosed: Aplite, cement, feldspar, gypsum, iron ore (pigment materials 1968–69), kyanite, salt, titanium concentrate, and values indicated by symbol W	XX	29,515	XX	27,575	XX	29,210	XX	26,564
Total	XX	295,663	XX	317,527	XX	374,321	XX	385,161
WASHINGTON								
Cement:								
Portland ... thousand 376-pound barrels	6,328	23,030	6,356	22,724	6,495	24,832	W	W
Masonry ... thousand 280-pound barrels	56	175	58	204	41	158	W	W
Clays [8] ... thousand short tons	255	253	230	434	240	436	255	$549
Coal (bituminous) ... do	178	823	58	480	37	470	1,134	7,614
Copper (recoverable content of ores, etc.) ... short tons	22	18	18	17	9	11	W	W
Gem stones	NA	100	NA	150	NA	150	NA	155
Lead (recoverable content of ores, etc.) ... short tons	5,655	1,494	8,649	2,577	6,784	2,119	5,117	1,429
Peat ... thousand short tons	40	159	33	134	17	71	17	72
Sand and gravel ... do	31,432	27,839	34,245	31,046	25,089	27,902	22,702	26,658
Stone ... do	14,331	16,690	15,742	21,069	13,701	19,100	12,436	20,489
Talc and soapstone ... short tons	W	W	4,228	W	W	W	W	W
Zinc (recoverable content of ores, etc.) [7] ... do	13,884	3,749	9,738	2,843	11,956	3,663	5,782	1,862
Value of items that cannot be disclosed: Abrasives (1971), bauxite (1970), clay (fire clay), diatomite, gold, gypsum (1968–69, 1971), lime, magnesite (1968), mercury (1968), olivine, pumice, silver, uranium (1970–71), and values indicated by symbol W	XX	7,095	XX	6,948	XX	12,010	XX	35,773
Total	XX	81,425	XX	88,626	XX	90,922	XX	94,601

See footnotes at end of table.

Table 5.—Mineral production [1] in the United States, by State—Continued

Mineral	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
WEST VIRGINIA								
Clays [3] ... thousand short tons	193	$219	247	$348	191	$238	232	$336
Coal (bituminous) ... do	145,921	775,720	141,011	807,811	144,072	1,142,245	118,258	1,128,282
Gem stones	NA	W	NA	W	NA	W	NA	2
Lime ... thousand short tons	207	2,848	269	3,648	262	3,757	197	3,073
Natural gas ... million cubic feet	236,971	62,086	231,759	62,575	r 242,452	61,583	234,027	60,613
Petroleum (crude) ... thousand 42-gallon barrels	3,312	13,149	3,104	11,888	3,124	11,871	2,969	11,609
Salt ... thousand short tons	1,308	4,971	1,309	4,978	1,190	5,171	1,174	4,778
Sand and gravel ... do	5,657	11,900	5,021	11,475	4,396	11,473	7,107	16,756
Stone [4] ... do	9,011	16,789	9,031	15,801	9,740	16,722	9,880	18,066
Value of items that cannot be disclosed: Cement (portland and masonry), clay (fire clay), natural gas liquids, stone, and value indicated by symbol W	XX	30,026	XX	28,715	XX	32,304	XX	30,445
Total	XX	917,708	XX	947,239	XX	1,285,364	XX	1,273,960
WISCONSIN								
Clays ... thousand short tons	17	34	12	24	8	14	4	8
Iron ore (usable) ... thousand long tons, gross weight	--	--	36	W	806	W	824	W
Lead (recoverable content of ores, etc.) ... short tons	1,126	298	1,102	328	761	238	752	207
Lime ... thousand short tons	224	3,620	244	4,080	247	4,503	246	4,570
Peat ... do	2	153	2	155	2	W	2	153
Sand and gravel ... do	39,807	30,903	42,815	35,414	41,103	35,107	38,561	32,748
Stone ... do	17,000	25,223	18,954	27,571	17,577	25,167	15,568	25,105
Zinc (recoverable content of ores, etc.) [7] ... short tons	25,711	6,942	22,901	6,687	20,634	6,322	10,645	3,428
Value of items that cannot be disclosed: Abrasive stones, cement, gem stones, and values indicated by symbol W	XX	4,522	XX	5,533	XX	16,319	XX	17,817
Total	XX	71,695	XX	79,792	XX	87,670	XX	84,036
WYOMING								
Clays ... thousand short tons	1,828	17,275	1,992	18,970	1,950	18,829	1,798	17,378
Coal (bituminous) ... do	3,829	12,117	4,602	15,443	7,222	24,423	8,052	27,335
Gem stones	NA	127	NA	129	NA	130	NA	135
Gypsum ... thousand short tons	W	W	W	W	216	868	232	918
Iron ore (usable) ... thousand long tons, gross weight	1,967	19,452	2,048	20,751	W	W	1,808	W
Lime ... thousand short tons	28	W	27	W	22	W	27	W
Natural gas ... million cubic feet	248,481	36,278	303,517	44,617	338,520	49,762	380,105	58,156
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	2,331	6,501	2,523	7,051	2,597	7,085	2,514	7,415
LP gases ... do	3,917	7,090	4,428	7,085	4,556	7,472	5,474	10,127

Petroleum (crude) ... do	144,250	380,589	154,945	433,846	160,345	469,811	148,114	459,079
Sand and gravel ... thousand short tons	9,350	8,973	7,568	7,288	9,447	9,298	9,820	8,750
Stone ... do	1,434	2,754	1,584	3,012	1,266	2,758	2,894	4,789
Uranium (recoverable content U_3O_8) ... thousand pounds	5,928	44,343	6,716	40,318	6,346	38,768	6,986	43,311
Value of items that cannot be disclosed: Cement, copper (1969), feldspar (1968, 1970–71), gold (1969), phosphate rock, pumice (1969), sodium carbonate, sodium sulfate (1968–70), and values indicated by symbol W	XX	40,691	XX	48,933	XX	76,329	XX	80,544
Total	XX	576,190	XX	647,443	XX	705,533	XX	717,937

[e] Estimate. [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 stone, included with "Value of items that cannot be disclosed."
[5] Value based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968: and Engelhard selling quotations Mar. 20, 1968 through 1971.
[6] Excludes salt in brine, included with "Value of items that cannot be disclosed."
[7] Recoverable zinc valued at the yearly average price of Prime Western slab, East St. Louis market. Represents value established after transportation, smelting and manufacturing charges have been added to the value of ore at mine.
[8] Less than ½ unit.

Table 6.—Mineral production[1] in the Canal Zone and islands administered by the United States

Area and mineral	1968		1969		1970		1971	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Pumice ....thousand short tons..	21	$51	2	$5	2	$6	10	$35
Sand and gravel ....do....	20	19	7	7	26	25	24	25
Stone ....do....	53	79	54	108	49	69	W	W
Total	XX	149	XX	120	XX	100	XX	[2] 60
Canal Zone:								
Sand and gravel ....thousand short tons..	55	77	60	97	60	97	--	--
Stone ....do....	106	290	74	231	85	265	--	--
Total	XX	367	XX	328	XX	362	XX	--
Guam: Stone ....thousand short tons..	560	998	654	1,399	636	1,289	718	1,705
Virgin Islands: Stone ....do....	366	1,555	411	1,682	514	2,226	2,236	W
Wake: Stone ....do....	41	132	9	45	4	18	4	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).
[2] Total does not include value of items withheld.

Table 7.—Mineral production[1] in the Commonwealth of Puerto Rico

Mineral	1968		1969		1970		1971	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement ......thousand 376-pound barrels..	8,923	$27,577	8,943	$27,920	9,460	$29,515	10,642	$38,413
Clays ....thousand short tons..	512	481	438	454	429	486	342	358
Lime ....do....	39	1,187	41	1,505	41	W	44	W
Salt ....do....	32	395	32	395	32	395	29	570
Sand and gravel ....do....	16,146	24,723	9,432	23,296	r 11,506	r 28,001	7,292	20,607
Stone ....do....	7,367	13,580	6,985	13,550	7,296	13,947	12,130	29,847
Total	XX	67,943	XX	67,120	XX	[2] r 72,344	XX	[2] 89,795

r Revised. 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 8.—U.S. exports of principal minerals and products

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude ____ short tons	408,452	$214,780	112,295	$58,040
Scrap ____ do	[r] 57,087	[r] 20,923	30,675	9,995
Plates, sheets, bars, etc ____ do	[r] 137,764	[r] 106,989	141,061	111,787
Castings and forgings ____ do	3,438	9,068	3,561	8,245
Aluminum sulfate ____ do	17,726	578	16,840	568
Other aluminum compounds ____ do	1,134,707	92,633	1,120,969	95,578
Antimony: Metals and alloys, crude ____ do	544	634	1,023	761
Bauxite, including bauxite concentrates thousand long tons	3	245	34	1,529
Beryllium ____ pounds	41,353	1,021	41,114	1,051
Bismuth: Metals and alloys ____ do	910,275	2,332	71,187	199
Cadmium ____ thousand pounds	373	997	66	172
Chrome:				
Ore and concentrates:				
Exports ____ thousand short tons	41	2,582	35	2,094
Reexports ____ do	73	2,572	145	6,081
Ferrochrome ____ do	28	8,259	9	3,620
Cobalt ____ thousand pounds	2,699	5,798	1,212	2,108
Columbium metals, alloys and other forms do	46	562	21	588
Copper:				
Ore, concentrate, composition metal and unrefined (copper content) ____ short tons	69,343	65,869	36,824	30,672
Refined copper and semimanufactures do	249,717	370,388	215,705	267,303
Other copper manufactures ____ do	6,057	8,568	7,746	9,145
Copper sulfate or blue vitriol ____ do	2,485	1,543	2,815	2,078
Copper base alloys ____ do	127,593	138,327	97,955	106,829
Ferroalloys:				
Ferrosilicon ____ do	44,694	11,887	25,506	5,603
Ferrophosphorous ____ do	33,106	1,199	35,111	1,419
Gold:				
Ore and base bullion ____ troy ounces	106,117	3,903	577,502	23,470
Bullion, refined ____ do	968,108	33,887	761,302	27,779
Iron ore ____ thousand long tons	5,492	67,898	3,061	38,147
Iron and steel:				
Pig iron ____ short tons	309,746	18,339	34,164	2,352
Iron and steel products (major):				
Semimanufactures ____ do	[r] 6,593,540	[r] 846,767	2,504,263	403,370
Manufactures steel mill products ____ do	[r] 1,063,399	[r] 528,074	1,023,871	538,994
Iron and steel scrap: Ferrous scrap, including rerolling materials thousand short tons	[r] 10,893	[r] 458,848	6,653	222,222
Lead:				
Pigs, bars, anodes ____ short tons	7,747	4,757	5,925	3,889
Scrap ____ do	4,214	1,056	9,573	1,410
Magnesium:				
Metal and alloys and semimanufactured forms, n.e.c ____ do	35,732	22,542	24,311	15,692
Manganese:				
Ore and concentrate ____ do	20,294	2,461	55,413	2,683
Ferromanganese ____ do	21,747	4,356	4,526	1,205
Mercury:				
Exports ____ 76-pound flasks	4,653	2,133	7,232	2,789
Reexports ____ do	50	19	--	--
Molybdenum:				
Ore and concentrates (molybdenum content) thousand pounds	55,737	95,246	46,284	79,111
Metals and alloys, crude and scrap ____ do	671	802	222	227
Wire ____ do	107	1,252	140	1,212
Semifabricated forms, n.e.c ____ do	133	643	623	1,195
Powder ____ do	329	528	41	170
Ferromolybdenum ____ do	2,014	3,088	1,355	1,978
Nickel:				
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc ____ short tons	26,007	64,830	18,923	48,503
Catalysts ____ do	2,524	6,451	3,740	10,018
Nickel-chrome electric resistance wire ____ do	870	5,642	643	3,269
Semifabricated forms, n.e.c ____ do	2,055	9,001	2,837	12,780
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap ____ troy ounces	270,584	32,978	320,842	29,432
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap) ____ do	143,182	10,034	83,768	4,021
Platinum group manufactures, except jewelry ____	NA	5,727	NA	4,769

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Metals—Continued				
Rare earths:				
Cerium ore, metal, alloys and lighter flints pounds	77,523	$275	60,044	$164
Silver:				
Ore, concentrates, waste and sweepings thousand troy ounces	10,375	18,102	3,728	6,164
Bullion, refined do	17,239	31,037	8,496	13,634
Tantalum:				
Ore, metal, and other forms thousand pounds	762	3,884	242	2,611
Powder do	139	4,367	85	2,519
Tin:				
Ingots, pigs, bars, etc:				
Exports long tons	4,009	15,222	1,821	6,648
Reexports do	443	1,701	441	1,620
Tin scrap and other tin-bearing material except tinplate scrap do	2,756	2,466	2,605	1,780
Titanium:				
Ore and concentrate short tons	r 1,058	r 201	1,760	299
Sponge (including iodide titanium and scrap) do	r 2,902	r 2,588	1,711	1,139
Intermediate mill shapes and mill products, n.e.c do	1,740	10,435	430	4,788
Dioxide and pigments do	r 26,194	r 7,950	26,759	9,378
Tungsten: Ore and concentrates:				
Exports thousand pounds	19,470	61,131	2,006	7,323
Reexports do	188	341	1	1
Vanadium ore and concentrate, pentoxide, etc. (vanadium content) do	1,946	5,808	520	1,834
Zinc:				
Slabs, pigs, or blocks short tons	288	114	13,346	2,337
Sheets, plates, strips, or other forms, n.e.c. do	1,412	1,173	1,686	1,486
Scrap (zinc content) do	3,112	1,049	2,000	504
Semifabricated forms, n.e.c do	25,528	5,635	6,042	2,709
Zirconium:				
Ore and concentrate do	4,380	591	9,429	802
Metals and alloys and other forms pounds	600,035	6,284	1,125,242	13,054
Nonmetals:				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder thousand carats	7,258	18,711	7,506	18,726
Crushing bort do	33	154	20	94
Industrial diamonds do	339	1,838	415	1,831
Diamond grinding wheels do	614	3,117	526	2,932
Other natural and artificial, metallic abrasives and products	NA	40,518	NA	37,102
Asbestos, unmanufactured:				
Exports short tons	38,235	5,340	52,202	7,571
Reexports do	8,350	1,656	1,476	292
Boron: Boric acid, borates, crude and refined do	r 232,958	r 25,654	202,496	24,411
Cement thousand 376-pound barrels	847	5,211	663	3,467
Clays:				
Kaolin or china clay short tons	816,284	27,294	673,083	26,125
Fire clay do	167,308	3,464	161,934	3,566
Other clays do	r 1,093,001	35,358	1,137,723	35,638
Fluorspar do	14,952	1,145	12,491	525
Graphite do	5,783	701	5,733	680
Gypsum:				
Crude, crushed or calcined thousand short tons	41	1,915	41	2,318
Manufactures, n.e.c	NA	1,560	NA	1,896
Kyanite and allied minerals short tons	24,024	1,622	31,554	2,097
Lime do	53,876	1,391	65,862	1,971
Mica sheet, waste and scrap and ground pounds	17,459,607	1,422	14,383,388	1,209
Mica, manufactured do	1,260,780	3,310	798,956	2,559
Mineral-earth pigments: Iron oxide, natural and manufactured short tons	4,565	1,621	3,984	1,680
Nitrogen compounds (major) thousand short tons	r 3,414	r 150,515	3,126	141,381
Phosphate rock do	11,738	89,898	12,687	94,816
Phosphatic fertilizers (superphosphates) do	774	28,645	750	30,464
Pigments and compounds (lead and zinc):				
Lead pigments short tons	1,516	649	1,955	833
Zinc pigments do	7,867	2,866	7,229	2,864

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Nonmetals—Continued				
Potash:				
Fertilizer short tons	r 956,638	r $28,473	1,032,948	$35,323
Chemical do	80,377	8,450	55,188	8,072
Quartz, natural, quartzite, cryolite and chiolite do	671	108	431	54
Salt:				
Crude and refined thousand short tons	423	3,657	670	4,182
Shipments to noncontiguous Territories do	16	969	19	1,898
Sodium and sodium compounds:				
Sodium sulfate do	55	1,668	66	1,825
Sodium carbonate do	336	12,007	437	15,400
Stone:				
Dolomite, block do	77	1,454	87	1,639
Limestone, crushed, ground, broken do	1,755	3,459	1,822	3,751
Marble and other building and monumental thousand cubic feet	NA	877	NA	905
Stone, crushed, ground, broken thousand short tons	388	3,288	585	3,871
Manufactures of stone	NA	1,318	NA	1,322
Sulfur:				
Crude thousand long tons	1,429	33,096	1,532	27,844
Crushed, ground, flowers of do	4	955	4	1,019
Talc, crude and ground short tons	104,946	r 5,739	135,881	4,844
Fuels:				
Carbon black thousand pounds	192,636	24,505	163,246	20,425
Coal:				
Anthracite thousand short tons	789	11,215	671	10,104
Bituminous do	r 70,944	r 950,790	56,633	891,484
Briquets do	69	3,736	72	4,335
Coke do	r 2,478	r 78,327	1,509	44,819
Natural gas thousand cubic feet	66,229,687	30,930	84,196,444	38,430
Natural gas liquids, including liquefied petroleum gas, n.e.c thousand barrels	6,134	19,046	6,339	19,417
Petroleum:				
Crude thousand barrels	4,991	17,225	503	1,563
Gasoline do	1,049	10,362	1,783	15,259
Jet do	63	228	211	898
Naphtha do	2,052	19,249	1,593	16,401
Kerosine do	118	973	172	1,356
Distillate oil do	1,631	5,555	2,869	12,328
Residual oil do	19,801	45,734	13,162	40,991
Lubricating oil do	r 15,717	r 189,555	15,218	183,032
Asphalt do	399	4,668	304	3,449
Liquefied petroleum gases do	9,932	31,674	9,379	29,235
Wax do	1,783	40,862	1,638	36,017
Coke do	30,515	97,654	26,823	106,594
Petrochemical feedstocks do	r 3,834	r 20,076	5,243	27,555
Miscellaneous do	1,061	21,331	1,006	20,132
Total	XX	r 5,664,158	XX	4,369,767

r Revised. NA Not available. XX Not applicable.

Table 9.—U.S. imports for consumption of principal minerals and products

Mineral	1970		1971	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Metal ---- short tons	350,060	$164,227	554,208	$257,473
Scrap ---- do	36,779	12,979	62,840	21,504
Plates, sheets, bars, etc ---- do	78,660	53,836	70,944	45,702
Aluminum oxide (alumina) ---- do	2,554,807	152,537	2,390,677	138,841
Antimony:				
Ore (antimony content) ---- do	13,820	12,733	9,619	8,787
Needle or liquated ---- do	18	54	32	47
Metal ---- do	1,290	3,493	1,638	1,914
Oxide ---- do	4,256	10,023	2,791	4,317
Arsenic: White (As_2O_3 content) ---- do	18,763	2,089	16,406	2,187
Bauxite: Crude ---- thousand long tons	12,620	156,362	12,326	153,639
Beryllium ore ---- short tons	4,942	1,912	4,026	1,475
Bismuth ---- pounds	997,924	5,636	848,708	4,050
Boron carbide ---- do	52,652	166	18,298	56
Cadmium:				
Metal ---- thousand pounds	2,492	7,800	3,499	6,264
Flue dust (cadmium content) ---- do	1,111	2,438	1,112	1,118
Calcium:				
Metal ---- pounds	164,769	141	48,391	30
Chloride ---- short tons	8,280	359	13,019	544
Chromate:				
Ore and concentrates (Cr_2O_3 content) thousand short tons	647	31,805	590	32,107
Ferrochrome ---- do	[r]27	9,620	54	22,697
Metal ---- do	2	3,052	2	2,966
Cobalt:				
Metal ---- thousand pounds	11,873	26,020	10,381	22,287
Oxide (gross weight) ---- do	710	1,394	726	1,426
Salts and compounds (gross weight) ---- do	157	92	40	27
Columbium ore ---- do	5,719	4,345	3,054	2,222
Copper: (copper content)				
Ore and concentrates ---- short tons	64,540	77,367	5,547	4,091
Regulus, black, coarse ---- do	247	346	119	220
Unrefined, black, blister ---- do	224,289	245,778	153,625	144,395
Refined in ingots, etc ---- do	132,143	[r]149,169	163,988	165,686
Old and scrap ---- do	2,308	2,044	7,459	6,679
Ferroalloys: Ferrosilicon (silicon content) ---- do	10,060	4,117	12,684	5,988
Gold:				
Ore and base bullion ---- troy ounces	286,988	9,992	191,470	7,264
Bullion ---- do	6,365,380	227,472	7,009,241	276,683
Iron ore ---- thousand long tons	[r]44,891	[r]479,518	40,124	450,644
Iron and steel:				
Pig iron ---- short tons	249,241	13,729	306,320	16,964
Iron and steel products (major):				
Iron products ---- do	[r]44,428	[r]15,332	37,519	13,964
Steel products ---- do	[r]13,655,762	[r]2,050,668	18,605,589	2,727,879
Scrap ---- do	279,586	10,609	263,192	10,713
Tinplate ---- do	21,707	591	20,239	546
Lead:				
Ore, flue dust, matte (lead content) ---- do	42,606	8,360	88,184	19,362
Base bullion (lead content) ---- do	1,177	448	41	16
Pigs and bars (lead content) ---- do	244,623	73,397	192,570	48,021
Reclaimed scrap, etc. (lead content) ---- do	2,981	798	2,518	579
Sheet, pipe and shot ---- do	513	241	237	86
Magnesium:				
Metallic and scrap ---- do	2,948	1,566	3,442	1,633
Alloys (magnesium content) ---- do	122	300	99	286
Sheets, tubing, ribbons, wire and other forms (magnesium content) ---- do	225	637	130	397
Manganese:				
Ore (35 percent or more manganese) (manganese content) ---- do	846,706	34,263	928,122	42,184
Ferromanganese (manganese content) do	226,979	31,563	189,260	32,392
Mercury:				
Compounds ---- pounds	196	3	1,220	9
Metal ---- 76-pound flasks	21,972	[r]9,068	28,449	8,165
Minor metals: Selenium and salts ---- pounds	461,974	4,329	409,264	4,134
Nickel:				
Pigs, ingots, shot, cathodes ---- short tons	[r]117,334	[r]302,578	100,531	259,931
Scrap ---- do	2,149	4,485	1,336	1,896
Oxide ---- do	6,423	12,611	5,769	11,604

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Metals—Continued				
Platinum group:				
Unwrought:				
Grains and nuggets (platinum) troy ounces	r 29,065	r $3,861	34,958	$3,170
Sponge (platinum) do	346,069	39,585	335,332	37,070
Sweepings, waste and scrap do	r 64,197	r 6,541	75,031	7,477
Iridium do	8,459	1,239	14,293	1,908
Palladium do	r 270,034	r 9,877	215,518	7,731
Rhodium do	38,626	r 7,527	33,764	5,980
Ruthenium do	20,816	984	28,063	1,222
Other platinum group metals do	9,242	495	15,037	2,067
Semimanufactured:				
Platinum do	r 115,073	16,323	105,806	11,475
Palladium do	r 503,783	17,532	442,465	15,198
Rhodium do	r 2,386	r 417	898	169
Other platinum group metals do	3,036	442	1,575	207
Radium: Radioactive substitutes	NA	r 3,471	NA	5,671
Rare earths: Ferrocerium and other cerium alloys pounds	9,373	54	16,190	82
Silver:				
Ore and base bullion thousand troy ounces	29,246	45,040	33,452	45,003
Bullion do	29,569	52,637	22,388	33,979
Tantalum ore thousand pounds	1,046	3,231	1,180	3,332
Tin:				
Ore (tin content) long tons	4,667	13,987	3,060	10,564
Blocks, pigs, grains, etc do	50,554	187,662	46,940	164,403
Dross, skimmings, scrap, residues and tin alloys, n.s.p.f do	776	275	4,125	1,385
Tin foil, powder, flitters, etc	NA	4,311	NA	4,471
Titanium:				
Ilmenite [1] short tons	r 261,863	r 6,829	378,049	10,459
Rutile do	r 243,089	r 19,796	215,109	23,155
Metal pounds	r 13,740,209	r 13,520	6,594,448	6,355
Ferrotitanium do	146,300	48	173,057	154
Compounds and mixtures do	121,000,983	22,566	86,230,153	16,125
Tungsten: (tungsten content)				
Ore and concentrates thousand pounds	1,284	3,176	418	1,033
Metal do	35	173	17	117
Other alloys do	190	1,560	129	1,804
Zinc:				
Ore (zinc content) short tons	450,770	67,164	467,368	62,678
Blocks, pigs, and slabs do	260,132	73,695	324,751	93,766
Sheets do	692	419	509	237
Old, dross, and skimmings do	1,915	284	1,967	287
Dust do	9,359	3,161	8,184	2,949
Manufactures	NA	1,276	NA	1,347
Zirconium: Ore, including zirconium sand do	94,759	3,704	96,387	3,656
Nonmetals:				
Abrasives: Diamonds (industrial) thousand carats	13,365	49,037	12,910	46,023
Asbestos short tons	649,402	75,146	681,367	80,090
Barite:				
Crude and ground do	707,028	6,360	484,762	4,490
Witherite do	182	35	511	42
Chemicals do	7,238	1,173	7,800	1,299
Cement thousand 376-pound barrels	13,812	34,176	16,422	44,348
Clays:				
Raw short tons	81,393	1,610	58,965	1,289
Manufactured do	5,147	192	5,084	212
Cryolite do	r 21,399	r 4,586	23,127	5,056
Feldspar: Crude long tons	225	23	120	19
Fluorspar short tons	1,092,318	32,758	1,072,405	34,530
Gem stones:				
Diamond thousand carats	4,275	424,897	4,667	463,242
Emeralds do	326	7,715	351	7,731
Other	NA	53,431	NA	55,010
Graphite short tons	66,449	3,027	57,755	2,727
Gypsum:				
Crude, ground, calcined thousand short tons	6,130	r 13,897	6,096	13,552
Manufactures	NA	2,684	NA	2,780
Iodine, crude thousand pounds	r 6,043	r 6,834	7,275	11,510
Kyanite short tons	1,179	56	1,343	65
Lime:				
Hydrated do	34,158	479	39,807	618
Other do	167,432	1,946	202,477	2,690

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Nonmetals—Continued				
Magnesium compounds:				
Crude magnesite short tons	21	(2)	7	(2)
Lump, ground, caustic calcined magnesia do	11,476	$702	11,518	$736
Refractory magnesia, dead-burned fused magnesite, dead-burned dolomite do	128,193	9,032	129,025	10,014
Compounds do	r 40,700	r 1,362	49,731	1,257
Mica:				
Uncut sheet and punch thousand pounds	875	966	1,355	1,171
Scrap do	6,048	r 136	7,284	171
Manufactures do	4,530	2,549	4,464	2,476
Mineral-earth pigments, Iron oxide pigments:				
Natural short tons	2,115	155	1,794	171
Synthetic do	24,138	5,264	28,236	5,592
Ocher, crude and refined do	62	4	--	--
Siennas, crude and refined do	1,051	115	1,427	125
Umber, crude and refined do	4,883	171	4,681	228
Vandyke brown do	435	50	358	39
Nitrogen compounds (major), including urea thousand short tons	2,495	119,176	2,573	118,281
Phosphate, crude do	136	3,790	84	2,478
Phosphatic fertilizers do	110	5,679	92	6,972
Pigments and salts:				
Lead pigments and compounds short tons	22,591	5,845	21,669	4,734
Zinc pigments and compounds do	20,766	4,106	20,920	4,187
Potash do	4,418,064	101,337	4,687,379	118,481
Pumice:				
Crude or unmanufactured do	10,639	74	8,833	109
Wholly or partly manufactured do	354,681	902	390,900	975
Manufactures, n.s.p.f	NA	29	NA	18
Quartz crystal (Brazillian pebble) pounds	975,679	421	752,001	368
Salt thousand short tons	3,536	13,329	3,855	14,429
Sand and gravel:				
Glass sand do	64	262	48	243
Other sand and gravel do	815	1,338	667	984
Sodium sulfate do	269	4,753	269	4,667
Stone and whiting	NA	35,674	NA	33,643
Strontium: Mineral short tons	37,254	827	45,505	1,115
Sulfur and pyrites:				
Sulfur ore and other forms n.e.s. thousand long tons	1,537	34,149	1,297	25,419
Pyrites do	197	662	285	962
Talc: Unmanufactured short tons	29,988	1,294	17,382	745
Mineral fuels:				
Carbon black:				
Acetylene pounds	5,876,221	1,103	6,125,541	1,405
Gas black and carbon black do	168,997	39	386,246	41
Coal:				
Bituminous, slack, culm and lignite short tons	36,441	457	111,036	1,772
Briquets do	3,208	93	4,145	63
Coke do	152,879	3,531	173,914	5,038
Natural gas, ethane, methane, and mixtures thereof thousand cubic feet	1,004,983,099	257,542	1,115,381,461	312,067
Peat:				
Fertilizer grade short tons	281,429	13,398	293,810	14,988
Poultry and stable grade do	1,782	104	2,473	154
Petroleum:				
Crude petroleum thousand barrels	r 535,052	r 1,260,164	670,972	1,687,279
Distillate do	r 19,198	r 62,203	36,108	103,227
Residual do	r 530,602	r 1,020,970	498,546	1,109,102
Unfinished oils do	4,636	9,883	4,801	12,292
Gasoline do	1,941	8,117	353	1,684
Jet fuel do	r 53,971	r 165,425	54,390	175,112
Motor fuels, n.e.s do	883	2,838	1,127	3,538
Kerosine do	2,643	8,408	211	779
Lubricants do	238	3,179	14	593
Wax do	120	480	96	505
Naphtha do	r 63,243	r 153,588	69,066	169,273
Liquefied petroleum gases do	18,928	35,246	26,247	57,208
Asphalt do	6,507	13,371	7,248	16,242
Miscellaneous do	4,735	15,005	4,241	15,088
Total	XX	r 9,176,713	XX	10,406,340

r Revised. NA Not available. XX Not applicable.

1 Includes titanium slag averaging about 70 percent TiO_2. For detail see Titanium Chapter, table 5.

2 Less than ½ unit.

Table 10.—Comparison of world and United States production of principal metals and minerals

Mineral	1970 r World [1]	1970 r United States		1971 p World [1]	1971 p United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
MINERAL FUELS						
Carbon black ---- thousand pounds	5,959,667	2,931,153	49	6,170,182	3,017,135	49
Coal:						
Bituminous	[2] 2,231,453	596,969	27	2,226,826	545,790	25
Lignite	865,354	5,963	1	883,609	6,402	1
Pennsylvania anthracite	198,664	9,729	5	198,508	8,727	4
Coke (excluding breeze):						
Gashouse [3]	28,090	--	--	24,152	--	--
Oven and beehive	386,203	66,525	17	374,098	57,436	15
Natural gas (marketable) million cubic feet	37,921,317	21,920,642	58	43,846,430	22,493,012	51
Peat	215,550	517	(4)	215,412	605	(4)
Petroleum (crude) ---- thousand barrels	16,689,617	3,517,450	21	17,633,033	3,453,914	20
NONMETALS						
Asbestos	3,846	125	3	3,948	131	3
Barite	4,134	854	21	4,153	825	20
Cement ---- thousand 376-pound barrels	3,353,592	[5] 404,870	12	3,460,674	427,220	12
China clay	14,184	[6] 4,926	35	13,905	[6] 4,886	35
Corundum	8	--	--	8	--	--
Diamond ---- thousand carats	42,586	--	--	42,189	--	--
Diatomite	1,766	598	34	1,697	535	32
Feldspar ---- thousand long tons	2,346	648	28	2,231	663	30
Fluorspar	4,597	269	5	5,112	272	5
Graphite	426	W	NA	429	W	NA
Gypsum	57,244	9,436	16	58,564	10,418	18
Lime (sold or used by producers)	106,431	[5] 19,788	19	108,183	19,635	18
Magnesite	12,218	W	NA	12,933	W	NA
Mica (including scrap) ---- thousand pounds	356,045	237,686	67	367,041	254,185	69
Nitrogen, agricultural [7]	33,670	[5] 8,413	25	36,233	[5] 8,932	25
Phosphate rock	94,082	38,739	41	96,468	38,886	40
Potash (K_2O equivalent)	20,416	2,729	13	22,119	2,587	12
Pumice [8]	16,470	3,038	18	20,790	3,326	16
Pyrites ---- thousand long tons	21,874	W	NA	19,603	808	41
Salt	160,416	[5] 45,928	29	157,299	[5] 44,106	28
Strontium [8]	69	--	--	134	--	--
Sulfur, elemental ---- thousand long tons	21,749	9,551	44	22,516	9,572	43
Talc, pyrophyllite, and soapstone	5,382	1,028	19	5,388	1,037	19
Vermiculite [8]	431	285	66	457	301	66
METALS, MINE BASIS						
Antimony (content of ore and concentrate) short tons	75,618	1,130	1	70,161	1,025	1
Arsenic, white	58	W	NA	59	W	NA
Bauxite [9] ---- thousand long tons	56,260	[9] 2,082	4	61,981	[9] 1,988	3
Beryllium concentrate ---- short tons	8,307	W	NA	5,553	W	NA
Bismuth ---- thousand pounds	8,408	W	NA	7,891	W	NA
Cadmium ---- do	36,641	[10] 9,465	26	34,153	[10] 7,930	23
Chromite	6,672	--	--	6,936	--	--
Cobalt (contained)	26	W	NA	26	W	NA
Columbium-tantalum concentrates [8] thousand pounds	44,934	W	NA	23,261	W	NA
Copper (content of ore and concentrate)	6,634	[11] 1,720	26	6,665	1,522	23
Gold ---- thousand troy ounces	47,531	1,743	4	46,506	1,495	3
Iron ore ---- thousand long tons	754,484	[12] 89,760	12	773,376	80,762	10
Lead (content of ore and concentrate)	3,726	[11] 572	15	3,752	579	15
Manganese ore (35 percent or more Mn)	20,084	5	(4)	22,792	(4)	(4)
Mercury ---- thousand 76-pound flasks	284	27	10	306	18	6
Molybdenum (content of ore and concentrate) thousand pounds	177,982	111,352	63	173,024	109,592	63
Nickel (content of ore and concentrate)	694	16	2	706	16	2
Platinum group (Pt., Pd., etc.) thousand troy ounces	4,239	17	(4)	4,077	18	(4)
Silver ---- do	303,897	45,006	15	294,691	41,564	14
Tin (content of ore and concentrate) long tons	229,437	W	NA	229,533	W	NA
Titanium concentrates:						
Ilmenite [8]	3,956	868	22	3,721	683	18
Rutile [8]	460	--	--	416	--	--
Tungsten concentrate (contained tungsten) pounds	74,034	9,625	11	80,728	6,900	9
Vanadium (content of ore and concentrate) short tons	20,805	5,319	26	20,894	5,252	25
Zinc (content of ore and concentrate)	6,008	534	9	6,126	503	8
METALS, SMELTER BASIS						
Aluminum	10,630	3,976	37	11,339	3,925	35
Copper	6,731	[13] 1,641	24	6,736	1,500	22

See footnotes at end of table.

Table 10.—Comparison of world and United States production of principal metals and minerals—Continued

Mineral	1970 r			1971 p		
	World [1]	United States		World [1]	United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
METALS, SMELTER BASIS—Continued						
Iron, pig	471,066	91,293	19	474,347	81,382	17
Lead	3,622	667	18	3,492	650	19
Magnesium ... short tons	245,324	112,007	46	256,807	123,485	48
Selenium [8] ... thousand pounds	2,849	1,005	35	2,283	657	29
Steel ingots and castings	655,380	[15] 131,514	20	641,673	[15] 120,443	19
Tellurium [8] ... thousand pounds	365	158	43	318	164	52
Tin [16] ... long tons	220,939	W	NA	226,821	W	NA
Uranium oxide (U_3O_8) [8] ... short tons	23,858	12,768	54	24,582	12,907	53
Zinc	5,379	878	16	5,083	766	15

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

[1] Total is not strictly comparable with previous years because it does not represent total world production. Confidential U.S. data are excluded. These data include reported figures and reasonable estimates. In some instances where data were not available, no reasonable estimate could be made and none has been included except for gold, silver, and pyrites.

[2] Includes small quantities of lignite for People's Republic of China, Mongolia, North Korea, 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 U.S.S.R.

[9] Dry bauxite equivalent of crude ore.

[10] Includes secondary.

[11] Recoverable.

[12] Iron-nickel ore.

[13] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1969, 1,547,496: 1970, 1,605,256.

[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 ingots.

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

Injury Experience and Worktime in the Solid Mineral Mining Industries

By Forrest T. Moyer[1]

The safety record of the solid mineral mining and milling industries in 1971 was 342 fatal and 23,530 nonfatal injuries at respective frequency rates of 0.44 and 30.59 per million man-hours and at a severity rate of 4,056 days lost or charged per million man-hours for all injuries. One major disaster (a single accident which results in the death of five or more persons) occurred during 1971 in the solid mineral mining industries when seven men were killed by hydrogen sulfide gas in the Barnett Complex mine, Ozark–Mahoning Co., a fluorspar mine near Rosiclare, Ill. In 1970, there also was one major disaster, a coal-dust explosion which claimed 38 lives in the interconnected Nos. 15 and 16 mines, Finley Coal Co., a bituminous coal operation near Hyden, Ky.

This total experience covers an aggregate worktime of 769.1 million man-hours accumulated by an average of 379,500 men working on 248 active days at mineral mining and milling operations extracting minerals in solid form. Data are included on underground, open-pit, dredging, hydraulicking, and all other operations within the preceding limitations. Milling or cleaning and associated surface shop and yard activities at such operations also are included.

The coverage of the 1971 injury and worktime data, as indicated by the foregoing definitions and the changed title of this chapter, was limited to those mineral fuel and mineral mining and processing establishments covered by the Federal Coal Mine Health and Safety Act (30 U.S.C. 821) and the Federal Metal and Nonmetallic Mine Safety Act (30 U.S.C. 732). The limited coverage was required by the Federal Occupational Safety and Health Act (Public Law 91–596), which became effective April 28, 1971. As a result, the Bureau of Mines ceased collection of injury and worktime data on the oil and natural gas, sulfur, salt and other saline minerals obtained from wells or by evaporation, coke, primary nonferrous reduction and refining, and the slag industries. These responsibilities were transferred to the Department of Labor, Bureau of Labor Statistics. For 1970 and earlier years, the data on the aforementioned industries had been considered part of and included in the total figures for the mineral industries. Annual injury and worktime statistics on these industries are available in earlier Minerals Yearbooks or in other Bureau of Mines' reports; for example, such data on the coke industry started in 1916 and those on the oil and gas industries in 1942.

The 1971 data on the mineral industry subgroups in this chapter are comparable with those for earlier years except in the nonmetal mining group. In this latter subgroup, coverage was reduced in some of the component industries, as detailed later in the text.

Mine Safety Legislation and Regulations.—Federal activities under the Federal Coal Mine Health and Safety Act of 1969 (30 U.S.C. 821) continued to accelerate through 1971.[2] The number of mine inspectors, engineers, specialists, and aides in the field totaled 1,055 at the end of 1971 compared with 564 at the close of 1970. During 1971 more than 26,500 health and safety inspections of coal operations were made; 1,847 roof-control and 1,625 ventilation-dust control plans were approved, and more than one-third-million coal-dust samples were

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[1] Statistician (General), Health and Safety.
[2] Department of the Interior: Moving Forward in Coal Mine Health and Safety. 1971 Annual Report of the Secretary of the Interior, 84 pp.

processed. Noise surveys covering nearly 23,000 miners revealed that less than 5 percent were subjected to the excessive noise levels established by the standard. Dust control measures by the industry were effective, and at the end of 1971 more than 90 percent of the underground mining sections were in compliance with the standard of not more than 3.0 milligrams of respirable dust per cubic meter of air.

Title IV of the Coal Mine Health and Safety Act of 1969 established coal workers' pneumoconiosis (black lung) as a compensable occupational disease and provided for monthly benefit payments to coal miners totally disabled from pneumoconiosis and to widows and dependents of miners who died from the disease. From the start of the program up to the end of 1971, a total of 347,700[3] claims had been filed and of these 322,500 had been processed. Of the claims completed by December 31, 1971, 159,500 were allowances (88,100 miners and 71,400 widows) and 163,000 were denials (125,000 miners and 38,000 widows). By the end of the year, 9,900 allowances (7,200 miners and 2,700 widows) had been terminated. The total cumulative Federal disbursements since enactment of the program to the end of 1971 were $532.6 million, and current monthly recurring payments at the end of the year were $28.0 million.

Activities under the Federal Metal and Nonmetallic Mine Safety Act (30 U.S.C. 732) were increased through 1971. A total of 8,457 inspections, comprising 5,174 regular and 3,283 spot inspections, of metal, nonmetal, stone, and sand and gravel operations were made during the year. In 1970 a total of 2,088 inspections were made. In addition, 74 special surveys, concerned mainly with radiation, dust, and noise problems in mine and mill environments, were conducted in 1971. State plan agreements provide for enforcement of the act by State agencies. Of the four agreements in effect at the end of 1971, those with the States of Arizona and Colorado were effective throughout the year and those with California and New York became effective during July and August.

Scope of Report.—The statistics in this chapter comprise the disabling injury and work experience of all personnel engaged in production, exploration, development, maintenance, repair, and force-account construction work, including supervisory and technical personnel and working partners, at solid mineral-producing and -processing establishments in the United States. Data concerning officeworkers are excluded.

The coverage of the industries is complete. All injury rates are calculated from unrounded data, and in some instances the rates cannot be reproduced from rounded data shown in the tables. Most of the information was reported by the producer or operator, but to obtain complete coverage it was necessary to estimate some worktime data for nonreporting plants with information from other sources. Injury experience for these nonreporters was not estimated but was projected from the aggregate injury experience of reporters in the same industry.

INJURY EXPERIENCE

METAL MINES AND MILLS

Overall injury experience at metal mines and mills during 1971 was 56 fatal and 3,815 nonfatal injuries at respective frequency rates of 0.37 and 24.88 per million man-hours; the severity rate was 3,241 days lost or charged per million man-hours. These injuries occurred during a total worktime of 153.3 million man-hours at metal mines and mills during the year. All measures of injury experience at metal mines (table 1) were better than in 1970, but at metal mills (table 2) the fatality record worsened to a total of nine work-deaths, which resulted in an increased injury-severity rate for 1971. The 1971 record for nonfatal injuries at metal mills was better than that of 1970.

At copper mines, the totals of 12 fatal and 1,070 nonfatal injuries were, respectively, one less and 56 more than in 1970. The increased number of injuries coupled with the decreased worktime in 1971 resulted in a worsening of injury frequency to 25.34 per million man-hours. In copper

[3] Department of Health, Education, and Welfare, Social Security Administration. Second Annual Report to Congress on the Administration of Part B of Title IV of the Federal Coal Mine Health and Safety Act of 1969. June 1972, 25 pp.

mills, six fatal injuries, four more than in 1970, and 210 nonfatal injuries in 1971 resulted in a frequency rate of 13.09 for all injuries in 1971. Owing to the larger fatality total, the injury-severity rate of 2,736 was 61 percent higher than in 1970.

All general measures of injury-experience at gold-silver mines in 1971 were better than in 1970. The lower numbers of both fatal and nonfatal injuries resulted in better frequency and severity rates in 1971. There were no fatalities at gold-silver mills in either 1970 or 1971, but an increased number of nonfatal injuries in 1971 caused an increase in both the injury-frequency and severity rates.

The safety record at iron mines in 1971 was improved sharply in all measures of injury experience. The totals of three fatal and 430 nonfatal injuries were, respectively, five and 105 less than in 1970. In iron mills, the two fatal and 150 nonfatal injuries were, respectively, two and 12 less than in 1970. However, the overall injury-frequency rate at the mills in 1971 was slightly higher and the severity rate was only slightly lower than in 1970, owing to the reduced total man-hours of exposure in the current year.

Fatality experience at lead-zinc mines worsened in 1971 and was principally responsible for the increased severity rate for all injuries. However, the total of 895 nonfatal injuries was 177 less than in 1970 and resulted in an overall frequency rate of 62.15, 10 percent better than in 1970. The safety record at lead-zinc mills showed similar trends in 1971 with worsened fatality but better nonfatal injury experience.

Although the total number of injuries at uranium mines was higher in 1971, the frequency rate of 31.09 was slightly better than in 1970 owing to the increased worktime. However, work fatalities were lower in 1971 and resulted in an improved severity rate. At uranium mills, the absence of fatalities and the reduction in nonfatal injuries in 1971 resulted in frequency and severity rates of 9.96 and 403, respectively, both markedly better than in 1970.

At miscellaneous metal (bauxite, mercury, titanium, tungsten, etc.) mines, the four fatal and 235 nonfatal injuries resulted in overall injury rates of 37.60 for frequency and 5,386 for severity. All general measures of injury experience at miscellaneous metal mills were sharply better in 1971 than in 1970.

NONMETAL MINES AND MILLS

The safety record at all nonmetal (except stone, and sand and gravel) mining operations producing solid minerals in 1971 was 24 fatal and 2,310 nonfatal injuries at respective frequency rates of 0.28 and 27.39 per million man-hours and a severity rate of 2,989 days lost or charged per million man-hours. A major disaster in April killed seven men in the Barnett Complex mine, a fluorspar operation (miscellaneous nonmetal group) of the Ozark-Mahoning Co., near Rosiclare, Ill. The men died from exposure to hydrogen sulfide gas which was released from pressurized water entering the underground workings through an exploratory drill hole. The last previous major disaster in nonmetal mining occurred in 1968, when a shaft fire in a Louisiana salt mine killed 21 men. Injury experience on nonmetal mines is listed by industry subgroups in table 3 and on nonmetal mills in table 4.

These overall data are not comparable to those for earlier years owing to the transfer to the Department of Labor of data-collection responsibilities for information on operations which produce minerals in liquid form from wells or by solar evaporation. Such operations include those producing sulfur by the Frasch process, salt by solution mining or solar evaporation, sodium and potassium compounds from dry lake beds, and others. The aforementioned transfer has affected comparability of the data for 1971 with those for previous years in varying degrees on the following subgroups of nonmetal industries: Potash, salt, sulfur, and miscellaneous. Comparability of the 1971 data on the miscellaneous nonmetal group was affected further by the inclusion of the injury and worktime data on the peat industry for the first time. In years prior to 1971 such data had been treated separately, as listed in table 8. This inclusion resulted from an administrative action which placed peat operations under the Federal Metal and Nonmetallic Mine Safety Act.

At clay-shale mines, each general measure of injury experience in 1971 was better than in 1970. However, the opposite was true at clay-shale mills, where each general measure was worse than in 1970. There were no fatalities at either gypsum mines or mills in 1971 but the number of nonfatal injuries increased at both mines and mills. Injury-frequency rates, as a result, were higher at both mines and mills. The severity rate of all injuries at the mines in 1971 was better than in 1970 but was markedly worse at gypsum mills. At phosphate rock mines, fatality experience was improved in 1971, and as a result, the overall injury-severity rate was appreciably better than in 1970. However, there were more nonfatal injuries in 1971, and this increase resulted in a higher injury frequency than in 1970 at the mines. At phosphate rock mills, there was one fatal injury in both 1970 and 1971, but, with the sharp increase in nonfatal injuries, the overall injury-frequency and severity rates for 1971 were markedly higher than in 1970.

The frequency rates for all injuries at potash mines and mills in 1971 were, respectively, 41.46 and 9.06 per million man-hours. The overall severity rates of 7,441 at mines and 6,410 at mills in 1971 were relatively high, owing to the occurrences of more fatalities. At rock salt operations, the safety record in 1971 at the mines was an injury frequency of 38.65 and an injury-severity rate of 958; at the mills, the frequency rate was 21.45 with a severity rate of 493. There were no fatalities at salt mines or mills in 1971.

Injury experience in 1971 at miscellaneous nonmetal (barite, feldspar, fluorspar, magnesite, mica, talc, etc.) mines was 10 fatal and 230 nonfatal injuries with a frequency rate of 32.89 and a severity rate of 10,182. The fatality total included the seven men killed in the major disaster at a fluorspar mine in Illinois. At mills processing the miscellaneous nonmetallic minerals there were no fatal injuries in 1971, but the 335 nonfatal injuries resulted in a frequency rate of 27.09 and a severity rate of 1,348.

STONE QUARRIES AND MILLS

All general measures of injury experience at stone quarries and mills retrogressed in 1971. The totals of 57 fatal and 3,895 nonfatal injuries at all stone operations in 1971 were, respectively, 14 and 229 higher than in 1970. As a result, the combined frequency rate for all injuries in 1971 advanced to 21.40 per million man-hours, 6 percent worse than in 1970. Similarly, the overall injury-severity rate of 2,784 days lost or charged per million man-hours in 1971 was 21 percent higher than in the preceding year. Total worktime of 184.6 million man-hours in 1971 was only slightly higher than in 1970. Data for each of the component stone industries are listed in table 5.

The safety records of granite and sandstone operations in 1971 were better in all measures than in 1970. The numbers of fatal and nonfatal injuries during the year were reduced in each industry, and as result, the injury-frequency and severity rates for each industry were lowered. On the other hand, all general measures of injury experience for the cement, limestone, and miscellaneous stone (gneiss, quartz, schist, etc.) industries worsened for 1971. In each of these industries, the numbers of both fatal and nonfatal injuries were higher than in 1970. In fact, the frequency rate of 7.83 for all injuries in 1971 at cement operations was the highest annual rate since 1949, that of 27.20 for limestone quarries was the highest since 1961, and that of 35.91 for miscellaneous stone plants was the highest since 1960. Owing principally to the increased numbers of fatal injuries, the injury-severity rates for each of the latter industries in 1971 were appreciably higher than in 1970.

In the lime and marble industries the numbers of fatal injuries increased, but nonfatal injuries decreased, in 1971. However, total man-hours of worktime in each industry were lower in 1971, so that the frequency rate for all injuries worsened by 5 percent at lime operations and by 4 percent in the marble industry. Largely because of the increased fatal injuries, the overall severity rates for both the lime and marble industries were markedly higher in 1971 than in 1970. There were no fatalities at slate operations in 1971, but the total of nonfatal injuries was 16 higher than in 1970. Hence the frequency rate for all injuries during 1971 was sharply higher, whereas the severity rate was less than half that of 1970. At traprock quarries, the two fatal and 300 nonfatal injuries in 1971 were, respectively, one less and 21 more than in 1970, and resulted in an overall frequency rate of 33.12, 9 percent worse, and a severity rate of 1,981, 25 percent better than in 1970.

SAND AND GRAVEL OPERATIONS

Fatalities at sand and gravel plants decreased to 25, or four fewer than in 1970, and this decrease was primarily responsible for the better overall injury-severity rate of 2,552 days lost or charged per million man-hours in 1971, 11 percent better than in 1970. However, nonfatal injuries increased to a total of 2,130, 85 more than in 1970. The larger total coupled with the slight decrease in man-hours of worktime resulted in a frequency rate of 22.76 per million man-hours for all injuries in 1971, 4 percent higher than in 1970. The 5-year safety record is given in table 6.

COAL MINES AND CLEANING PLANTS

The safety record of the coal mining industry during 1971 improved in fatality experience but worsened slightly in nonfatal injury experience. Work fatalities in 1971 totaled 180 and occurred at a frequency rate of 0.71 per million man-hours of worktime. Both measures of fatality experience were better than for any other year of statistical history. The previous low annual fatality record was established in 1969 when 203 work-deaths occurred at a frequency rate of 0.85. The fatality total in 1971 was 80 less than in 1970, when 260 fatal work injuries had a frequency total in 1.00. There were no major disasters (a single accident which results in the death of five or more persons) in coal mines during 1971, whereas in 1970 a coal-dust explosion in the underground workings of a bituminous-coal mine at Hyden, Ky., claimed the lives of 38 men. Owing primarily to the better fatality record in 1971, the severity rate for all injuries decreased to 6,407 days lost or charged per million man-hours, 23 percent better than that of 8,308 in 1970.

The estimated total of 11,380 nonfatal work injuries during 1971 occurred at a frequency rate of 45.14 per million man-hours. This total was 172 less than that of 1970, but the rate of occurrence was 2 percent higher than that of 44.40 in 1970, owing to the reduced worktime in the current year. The frequency rate of nonfatal injuries in 1971 was the highest annual rate since 1957 when it was 46.04 per million man-hours. Aggregate worktime of 252 million man-hours in 1971 was 3 percent lower than in 1970, owing largely to the widespread work-stoppage in bituminous coal mines which greatly reduced mining activity during October and the first half of November 1971. This stoppage involved 80,000 men and resulted in the loss of 2.57 million man-days of work, according to the Department of Labor. The detailed injury experience and worktime for the coal-mining industries are listed in table 7.

In bituminous coal and lignite mining, the 176 work-deaths at a frequency rate of 0.73 per million man-hours in 1971 established record annual lows. The previous lows were in 1969 when 190 fatalities had a rate of occurrence of 0.84. In 1970, there were 255 fatal injuries at a rate of 1.02 per million man-hours. There were no major disasters in 1971, but in 1970 the aforementioned coal-dust explosion in a Kentucky mine killed 38 men. Primarily because of the better fatality record in 1971 the overall injury-severity rate of 6,512 days lost or charged per million man-hours for all injuries was 23 percent better than that of 8,460 in 1970. The 10,930 nonfatal injuries in 1971 occurred at a frequency rate of 45.17 per million man-hours. This total was 119 less than in 1970, but the rate of occurrence for nonfatal injuries in 1971 worsened 2 percent over that of 44.21 for 1970, owing to the reduced total worktime.

At anthracite operations all general measures of injury experience were better in 1971. The four fatalities in 1971 occurred at a frequency rate of 0.40 per million man-hours, compared with five fatalities in 1970 at a rate of occurrence of 0.49. The estimated total of 450 nonfatal injuries for 1971 was 53 lower than in 1970. The frequency rate of 44.56 for these injuries in 1971 was 9 percent better than that of 49.20 in 1970. In keeping with the general improvement, the severity rate of 3,891 days lost or charged per million man-hours in 1971 was 15 percent better than that of 4,598 for 1970.

WORKTIME AND WORK STOPPAGES

Worktime at solid mineral mining and milling operations in 1971 totaled 769.1 million man-hours.

A total of 656 work stoppages in the solid mineral industries during 1971 resulted in an aggregate time loss of 4.9 million man-days of work, according to the Bureau of Labor Statistics, U.S. Department of Labor. Most of the strikes, 606, were in the bituminous coal industry; these caused an aggregate loss of 4.2 million man-days of work. More than half of this lost worktime occurred in the widespread strike from October 1 until the middle of November during the industry-labor contract negotiations. The only other sizeable time loss at solid-mineral operations during 1971 was from the two strikes in copper mining (table 9).

SAFETY COMPETITIONS

The annual safety competitions conducted by the Bureau of Mines have been recognized as effective tools to promote accident prevention in the mineral industries. They are used at the enrolled operations to arouse and maintain the interest of employees in daily safe working practices as well as to provide recognition for outstanding work in safety. Nearly 1,500 mineral operations participated in these contests during 1971.

In 1971 a total of 935 mines, open pits, and quarries competed in the 47th National Safety Competition (the "Sentinels of Safety" contest) cosponsored by the Bureau and the American Mining Congress. Of the participants, 46 percent of the total operated throughout the year without a disabling work injury. The aggregate worktime of these injury-free plants was 20.0 million man-hours, or 13 percent of the total man-hours of exposure at all enrolled operations. The National Safety Competition comprises six groupings of plants so as to assure equality of competition among operations with relatively similar working conditions. The winning operation in each group is awarded the "Sentinels of Safety" trophy and a plant flag. In addition, each employee and official at the winning plant receives a personal "Certificate of Accomplishment in Safety" from the Bureau in recognition of his daily contribution to the winning record.

The following operations won the "Sentinels of Safety" trophies in each of the six competing groups for being worked the largest number of man-hours without any disabling injuries through 1971:

Underground Coal Mines.—Somerset mine, United States Steel Corp., Somerset, Colorado, 334,967 man-hours.

Surface Coal Mines.—Big Horn No. 1 strip mine, Big Horn Coal Co., Sheridan, Wyoming, 238,918 man-hours.

Underground Metal Mines.—Ozark Lead mine, Ozark Lead Co., Sweetwater, Missouri, 394,698 man-hours.

Underground Nonmetal Mines.—Big Island mine, Stauffer Chemical Co. of Wyoming, Green River, Wyoming, 193,287 man-hours.

Open-Pit Mines (Metal and Nonmetal).—Sherman mine, United States Steel Corp., Chisholm, Minnesota, 418,099 man-hours.

Stone Quarries.—Thornton quarry, General Dynamics Corp., Material Service Div., Thornton, Illinois, 407,030 man-hours.

A total of 238 operations participated in the National Sand and Gravel Safety Competition sponsored by the Bureau. The following plants won top safety honors for injury-free records in 1971 in the bank or pit and the dredge groups into which the contest is divided:

Bank or Pit.—Marlboro pit, Becker County Sand and Gravel Co., Berrellsville, South Carolina, 237,837 man-hours.

Dredge.—Kinder dredge, Gifford-Hill and Co., Inc., Kinder, Texas, 114,687 man-hours.

Two other annual safety competitions cosponsored with the Bureau by the National Lime Association, and the National Limestone Institute were conducted in 1971.

Table 1.—Worktime and injury experience at metal mines in the United States, by industry group

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Copper:								
1967	17,258	218	3,760	30,064	19	654	22.39	5,520
1968	15,492	267	4,168	33,461	18	601	18.50	4,146
1969	16,609	312	5,184	41,467	15	756	18.59	3,404
1970	17,019	328	5,582	44,756	13	1,014	22.95	2,721
1971 p	17,600	302	5,330	42,663	12	1,070	25.34	2,593
Gold-silver (lode-placer):								
1967	3,611	237	855	6,844	8	263	39.60	10,022
1968	3,681	221	824	6,610	10	320	49.93	12,433
1969	3,617	234	845	6,772	7	315	47.55	9,759
1970	3,491	247	864	6,929	8	350	51.67	9,123
1971 p	3,700	235	875	7,001	5	335	48.85	5,966
Iron:								
1967	12,772	282	3,600	28,859	11	478	16.94	2,846
1968	11,890	285	3,415	27,388	7	463	17.16	2,368
1969	11,477	274	3,141	25,195	6	436	17.54	2,182
1970	10,752	295	3,170	25,416	8	535	21.36	2,843
1971 p	9,800	301	2,948	23,631	3	430	18.32	1,356
Lead-zinc:								
1967	7,781	252	1,962	15,727	15	913	59.01	8,563
1968	7,518	258	1,973	15,749	13	897	57.78	7,459
1969	7,533	265	1,993	15,968	15	1,048	66.57	8,458
1970	7,412	266	1,970	15,776	16	1,072	68.97	9,024
1971 p	7,000	262	1,832	14,658	18	895	62.15	9,713
Uranium:								
1967	3,745	223	834	6,751	5	312	46.95	7,139
1968	4,552	219	1,024	8,564	6	312	37.13	5,426
1969	4,371	219	957	7,804	12	246	33.06	10,805
1970	4,052	215	870	7,213	8	220	31.61	7,802
1971 p	4,200	230	964	8,202	5	250	31.09	5,310
Miscellaneous:								
1967	3,329	283	943	7,549	8	261	35.64	8,455
1968	3,047	284	867	6,920	3	243	35.55	5,045
1969	2,887	292	842	6,767	7	310	46.84	7,555
1970	3,382	284	961	7,704	4	330	43.36	4,996
1971 p	2,800	279	794	6,357	4	235	37.60	5,386
Total: [1]								
1967	48,496	246	11,953	95,794	66	2,881	30.76	5,881
1968	46,180	263	12,271	98,693	57	2,836	29.31	4,910
1969	46,494	279	12,963	103,973	62	3,111	30.52	5,124
1970	46,108	291	13,416	107,794	57	3,521	33.19	4,586
1971 p	45,200	282	12,742	102,512	47	3,215	31.81	3,947

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

Table 2.—Worktime and injury experience at metal mills in the United States, by industry group

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Copper:								
1967	5,953	228	1,358	10,863	3	112	10.59	2,106
1968	5,612	286	1,621	12,969	1	135	10.49	894
1969	6,222	329	2,045	16,337	1	171	10.53	946
1970	6,435	351	2,260	18,092	2	231	12.88	1,704
1971 [p]	6,400	326	2,074	16,581	6	210	13.09	2,736
Gold-silver (lode-placer):								
1967	347	283	98	786	--	23	29.26	4,877
1968	225	304	68	547	--	4	7.31	6,633
1969	272	313	85	682	1	14	21.98	9,021
1970	288	298	86	686	--	11	16.04	181
1971 [p]	300	292	82	653	--	15	21.42	402
Iron:								
1967	6,137	305	1,875	15,032	1	149	9.98	1,049
1968	6,579	321	2,129	17,071	--	135	7.91	426
1969	7,169	304	2,177	17,439	2	150	8.72	962
1970	6,588	334	2,203	17,641	4	162	9.41	1,661
1971 [p]	6,100	325	1,967	15,754	2	150	9.59	1,645
Lead-zinc:								
1967	1,410	251	354	2,835	1	78	27.86	3,430
1968	1,230	265	340	2,725	--	92	33.77	2,316
1969	1,257	281	353	2,836	1	68	24.33	3,155
1970	1,233	284	350	2,806	--	75	26.72	966
1971 [p]	1,200	268	328	2,627	1	60	23.22	5,348
Uranium:								
1967	1,518	281	427	3,419	--	56	16.38	342
1968	1,626	302	491	3,977	1	38	9.81	1,627
1969	1,461	303	442	3,585	--	62	17.30	481
1970	1,715	307	527	4,384	--	72	16.42	676
1971 [p]	1,400	316	442	3,613	--	35	9.96	403
Miscellaneous:								
1967	5,563	315	1,752	14,015	2	169	12.20	1,176
1968	5,026	321	1,612	12,893	--	135	10.47	720
1969	5,890	298	1,757	13,922	1	155	11.21	1,092
1970	5,276	324	1,710	13,689	2	171	12.64	1,709
1971 [p]	4,900	298	1,450	11,605	--	130	11.29	464
Total: [1]								
1967	20,928	280	5,863	46,951	7	587	12.65	1,488
1968	20,298	306	6,262	50,182	2	539	10.78	888
1969	22,271	308	6,861	54,800	6	620	11.42	1,173
1970	21,535	331	7,136	57,297	8	722	12.74	1,559
1971 [p]	20,200	314	6,342	50,834	9	600	12.00	1,818

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

Table 3.—Worktime and injury experience at nonmetal (except stone) mines in the United States, by industry group

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Clay-shale:								
1967	5,213	227	1,182	9,607	2	247	25.92	1,967
1968	4,785	218	1,044	8,496	1	175	20.72	1,956
1969	4,462	210	976	7,974	4	201	25.71	3,886
1970	4,183	210	880	7,200	4	172	24.44	4,068
1971 p	4,100	207	855	7,039	1	165	23.87	1,583
Gypsum:								
1967	891	249	222	1,799	1	12	7.23	3,628
1968	898	254	228	1,839	1	19	10.88	3,518
1969	907	259	235	1,900	--	21	11.06	517
1970	912	252	229	1,853	2	13	8.09	7,121
1971 p	800	263	223	1,824	--	15	8.22	4,519
Phosphate rock:								
1967	3,181	272	865	6,991	3	160	23.32	3,554
1968	2,822	273	771	6,249	2	163	26.40	2,654
1969	2,761	283	781	6,281	3	62	10.35	3,489
1970	2,170	278	602	4,880	2	35	7.58	2,746
1971 p	2,300	282	651	5,245	1	45	8.96	1,619
Potash:								
1967	1,913	328	627	5,017	3	163	33.09	4,713
1968	1,630	326	531	4,245	2	157	37.45	3,495
1969	1,429	346	495	3,960	4	130	33.84	7,328
1970	1,347	342	460	3,684	2	151	41.54	5,046
1971 p	1,200	357	437	3,497	3	140	41.46	7,441
Salt:								
1967	1,768	266	470	3,892	2	168	43.68	4,318
1968	1,762	276	486	3,961	24	175	50.23	39,168
1969	1,691	280	473	3,893	2	170	44.18	5,951
1970	1,791	278	498	4,013	5	124	32.14	8,212
1971 p	1,600	281	452	3,623	--	140	38.65	958
Sulfur:								
1967	1,640	365	598	4,783	2	54	11.71	2,873
1968	1,672	347	581	5,117	--	86	16.81	904
1969	1,979	324	642	5,171	--	95	18.37	976
1970	1,726	314	541	4,332	--	57	13.16	311
1971 [1]	--	--	--	--	--	--	--	--
Miscellaneous:								
1967	3,414	235	801	6,461	4	222	34.98	4,709
1968	3,061	232	711	5,725	6	178	32.14	7,268
1969	3,178	232	738	5,969	4	201	34.34	4,961
1970	3,207	249	798	6,451	3	247	38.75	5,305
1971 p	3,900	230	909	7,327	10	230	32.89	10,182
Total: [2]								
1967	18,020	264	4,765	38,550	17	1,026	27.06	3,499
1968	16,630	262	4,352	35,633	36	953	27.76	7,182
1969	16,587	262	4,341	35,147	17	880	25.52	4,004
1970	15,336	261	4,010	32,414	18	799	25.21	4,412
1971 p	14,100	251	3,526	28,555	15	740	26.48	4,622

p Preliminary.
[1] The Federal Occupational Safety and Health Act of 1970 (Public Law 91-596) was approved Dec. 29, 1970, and became effective Apr. 28, 1971. Under its provision, recordkeeping and reporting requirements for safety and health data on sulfur operations became the responsibility of the U.S. Departments of Labor and Health, Education, and Welfare.
[2] Data may not add to totals shown because of independent rounding.

Table 4.—Worktime and injury experience at nonmetal (except stone) mills in the United States, by industry group

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Clay-shale:								
1967	15,874	256	4,068	32,742	6	1,007	30.94	2,172
1968	14,764	265	3,929	31,576	2	954	30.28	1,506
1969	13,164	272	3,578	28,730	6	868	30.42	2,413
1970	12,612	273	3,445	27,632	4	889	32.32	2,031
1971 p	14,300	274	3,914	31,538	7	1,105	35.29	2,320
Gypsum:								
1967	2,094	265	555	4,473	--	15	3.35	163
1968	1,638	269	441	3,613	--	21	5.81	275
1969	1,734	268	465	3,829	1	29	7.84	2,020
1970	1,509	270	408	3,319	--	9	2.71	71
1971 p	1,600	292	462	3,699	--	35	10.00	2,155
Phosphate rock:								
1967	2,042	297	607	4,854	1	55	11.54	3,420
1968	1,632	303	495	3,964	--	51	12.87	600
1969	1,796	333	598	4,799	1	29	6.25	1,461
1970	2,054	323	663	5,308	1	16	3.20	1,434
1971 p	1,900	325	604	4,835	1	40	8.48	2,222
Potash:								
1967	992	347	344	2,751	2	49	18.54	4,921
1968	647	309	203	1,625	--	42	25.85	702
1969	637	351	224	1,788	--	25	13.98	322
1970	730	313	228	1,827	--	28	15.32	571
1971 p	600	358	207	1,656	1	15	9.06	6,410
Salt:								
1967	3,704	283	1,047	8,393	--	156	18.59	448
1968	3,396	279	947	7,619	--	170	22.31	535
1969	3,507	277	970	7,796	--	216	27.71	466
1970	3,451	286	986	7,939	1	221	27.96	1,239
1971 p	700	276	204	1,632	--	35	21.45	493
Sulfur:								
1967	1	250	(1)	2	--	1	500.00	12,500
1968	--	--	--	--	--	--	--	--
1969	--	--	--	--	--	--	--	--
1970	--	--	--	--	--	--	--	--
1971 p	--	--	--	--	--	--	--	--
Miscellaneous:								
1967	6,720	289	1,944	15,635	4	242	15.73	2,232
1968	6,869	279	1,915	15,385	1	281	18.33	1,259
1969	7,177	290	2,079	16,708	2	314	18.91	1,593
1970	6,769	299	2,021	16,267	4	432	26.80	3,593
1971 p	5,300	292	1,535	12,365	--	335	27.09	1,348
Total: [2]								
1967	31,427	273	8,565	68,850	13	1,525	22.34	2,043
1968	28,946	273	7,930	63,781	3	1,519	23.86	1,184
1969	28,015	282	7,914	63,651	10	1,481	23.42	1,805
1970	27,125	286	7,752	62,293	10	1,595	25.77	2,140
1971 p	24,300	285	6,926	55,723	9	1,565	28.28	2,153

p Preliminary.
[1] Less than 500.
[2] Data may not add to totals shown because of independent rounding.

Table 5.—Worktime and injury experience at stone quarries and mills in the United States, by industry group

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Cement: [1]								
1967	22,073	317	7,008	56,119	4	347	6.25	1,140
1968	21,942	320	7,025	56,218	10	380	6.94	1,568
1969	22,278	318	7,088	55,840	8	352	6.45	1,429
1970	21,140	320	6,772	54,347	4	363	6.75	912
1971 p	20,900	324	6,763	54,270	6	420	7.83	1,100
Granite:								
1967	7,853	249	1,958	16,351	3	401	24.71	2,296
1968	7,980	246	1,962	16,514	4	384	23.50	3,155
1969	7,221	253	1,828	15,594	5	397	25.78	3,287
1970	7,598	247	1,873	16,250	5	429	26.71	3,097
1971 p	8,000	245	1,968	17,064	4	425	25.02	2,182
Lime: [1]								
1967	7,764	282	2,190	17,583	5	285	16.49	2,417
1968	7,527	283	2,134	17,210	5	258	15.28	2,108
1969	7,815	292	2,281	18,215	3	354	19.60	1,962
1970	7,395	305	2,256	18,289	1	372	20.40	933
1971 p	6,800	308	2,085	16,789	6	355	21.38	2,767
Limestone:								
1967	31,145	245	7,619	64,907	26	1,429	22.42	3,327
1968	30,726	248	7,621	65,130	29	1,442	22.59	3,533
1969	31,115	251	7,804	67,451	31	1,492	22.58	3,800
1970	31,245	247	7,715	66,762	24	1,650	25.07	3,304
1971 p	32,800	242	7,949	69,006	35	1,840	27.20	4,510
Marble:								
1967	2,894	251	725	6,080	--	189	31.09	1,115
1968	2,806	246	691	5,782	--	174	30.09	2,134
1969	2,406	250	602	5,124	2	159	31.42	4,418
1970	2,295	249	571	4,740	--	140	29.54	1,444
1971 p	2,100	250	526	4,210	1	130	30.64	2,061
Sandstone:								
1967	5,012	241	1,209	10,047	--	242	24.09	622
1968	5,147	232	1,194	9,858	6	237	24.65	4,403
1969	4,774	247	1,179	9,775	2	245	25.27	2,246
1970	4,488	240	1,076	8,886	4	296	33.76	3,728
1971 p	4,400	240	1,060	8,661	--	250	28.63	819
Slate:								
1967	1,423	260	371	3,024	3	100	34.06	6,611
1968	1,380	261	360	2,907	--	91	31.30	573
1969	1,162	250	291	2,400	--	74	30.83	480
1970	1,096	255	279	2,251	1	49	22.21	5,297
1971 p	1,000	250	261	2,128	--	65	29.60	2,104
Traprock:								
1967	4,794	224	1,075	8,940	4	210	23.94	3,281
1968	4,535	242	1,096	9,083	2	218	24.22	2,735
1969	4,559	243	1,107	9,256	2	230	25.06	2,119
1970	4,882	229	1,118	9,264	3	279	30.44	2,630
1971 p	4,900	224	1,096	9,088	2	300	33.12	1,981
Miscellaneous:								
1967	1,807	217	393	3,176	1	64	20.47	2,333
1968	2,041	227	462	3,918	2	76	19.91	3,794
1969	1,819	223	406	3,348	--	86	25.69	1,224
1970	1,871	225	421	3,437	1	88	25.89	2,449
1971 p	1,800	227	418	3,398	3	120	35.91	6,208
Total: [2]								
1967	84,765	266	22,548	186,227	46	3,267	17.79	2,308
1968	84,084	268	22,543	186,620	58	3,260	17.78	2,700
1969	83,149	272	22,586	187,003	53	3,389	18.41	2,634
1970	82,010	269	22,082	184,225	43	3,666	20.13	2,292
1971 p	82,800	267	22,126	184,615	57	3,895	21.40	2,784

p Preliminary.
[1] Includes burning or calcining and other mill operations.
[2] Data may not add to totals shown because of independent rounding.

Table 6.—Worktime and injury experience at sand and gravel plants in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1967	52,363	216	11,296	96,645	32	1,919	20.19	2,933
1968	49,901	219	10,930	93,156	26	1,992	21.66	2,688
1969	50,161	219	10,964	94,223	31	1,929	20.80	3,024
1970	50,674	218	11,034	95,067	29	2,045	21.82	2,853
1971 p	50,500	217	10,977	94,786	25	2,130	22.76	2,552

p Preliminary.

Table 7—Worktime and injury experience at coal mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Bituminous coal and lignite mines:								
1967	131,562	220	28,910	229,415	213	9,506	42.36	7,817
1968	127,535	221	28,144	223,406	307	9,135	42.26	10,825
1969	127,375	225	28,677	227,411	190	9,425	42.28	7,282
1970	138,542	227	31,423	249,945	255	11,049	45.23	8,460
1971 p	136,600	221	30,142	241,963	176	10,930	45.90	6,512
Anthracite mines:								
1967	7,750	219	1,701	12,359	9	609	50.00	5,511
1968	6,932	217	1,508	11,011	4	504	46.13	4,182
1969	5,927	232	1,377	10,073	13	492	50.14	9,090
1970	5,938	234	1,392	10,224	5	503	49.69	4,598
1971 p	5,800	239	1,385	10,099	4	450	44.95	3,891
Total: [1]								
1967	139,312	220	30,611	241,774	222	10,115	42.75	7,699
1968	134,467	221	29,651	234,417	311	9,639	42.45	10,513
1969	133,302	225	30,053	237,484	203	9,917	42.61	7,359
1970	144,480	227	32,814	260,169	260	11,552	45.40	8,308
1971 p	142,400	221	31,527	252,062	180	11,380	45.86	6,407

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

Table 8.—Worktime and injury experience in the peat industry in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1967	506	187	95	785	--	15	19.11	733
1968	533	186	99	798	--	8	10.02	244
1969	567	172	98	831	--	8	9.62	184
1970	542	172	93	763	--	14	18.36	587
1971 [1]	--	--	--	--	--	--	--	--

[1] Beginning in 1971, data concerning peat operations are included in the miscellaneous nonmetal industry group in table 3.

Table 9.—Work stoppages in certain mineral industries in the United States

Industry and year	Work stoppages	
	Number	Man-days lost (thousands)
COAL MINING		
Anthracite:		
1967	3	1.4
1968	2	4.2
1969	7	13.1
1970	3	11.4
1971	2	.5
Bituminous and lignite:		
1967	207	[1] 158.0
1968	266	[1] 956.6
1969	457	900.6
1970	500	627.0
1971	606	4,215.1
METAL MINING		
Iron:		
1967	--	--
1968	2	32.7
1969	--	[2] 1.5
1970	--	--
1971	5	30.6
Copper:		
1967	7	2,660.0
1968	6	[1] 1,453.1
1969	6	[1] 97.4
1970	5	3.2
1971	2	591.1
Lead-zinc:		
1967	3	[1] 93.4
1968	1	[1] 31.1
1969	5	9.4
1970	4	8.0
1971	4	14.3
Gold-silver:		
1967	2	26.9
1968	--	[1] 31.1
1969	--	--
1970	1	.5
1971	--	--
Bauxite and other aluminum ores:		
1967	--	--
1968	--	--
1969	--	--
1970	--	--
1971	1	2.3
Ferroalloy metal ores:		
1967	1	(3)
1968	--	--
1969	1	5.4
1970	--	--
1971	1	15.8
Metal mining services:		
1967	--	--
1968	--	--
1969	--	--
1970	1	1.5
1971	--	--
Miscellaneous metal ores:		
1967	1	1.0
1968	--	--
1969	--	--
1970	1	1.7
1971	2	16.9
NONMETAL, STONE, AND SAND-GRAVEL MINING		
Dimension stone:		
1967	--	--
1968	1	3.4
1969	2	5.9
1970	--	--
1971	4	12.3
Crushed and broken stone:		
1967	1	9.0
1968	11	17.1
1969	7	14.7
1970	11	8.1
1971	18	14.9
Sand and gravel:		
1967	15	[1] 26.8
1968	6	6.3
1969	3	[1] 4.1
1970	9	71.6
1971	6	12.8
Clay, ceramic and refractory minerals:		
1967	--	--
1968	2	6.2
1969	1	.2
1970	--	--
1971	--	--
Chemical and fertilizer mineral mining:		
1967	10	38.9
1968	1	7.0
1969	1	38.5
1970	6	16.8
1971	4	7.6
Miscellaneous nonmetallic minerals:		
1967	1	(3)
1968	--	--
1969	1	.5
1970	2	8.6
1971	--	--
Cement, hydraulic:		
1967	9	67.4
1968	2	4.7
1969	12	130.0
1970	2	6.2
1971	1	.5

[1] Includes idleness from stoppages which began in the previous year.
[2] Idleness from a stoppage that began in the previous year.
[3] Less than 100 man-days.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

Abrasive Materials

By Robert G. Clarke [1]

The general downtrend of business activity continued into 1971 and as a result the overall output and value of abrasive materials, except garnet and tripoli, declined.

Output of natural abrasive materials increased 7 percent but value decreased 2 percent. Output of tripoli types of crude materials increased 10 percent and value increased 9 percent. Production of special silica stone products decreased 25 percent in quantity and 15 percent in value. Garnet output increased 1 percent but was essentially unchanged in value.

Artificial abrasives included aluminum oxide, silicon carbide, and metallic abrasives. Production of aluminum oxide decreased 24 percent in quantity and 11 percent in value, and yearend stocks decreased 17 percent. Silicon carbide production also decreased in all categories: quantity, 22 percent; value, 12 percent; and stocks, 24 percent. The tonnage and value of metallic abrasives decreased 7 percent each but stocks increased 1 percent. Diamond products were also affected by the downtrend although synthetic and natural diamonds were not segregated. Industrial diamond imports decreased 3 percent in caratage and 6 percent in value; also, exports plus reexports of industrial diamond decreased 7 percent in caratage and 13 percent in value.

Foreign Trade.—Imports of abrasive materials continued to decline and were the lowest in value since 1963. Exports and reexports decreased to the level of 1968. Net imports, the excess of imports over exports and reexports were $6.7 million, a 68-percent increase over 1970 net imports. Synthetic diamond manufacture was important in holding down the value of net imports.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient abrasive statistics in the United States

Kind	1967	1968	1969	1970	1971
Natural abrasives (domestic) sold or used by producers:					
Tripoli ---- short tons--	70,984	85,534	84,673	68,105	75,134
Value ---- thousands--	$377	$796	$734	$520	$569
Special silica-stone products [1] ---- short tons--	2,701	3,141	3,311	3,134	2,349
Value ---- thousands--	$574	$629	$600	$665	$563
Garnet ---- short tons--	20,494	22,136	20,458	18,837	18,984
Value ---- thousands--	$1,849	$1,922	$1,874	$1,936	$1,934
Emery ---- short tons--	W	W	W	W	1,586
Value ---- thousands--	W	W	W	W	W
Artificial abrasives [2] ---- short tons--	552,812	567,814	608,622	561,107	472,299
Value ---- thousands--	$80,405	$86,316	$92,589	$85,772	$79,027
Foreign trade (natural and artificial abrasives):					
Exports (value) ---- do----	$50,896	$60,266	$70,687	$64,338	$60,685
Reexports (value) ---- do----	$17,239	$19,807	$20,373	$28,085	$21,711
Imports for consumption (value) ---- do----	$100,427	$103,150	$100,748	$96,467	$89,085

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).

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

(Thousands)

Kind	1970 Quantity	1970 Value	1971 Quantity	1971 Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semi-precious stones, including diamond dust and powder..carats..	7,258	$18,711	7,506	$18,726
Crushing bort..do....	33	154	20	94
Industrial diamond..do....	339	1,838	415	1,831
Emery, natural corundum, and other natural abrasives, n.e.c. pounds..	33,375	3,403	20,888	2,368
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide)..do....	35,949	6,869	31,655	6,792
Silicon carbide, crude or in grains..do....	12,883	2,319	13,592	2,414
Carbide abrasives, n.e.c..do....	4,730	7,332	2,733	6,624
Grinding and polishing wheels and stones:				
Diamond..carats..	614	3,117	526	2,932
Pulpstones..pounds..	2,315	690	2,520	740
Hand polishing stones, whetstones, oilstones, hones, and similar stones..do....	905	1,229	640	901
Wheels and stones, n.e.c..do....	4,247	7,549	4,576	8,058
Abrasive paper and cloth, coated with natural or artificial abrasive materials..reams..	334	8,240	281	7,058
Coated abrasives, n.e.c..	NA	2,887	NA	2,147
Total..	XX	64,338	XX	60,685

NA Not available. XX Not applicable.

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

(Thousands)

Kind	1970 Quantity	1970 Value	1971 Quantity	1971 Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semi-precious stones, including diamond dust and powder..carats..	378	$920	392	$1,038
Crushing bort..do....	364	2,326	348	2,181
Industrial diamond..do....	3,837	24,604	2,610	18,361
Emery, natural corundum, and other natural abrasives, n.e.c. pounds..	751	112	244	59
MANUFACTURED ABRASIVES				
Carbide abrasives, n.e.c..do....	24	37	--	--
Grinding and polishing wheels and stones:				
Diamond..carats..	3	50	4	39
Pulpstones..pounds..	22	3	--	--
Wheels and stones, n.e.c..do....	11	12	6	7
Hand polishing stones, whetstones, oilstones, hones and similar stones..do....	(1)	3	--	--
Abrasive paper and cloth, coated with natural or artificial abrasive materials..reams..	(1)	(1)	1	3
Coated abrasives, n.e.c..	NA	18	NA	23
Total..	XX	28,085	XX	21,711

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 kinds

(Thousands)

Kind	1970 Quantity	1970 Value	1971 Quantity	1971 Value
Burrstones in blocks, rough short tons	(1)	(1)	--	--
Emery, flint, rottenstone, and tripoli, crude or crushed do	14	$437	8	$276
Silicon carbide, crude do	107	15,356	99	13,958
Aluminum oxide, crude do	161	20,412	126	18,166
Other crude artificial abrasives do	1	123	1	133
Abrasives, ground, grains, pulverized or refined:				
Silicon carbide do	2	684	2	635
Aluminum oxide do	7	2,007	5	1,440
Emery, corundum, flint, garnet, and other, including artificial abrasives do	1	288	(1)	52
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasives	(2)	5,682	(2)	6,191
Hones, whetstones, oilstones, and polishing stones number	296	77	407	86
Abrasive wheels and millstones:				
Burrstones, manufactured or bound up into millstones short tons	--	--	4	(1)
Solid natural stone wheels number	12	11	(1)	3
Diamond do	65	616	59	371
Other	(2)	1,181	(2)	1,136
Articles not especially provided for:				
Emery or garnet	(2)	19	(2)	19
Natural corundum or artificial abrasive materials	(2)	241	(2)	206
Other	(2)	66	(2)	154
Diamond:				
Diamond dies number	11	230	12	236
Crushing bort carats	363	994	299	777
Other industrial diamond do	4,752	27,374	3,972	23,472
Miners' diamond do	1,131	5,669	913	4,653
Dust and powder do	7,119	15,000	7,726	17,121
Total	XX	96,467	XX	89,085

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

TRIPOLI

Fine-grained porous silica materials are discussed as a group, which includes tripoli from Arkansas, Missouri, and Oklahoma; amorphous or soft silica from Illinois; and rottenstone from Pa. The output of crude tripoli increased 10 percent in quantity and 9 percent in value in 1971. Finished material sold or used for abrasive use declined to 67 percent of the total, and filler use increased to 31 percent, compared with 68 percent and 30 percent, respectively, in 1970.

Tripoli producers in 1971 were Malvern Minerals Co., Garland County, Ark., Hercules Minerals Corp., Pike County, Ark., and The Carborundum Co., Newton County, Mo., and Ottawa County, Okla. The major use for tripoli was for abrasive applications; it was also used as a filler. Amorphous silica producers were Illinois Minerals Co., and Tammasco, Inc., both in Alexander County, Ill. Rottenstone producers were Keystone Filler & Manufacturing Co. and Penn Paint & Filler Co., both in Lycoming County, Pa. Amorphous silica and rottenstone also were used for abrasives and fillers.

Prices quoted in Engineering and Mining Journal, December 1971, 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	1.30
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:	
Illinois:	
Through 200 mesh, 90 to 95 percent	26
Through 200 mesh, 96 to 99 percent	27
Through 325 mesh, 90 to 95 percent	29
Through 325 mesh, 96 to 98 percent	30.50
Through 325 mesh, 98 to 99.4 percent	31.50
Through 325 mesh, 99.5 percent	45
Through 400 mesh, 99.9 percent	65
Below 15 microns, 99 percent	72
Below 10 microns, 99 percent	92
Dierks, Ark.:	
200 mesh	26
325 mesh	33

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

Kind		1967	1968	1969	1970	1971
Abrasives	short tons	44,961	52,837	50,337	41,703	44,899
Value	thousands	$1,916	$2,201	$2,013	$1,583	$1,692
Filler	short tons	11,240	13,418	14,352	18,093	20,457
Value	thousands	$354	$388	$413	$545	$681
Other	short tons	4,797	5,203	5,487	1,134	1,327
Value	thousands	$143	$149	$157	$28	$32
Total [3]	short tons	60,998	71,458	70,176	60,930	66,683
Value [3]	thousands	$2,413	$2,737	$2,584	$2,156	$2,406

[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 included oilstone from Arkansas, whetstones from Indiana, grindstones from Ohio, grinding pebbles from Minnesota and Washington and tube-mill liners from Minn. The total tonnage decreased 25 percent but the value decreased 15 percent. The product mix is variable so that value fluctuations from year to year are possible because of the variations in the unit value of items.

Novaculite for oilstones was produced by Arkansas Abrasives, Inc., Arkansas Oilstones Co., Inc., John O. Glassford, Cleve Milroy, M. V. Smith, Norton Pike Division of Norton Co., and Hiram A. Smith Whetstone Co., all from operations in Garland County, Ark. Hindostan Whetstone Co. produced whetstone in Orleans County, Ind. Cleveland Quarries Co. produced grindstones at its Amherst Quarry, Amherst County, Ohio. Manufacturers Mineral Co. produced grinding pebbles in Renton County, Wash. Jasper Stone Co. produced both grinding pebbles and tube-mill liners from its quarry in Jasper County, Minn.

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

Year	Short tons	Value (thousands)
1967	2,701	$574
1968	3,141	629
1969	3,311	600
1970	3,134	665
1971	2,349	563

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

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet, finished by crushing, concentrating, grinding, and screening to specified particle size or grit by the producers were 1 percent more in 1971 as compared with those of 1970. Four producers were active—two in New York and two in Idaho. Barton Mines Corp., the largest producer, operated in Warren County, N.Y., and processed the garnet for use in coated abrasives, metal lapping, glass grinding and glass polishing, both optical glass and plate glass. Interpace Corp. recovered garnet as a byproduct in the processing of wollastonite ore in Essex County, N.Y. Idaho Garnet Abrasive Co. and Emerald Creek Garnet Milling Co. produced garnet from placer deposits in Benewah County, Idaho. Garnet from both Idaho producers and from Essex County, N.Y., was used for sand-blast abrasive, nonskid paints, water filtration, and miscellaneous abrasive applications.

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

Year	Short tons	Value (thousands)
1967	20,494	$1,849
1968	22,136	1,922
1969	20,458	1,874
1970	18,837	1,936
1971	18,984	1,934

NATURAL ALUMINA ABRASIVES

Corundum.—Abrasive-grade natural corundum has not been mined commercially in the United States for more than 60 years, and for many years all of the corundum used by domestic industry was imported from Southern Rhodesia. The imposition of sanctions by the United Nations in 1968 halted imports of corundum. In 1969 the Office of Emergency Preparedness (OEP) dropped corundum from the list of strategic and critical materials for stockpiling and in 1970 Congressional approval was granted to dispose of 1,964 short tons in Government inventory by the Stockpile Disposal Division of the General Services Administration (GSA). Bendix Abrasives Division, Westfield Facility, formerly American Abrasive Co. of Westfield, Mass., acquired the entire stockpile in 1971 and imported 48 tons of crude corundum from Kenya in 1971 for evaluation.

Emery.—Domestic production of emery in 1971 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. Emery use was mostly in miscellaneous abrasive applications such as antiskid aggregate in floors, stair treads, and pavements, while a minor use was in coated abrasives, and tumbling abrasive.

Table 8.—Natural corundum: World production by country

(Short tons)

Country [1]	1969	1970	1971 [p]
India	[r] 498	454	345
Kenya	129	66	[e] 70
Malagasy Republic	--	2	[e] 2
Malawi	--	(2)	NA
South Africa, Republic of	252	272	244
U.S.S.R.[e]	6,600	7,200	7,200
Total	[r] 7,479	7,994	7,861

[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] Less than ½ unit.

INDUSTRIAL DIAMOND

The United States has no source of natural industrial diamond but depends on imports for natural stones which exceed 25 mesh (0.003 carat), the present commercial limit for synthetic diamond. Domestic production of synthetic industrial diamond in 1971 was estimated at 13 million carats, unchanged from 1970. Secondary production (salvage from used diamond tools and from sludge, wet, and, swarf, dry, diamond-containing wastes) was estimated to be 3 million carats.

A Government-Industry Working Group on Industrial Diamond held a conference in New York City on February 12, 1971, to discuss a disposal program for 18.9 million carats of crushing bort, 5.1 million carats of stones, and 64,000 tools, in anticipation of Congressional hearings. Congressional approval was granted in August 1971 for the disposal of these excesses. The stockpile inventory up to objectives as of December 30, 1971, was 23.7 million carats of crushing bort and 20 million carats of stones. For tools, the objective was zero.

Exports of industrial diamond dust and powder, which includes synthetics, increased from 7.3 million carats in 1970 to 7.5 million carats in 1971, but the value remained unchanged at $18.7 million. The total of exports and reexports of dust and powder, bort, and stones decreased from 12.2 million carats in 1970 to 11.3 million carats, and the value decreased from $48.6 million to $42.2 million.

Imports of industrial diamond in 1971 declined 3 percent in number of carats and 6 percent in value from 1970. Shipments from Ireland decreased from 6.2 million carats valued at $16.3 million to

6.0 million carats valued at $15.9 million, decreases of 3 percent in quantity and 2 percent in value, respectively. However, Ireland maintained its share of imports at 47 percent of quantity and 35 percent of value.

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

(Thousand carats and thousand dollars)

Year	Quantity	Value
1969	14,076	$52,821
1970	13,365	49,037
1971	12,910	46,023

WORLD REVIEW

Angola.—The Portuguese Government awarded a concession to Companhia de Diamantes de Angola (DIAMANG) of Lisbon, and De Beers Consolidated Mines Ltd. of Kimberley, Republic of South Africa.[2] Two large companies have formed a new firm, Consorcio Mineiro de Diamantes (Condiama), which was granted exclusive rights to diamond areas relinquished by DIAMANG. Prospecting areas for the new company will be 500,000 square kilometers (km^2) in 1972, 250,000 km^2 in 1973, 125,000 km^2 in 1974, 100,000 km^2 in 1975, 50,000 km^2 in 1976, and 30,000 km^2 in 1977. Exploration rights, if diamond is found, are granted for an initial period of 25 years and may be extended an additional 25 years, and the area will be reduced to the actual boundaries of mines in operation. Development of the concession area will be at terms more favorable to the Angolan economy than under the prior contract with DIAMANG.

Botswana.—The Orapa diamond mine of De Beers Botswana Mining Company (Pty.) Ltd. came into operation at the beginning of July 1971.[3] De Beers brought the mine into production in the record time of 18 months. Approximately 8,000 tons of diamond-bearing ground are worked per day. At full production more than 2 million carats of diamond per year is expected and the output will consist predominantly of industrial grade stones. The Government of Botswana has a 15-percent equity in the enterprise and will also derive revenue from royalties, income taxes, and dividends on shares.

Brazil.—The largest diamond mining operation in Brazil is that of Mineração Tejucana S.A. on the Jequitinhonha River north of Diamantina, Minas Gerais. The company operated two dredges, one with 12-cubic foot buckets and the other with 9-cubic foot buckets. The company plans to put a 20-inch suction dredge, now under construction, into operation early in 1972. In 1970, Mineração Tejucana recovered 61,855 carats of diamond, more than 50 percent industrial, from 5 million cubic yards of material dredged. No close governmental control is exercised over the many small hand mining (garimpeiro) operations, so that total output for Brazil has to be estimated. Estimates vary from 150,000 to 800,000 carats per year.

Canada.—North America's first major diamond mine could result from Kelver Mines, Inc.. exploration in Northern Ontario, where the company is seeking a kimberlite as the potential source of diamond carried southward by glacial movement.[4]

Central African Republic (CAR).—The year 1971 marked the third consecutive year of decreased diamond production, down to 467,000 carats valued at $12.6 million. The diamond industry in current years has provided about 50 percent of the CAR's export revenue and the Government has associated itself with a program to expand diamond production and to exercise close control over diamond buying and sales.

Dahomey.—A United Nations exploration report disclosed evidence of diamond in Dahomey. Further feasibility studies have been authorized by the Government.

Guyana.—Diamond is mined on a small scale in the interior. The three leading districts, by rank in both quantity and value, are Mazaruni, Potaro, and Cuyuni.

India.—The Government owned National Mineral Development Corp. started operations in the Majhgawan diamond pipe (kimberley type) of 21 surface acres at Panna in Central India.[5] The yield is mostly gem stones, so that India will still be dependent on imports for industrial diamond.

[2] Bureau of Mines. Mineral Trade Notes. V. 68, No. 12, December 1971 pp. 10–12.
[3] Bureau of Mines Mineral Trade Notes. V. 68, No. 11, November 1971, p. 13.
[4] Staff. Exploration Round-Up. Engineering and Mining Journal, v. 172, No. 4, April 1972, p. 18.
[5] Staff. Diamond Mining in India Today. World Mining, v. 24, No. 6, June 1971, pp. 34–35.

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			
	1970		1971		1970		1971		1970		1971		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	(1)	$2	--	--	26	$182	22	$145	43	$188	52	$248	--	--	--	--
Belgium-Luxembourg	101	201	52	$112	988	4,309	981	4,044	33	70	10	57	236	$410	431	$798
Brazil	--	--	--	--	5	89	5	59	(1)	5	--	--	--	--	--	--
British West Africa	--	--	11	26	11	89	53	161	--	--	(1)	(1)	--	--	24	51
Canada	(1)	2	9	41	91	470	51	168	33	134	21	72	347	264	283	343
Central African Republic	4	8	8	17	49	484	52	260	1	1	--	--	2	4	--	--
Congo (Brazzaville)	--	--	--	--	--	--	20	118	--	--	1	5	--	--	8	21
Congo (Kinshasa)	32	66	[2] 64	[2] 141	93	199	[2] 96	[2] 253	--	--	[2] 9	[2] 50	1	1	[2] 29	[2] 76
France	--	--	--	--	5	178	(1)	1	3	17	2	22	2	3	1	2
Germany, West	--	--	--	--	6	70	5	29	--	--	--	--	24	36	4	9
Ghana	12	30	--	--	81	503	97	545	1	3	1	6	--	--	7	13
Hong Kong	--	--	--	--	--	--	7	204	--	--	--	--	--	--	--	--
Ireland	16	45	6	16	60	205	13	40	794	4,112	722	3,747	5,344	11,901	5,277	12,087
Israel	6	11	35	104	16	154	13	307	(1)	1	(1)	12	65	118	8	17
Japan	1	5	11	41	97	2,002	109	2,025	1	2	16	27	291	639	549	1,208
Liberia	--	--	--	--	--	--	4	171	--	--	--	--	--	--	--	--
Netherlands	20	41	39	85	649	3,178	464	2,772	2	5	1	4	66	151	244	504
Sierre Leone	--	--	--	--	3	9	--	--	--	--	--	--	1	2	--	--
South Africa, Republic of	138	523	64	194	1,479	9,633	1,242	7,727	98	505	35	160	77	175	238	498
Switzerland	--	--	--	--	10	16	21	122	--	--	--	--	36	60	30	56
United Kingdom	33	60	--	--	810	3,908	635	3,400	57	262	13	60	590	1,171	577	1,406
Venezuela	--	--	(1)	(1)	97	667	66	753	8	59	29	180	--	--	--	--
Western Africa n.e.c	--	--	--	--	171	987	[3] 3	[3] 12	--	--	--	--	9	20	--	--
Other	--	--	--	--	5	42	13	156	57	305	1	3	28	45	16	32
Total	363	994	299	777	4,752	27,374	3,972	23,472	1,131	5,669	913	4,653	7,119	15,000	7,726	17,121

[1] Less than ½ unit.
[2] Zaire, formerly Congo (Kinshasa).
[3] Dahomey, formerly part of Western Africa n.e.c

Ivory Coast.—Diamond production by the Ivory Coast in 1971 showed expected increases over that of 1970.[6] Société Anonyme de Recherches et d'Exploitations Minierès en Côte d'Ivoire (SAREMCI) at Tortiya (south of Korogho) added a new plant of 300,000-cubic-meter-per-year capacity to its existing 645,000-cubic-meter plant, for which the average yield was about 0.35 carat per cubic meter in December 1970. Société Diamantifere de la Côte d'Ivoire (Sodiamci) also added to its plant capacity at Seguela, but the yield per cubic meter is down to 0.16 carat. Société Minières des Bandamas (SMB), ceased operations south of Tortiya because its reserves were exhausted.

Lesotho.—On July 31, 1971, the Lesotho National Development Corporation (LNDC) released a statement in which it was announced that agreement was reached between the LNDC and the Maluti Diamond Corp. for the exploration of diamonds in the Kao area in the North Eastern part of the Maluti Mountains. The LNDC represents the Government of Lesotho, and Maluti Corp. was formed jointly by Newmont Mining Corp. of New York and Lonrho Ltd. of London. The LNDC has an option on a 30-percent share in Maluti. Prospecting rights are exclusive for 38 months.

Malagasy Republic.—The Government of Malagasy and De Beers Consolidated Mines of South Africa concluded a prospecting agreement for diamond and for eventual exploitation of any deposits that may be found.[7] De Beers is authorized to analyze 20,000 samples of ore concentrate from Malagasy. The Government is to have a 20-percent share of ownership in a future corporation and will be represented on the board of directors.

Nigeria.—The Government of Nigeria published Decree No. 55, Diamond Trading Decree 1971, in the Official Gazette, No. 64, Volume 58, December 31, 1971.[8] The decree contains 15 sections pertaining to mining, selling, buying, importing, and exporting diamond. The restrictions are expected to restore lost revenues to the Government.

Sierra Leone.—Diamond exports in 1971 continued to be the major economic earnings source for Sierra Leone but were well below the 1968–69 level because of world conditions. Production from alluvial small-scale operations declined because the rich deposits have been exploited and deeper digging has become necessary. The National Diamond Mining Co. (DIMINCO), owned 51 percent by the Government of Sierra Leone and 49 percent by Sierra Leone Selection Trust (SLST) increased production.

South Africa, Republic of.—The Central Selling Organization (CSO) of the De Beers group announced half-year sales of gem and industrial diamonds for 1971 at 8 percent more in value than at the first half of 1970.[9] Second-half sales were affected by the fact that the South African rand and the U.S. dollar floated between August and December 1971. Total sales for 1971 were 18 percent higher than for 1970 but were 10 percent lower than the record year of 1969, all expressed in South African rands.[10] Diamond stocks of De Beers increased by 19 percent in value in 1971 at yearend. No data were furnished on separate quantities of gem and industrial diamond in the stocks.

South-West Africa, Territory of.—Consolidated Diamond Mines, a subsidiary of De Beers group, announced cessation of offshore diamond mining operations in April 1971.[11] The method employed to recover diamond from the seabed was successful but reserves were low and the quality was falling.

Tanzania.—Exports of diamond increased from 139,341 carats in 1970 to 161,562 carats in 1971, up 15 percent. Diamond exports account for about 88 percent of the total value of mineral exports. Williamson Diamonds Ltd. accounts for nearly all Tanzanian diamond production. The Government owns 50 percent of Williamson Diamonds Ltd. through the National Development Corporation and De Beers owns the other 50 percent. All diamond sales are through the CSO.

Venezuela.—Diamond production in 1970 and 1971 increased substantially due princi-

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[6] Bureau of Mines. Mineral Trade Notes. V. 68, No. 8, August 1971, p. 11.

[7] Bureau of Mines. Mineral Trade Notes. V. 68, No. 7, July 1971, p. 17.

[8] Bureau of Mines. Mineral Trade Notes. V. 69, No. 4, April 1972, pp. 5–12.

[9] The Mining Journal. Diamond Sales Up to Expectations. V. 277, No. 7090, July 9, 1971, p. 40.

[10] The Mining Journal. De Beers Diamond Sales Improve. V. 278, No. 7117, Jan. 14, 1972, p. 38.

[11] Mineral Notes. Industrial Minerals. No. 43, April 1971, p. 47.

pally to the discovery of a rich field in the Guaniamo River area, a tributary of the Orinoco River, where a diamond rush started early in 1970.[12] About 60 percent of the diamond by weight is industrial. Diamond is the third largest export of Venezuela in value. About 12,000 miners are employed in a great number of small enterprises. River mining enterprises are generally small groups of people working with a variety of equipment which includes suction dredges, sandpumps, screens, rafts, canoes, down to skin diving with buckets. Land mining is restricted under Venezuelan law to a 10 square meter area per operating claim and to the use of shovel, spade, iron bar, screens, machete, and bucket. Also excavations must be shored to protect the miners from cave-ins. Each land claim is generally worked by four people who share the proceeds.

Zaire (formerly Congo, Kinshasa).—Production decreased from 14.1 million carats in 1970 to 13.7 million carats in 1971, nearly all of which was industrial diamond. Action by U.S. Congress to authorize GSA disposal of surplus industrial diamond holdings was studied for its effects on the Zaire economy.

TECHNOLOGY

Researchers for the U.S. Bureau of Mines investigated the effect of some organic additives in diamond drilling of quartzite and found that the coefficient of friction in drilling increased with the use of additives, although the wear coefficient decreased.[13] The wear of diamond turning tools was shown to depend considerably on the crystallographic orientation of diamond in the tool.[14] Inexpensive diamond dust and graphite were used to produce synthetic carbonado diamond by a simple procedure, economically feasible, in which sintering was accomplished at high pressures and high temperatures and in which cobalt was used as a binder.[15]

A patent described a process at high temperature and high pressure to produce diamond from a mixture of a carbonaceous material and either a nickel-beryllium or nickel-zirconium alloy.[16] Another patent described a process for producing synthetic diamond from a mixture of nondiamond carbon and an alloy of cobalt and phosphorous which was subjected to high temperatures and pressures although at a lower temperature than heretofore required.[17] A third patent described a process for producing synthetic diamond at a relatively low pressure, by doping diamond seed crystals with a monocarbon atom gas containing lithium vapor or a compound of boron or aluminum, subjected to a conventional crystal growth operation.[18]

A fourth patent was similar to Patent No. 3,607,061.[19] A fifth patent described the manufacture of diamond colored crystals or semiconductor crystals at low pressure by contacting seed crystals with a gaseous polycarbon atom compound doped with certain described additives.[20] A sixth patent was similar to Patent No. 3,630,678.[21] A seventh patent described equipment which uses shock waves in a magnetic hammer to attain the required pressures and temperatures.[22]

The utilization of industrial diamond was confronted with greater technological challenges as increasing scientific knowledge and expertise made greater demands in 1971. For example a moderate-depth lunar drill, incorporating natural diamonds, and the problems of slicing and polishing hard materials, which are the

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[12] Fairbain, W. C. Diamonds in Venezuela. Mining Magazine, v. 125, No. 4, October 1971, pp. 349–353.

[13] Strebig, K. C., A. Aly Selim, and C. W. Schultz. Effect of Organic Additives in Impregnated Diamond Drilling. BuMines RI 7494, March 1971, 31 pp.

[14] Casey, M., and J. Wilks. An Experiment on the Wear of Diamond Turning Tools. Diamond Research, 1972, London pp. 11–13.

[15] Katzman, H., and W. F. Libby. Science. Sintered Diamond Compacts with a Cobalt Binder. V. 172, No. 3988, June 1971, pp. 1132–1133.

[16] Horton, N. D. (assigned to Megadiamond Corp.) A Method of Making Diamonds. U.S. Patent No. 3,597,158, August 3, 1971.

[17] Kuratomi, T. A Method of Manufacturing Diamond Crystals. U.S. Patent No. 3,607,060, Sept. 21, 1971.

[18] Angus, J. C. (assigned to Case Western Reserve University). Manufacture of Synthetic Diamond. U.S. Patent No. 3,607,061, Sept. 21, 1971.

[19] Angus, J. C. (assigned to Case Western Reserve University). Manufacture of Synthetic Diamond. U.S. Patent No. 3,630,677, Dec. 28, 1971.

[20] Gardner, N. C. (assigned to Case Western Reserve University). Diamond Growth Process. U.S. Patent No. 3,630,678, Dec. 28, 1971.

[21] Angus, J. C. (assigned to Case Western Reserve University). Diamond Growth Process. U.S. Patent No. 3,630,679, Dec. 28, 1971.

[22] Rasquin, J. R. and W. F. Estes (assigned to U.S. Administrator of the N.A.S.A.). An Apparatus for Making Diamond. U.S. Patent No. 3,632,242, Jan. 4, 1972.

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

(Thousand carats)

Country	1969			1970			1971 p		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Africa:									
Angola	r 1,516	r 506	r 2,022	1,797	599	2,396	e 1,625	e 542	e 2,167
Botswana	NA	NA	NA	54	490	544	87	785	[2] 872
Central African Republic	r 348	r 187	535	r 313	r 169	482	304	163	467
Ghana	239	2,152	2,391	255	2,295	2,550	256	2,306	2,562
Guinea	22	50	72	22	52	[3] 74	e 22	e 52	e 74
Ivory Coast	81	121	202	85	128	213	e 88	e 132	e 220
Lesotho [4]	5	r 25	r 30	4	13	17	1	6	7
Liberia	[5] 562	[5] 184	[5] 746	[5] 577	[5] 235	[5] 812	525	214	739
Sierra Leone	736	1,253	1,989	723	1,232	1,955	715	1,220	1,935
South Africa, Republic of:									
Premier	631	1,891	2,522	623	1,867	2,490	[6] 652	[6] 1,955	[6] 2,607
Other DeBeers Company [7]	2,457	2,010	4,467	2,615	2,140	4,755	2,267	1,855	e 4,122
Other	524	350	874	520	347	867	181	121	e 302
Total	3,612	4,251	7,863	3,758	4,354	8,112	3,100	3,931	7,031
South-West Africa, Territory of	1,923	101	2,024	1,772	93	1,865	e 1,800	e 100	e 1,900
Tanzania	394	383	777	359	349	708	404	404	[2] 808
Zaire (formerly Congo-Kinshasa)	r 1,802	r 11,621	r 13,423	1,649	12,438	14,087	e 1,700	e 12,000	e 13,700
Other Areas:									
Brazil e	160	160	320	160	160	320	160	160	320
Guyana	21	31	52	24	37	61	19	29	48
India	10	2	12	17	3	20	16	3	19
Indonesia e	14	6	20	14	6	20	14	6	20
U.S.S.R. e	1,500	6,000	7,500	1,600	6,250	7,850	1,800	7,000	8,800
Venezuela	118	76	194	129	371	500	e 130	e 370	e 500
World total	r 13,063	r 27,109	r 40,172	13,312	29,274	42,586	12,766	29,423	42,189

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

[1] Total (gem plus industrial) diamond output of 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 all cases except Angola (1969 only), Lesotho (all years), Liberia (1969 and 1970), Zaire (1969 only), and Venezuela (1969 and 1970), where sources give both total output and detail. The estimated distribution of the total in the case of a number of countries is conjectural, based on unofficial information of varying reliability.

[2] Exports.

[3] Official estimate by Government of Guinea.

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

[5] Exports for year ended August 31 of that stated.

[6] Total nonalluvial output of Transvaal, presumably includes a small share of total originating from non-De Beers-owned properties other than the Premier mine.

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

most "expensive" on earth, the lunar rock brought back by the Apollo missions, were described.[23] An international file of abstracts relative to properties of diamond, hard materials, machines, and patents was published monthly.[24]

ARTIFICIAL ABRASIVES

Five firms produced crude fused aluminum oxide material in 1971 in the United States and Canada. The Carborundum Co., Norton Co., and General Abrasive Co., Inc., Division of U.S. Industries, Inc., each operated plants in both countries, Simonds Canada Abrasive Co., Ltd., and The Exolon Co. had operations in Canada. Of the combined output, 20,503 tons was white, high-purity material and 128,572 tons was regular grade. Nonabrasive applications, principally in the manufacture of refractories, were about 10 percent of the total, white and regular combined, and domestic and Canadian combined. Output was at 51 percent of rated plant capacity.

[23] Daniel, P. Moon Rock Sawing and Polishing Techniques are Available to Industry. Industrial Diamond Review, June 1971, pp. 221–224.

[24] Industrial Diamond Review. Published monthly, January to December 1971, inclusive, 540 pp. Each monthly issue generally contained 10 pages of abstracts.

Six firms produced silicon carbide in 1971 in the United States and Canada. The Carborundum Co. operated plants in both countries and Electro-Refractories & Abrasives, Ltd., The Exolon Co., General Abrasive Co., Division of U.S. Industries, and Norton Co. operated in Canada, all of which produced crude for abrasive, refractory, and miscellaneous uses. Satellite Alloy Corp., which has facilities only in the United States, produced silicon carbide for refractories and other nonabrasive applications. Production was estimated at 66 percent of capacity and consumption was estimated at about 52 percent for abrasive use and 48 percent for nonabrasive purposes.

As of December 31, 1971, GSA reported 427,725 short tons of fused, crude aluminum oxide in inventory, of which 127,725 tons was in excess of the objective of 300,000 tons; 50,905 tons of fused aluminum oxide abrasive grain at objective; and 196,453 tons of silicon carbide crude, of which 166,453 tons were in excess of the objective of 30,000 tons.

Manufacture of metallic abrasives in 1971 decreased 7 percent each in quantity and value compared with 1970, and the quantity manufactured was only slightly greater than the quantity sold or used. Steel shot and grit was 76 percent of the total sold or used, followed by chilled iron shot and grit at 13 percent, annealed iron shot and grit at 10 percent, and other metallic oxides and carbides at 1 percent. Ohio was the leading producing state with 28 percent of the total quantity. Michigan, Pennsylvania, and Indiana followed in order of quantity, and their combined total was 63 percent. Alabama, New York, and Connecticut accounted for the remaining 9 percent of quantity.

Producers of metallic abrasives were as follows:

Company	*Plants*
Abbott Ball Co	Hartford, Conn.
Abrasive Materials, Inc	Hillsdale, Mich.
Abrasive Metals Company	Pittsburgh, Pa.
Cleveland Metal Abrasive Co.	Birmingham, Ala. Howell, Mich. Springville, N.Y. Cleveland, Ohio Toledo, Ohio.
Durasteel Co	Pittsburgh, Pa.
Ervin Manufacturing Co	Adrian, Mich.
Globe Steel Abrasives Co	Mansfield, Ohio.
Industeel Corporation	Pittsburgh, Pa.
Kohler Co	Kohler, Wis.
Metal Blast Inc	Cleveland, Ohio.
National Metal Abrasive Co.	Cleveland Ohio.
Pellets, Inc	Tonowanda, N.Y.
Wheelabrator Corp	Mishawaka, Ind.

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

(Thousand short tons and thousand dollars)

Kind	1967	1968	1969	1970	1971
Silicon carbide [1]	142	159	161	167	130
Value	$19,612	$23,833	$23,945	$24,038	$21,123
Aluminum oxide (abrasive grade) [1]	207	192	217	195	149
Value	$28,183	$27,705	$31,276	$27,402	$24,514
Metallic abrasives [2]	204	216	230	199	193
Value	$32,610	$34,778	$37,369	$34,332	$33,390
Total [3]	553	568	609	561	472
Value [3]	$80,405	$86,316	$92,589	$85,772	$79,027

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

Table 13.—Production, shipments, and stocks of metallic abrasives in the United States, by products

(Short tons and thousand dollars)

Year and product	Manufactured		Sold or used		Stocks Dec. 31	Annual capacity [1]
	Quantity	Value	Quantity	Value		
1970:						
Chilled iron shot and grit	30,064	$3,469	29,369	$3,703	4,867	254,237
Annealed iron shot and grit	35,973	4,380	35,764	4,964	367	[2] 158,843
Steel shot and grit	140,707	21,344	132,204	25,366	21,579	190,163
Other [3]	1,687	224	1,782	300	57	10,750
Total [4]	208,431	29,417	199,119	34,332	26,866	455,150
1971:						
Chilled iron shot and grit	26,514	3,035	25,965	3,323	5,471	204,375
Annealed iron shot and grit	20,143	2,324	19,373	2,750	1,024	[2] 139,843
Steel shot and grit	145,444	21,651	146,330	26,876	20,663	207,163
Other [3]	1,778	298	1,769	441	64	8,500
Total [4]	193,879	27,308	193,437	33,390	27,222	420,038

[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.
[2] Included in capacity of chilled iron shot and grit.
[3] Includes cut wire shot.
[4] Data may not add to total shown because of independent rounding.

Table 14.—Stocks of crude artificial abrasives and capacity of manufacturing plants, as reported by producers in the United States and Canada

(Thousand short tons)

Year	Silicon carbide		Aluminum oxide		Metallic abrasives [1]	
	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity
1967	12.9	176.1	30.2	330.2	15.6	400.1
1968	17.7	179.7	25.5	357.2	16.3	406.4
1969	9.1	181.7	33.2	358.2	19.0	423.0
1970	18.7	179.1	30.8	359.2	26.9	455.0
1971	14.2	198.1	25.6	293.2	27.2	420.0

[1] United States only.

TECHNOLOGY

In the design of new abrasives, the important abrasive grain properties of hardness and toughness must be related. Structural and chemical factors affect grinding that must be related to the properties.[25]

An overview of the abrasive industry, worldwide, was presented in three magazine articles.[26]

A book was published on "Abrasive Materials Sciences."[27] Transmission electron microscopy provided direct evidence that plastic deformation occurs during the room-temperature indentation and abrasion of single-crystal and polycrystalline aluminum oxide.[28] The addition of a small percentage of vanadium to molten aluminum oxide resulted in a green-colored alloyed abrasive which has superior properties, according to the claims of its producers.[29]

The total number of patents on the materials used in abrasives and refractories was large, although most were aimed at improvements of existing materials and the machines that use abrasives and refractories. Numerous magazines and journals described new products, patents, and processes, of which the preceding excerpts are a sampling.

[25] Ueltz, Herbert F. G. New Developments in Abrasive Grain. Technical Paper MR 71-109, pres. at the meeting of the Society of Manufacturing Engineers, Philadelphia, Pa., April 1971.
[26] Industrial Minerals. An Introduction to Abrasives: Natural Gives Way to Synthetic. No. 45, June 1971, pp. 9–11. Diamond: pp. 13–28. Industrial Minerals. Abrasives: Uses Widening but Improved Quality Moderating Demand. No. 46, July 1971, pp. 9–28.
[27] Coes, L., Jr. Abrasives. Applied Mineralogy. V. 1. Springer-Verlag, New York, 1971.
[28] Hockey, Bernard J. Plastic Deformation of Aluminum Oxide by Indentation and Abrasion. J. of the Am. Ceramic Sec., v. 54, No. 5, May 1971, pp. 223–232.
[29] McKee, Richard L. Aluminum Oxide Alloy Improves Hard-Steel Grinding. Abrasive Eng., v. 17, No. 8 November/December 1971, pp. 26–27.
Staff. Grinding Industry Turns to Alloyed Abrasive. Iron Age, v. 28, No. 18, Oct. 28, 1971, pp. 48–49.

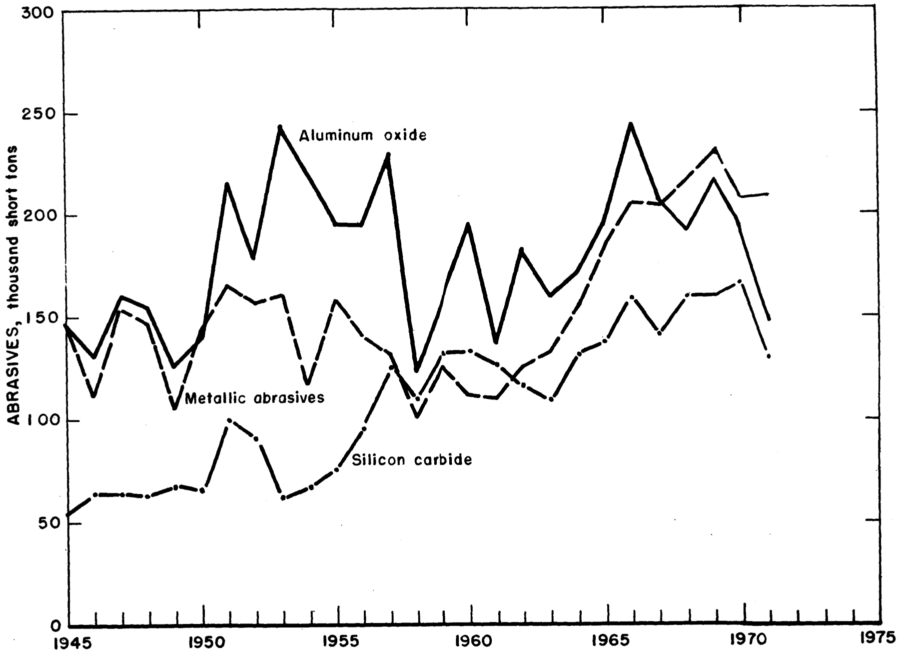

Figure 1.—Artificial Abrasives Production.

Aluminum

By John W. Stamper [1]

Demand for aluminum in the United States made a moderate recovery from the low consumption in 1970. However, the oversupply situation, which developed early in 1970, persisted throughout the year. Most of the larger domestic producers reduced operations in attempts to bring supply into balance with demand. The operating rate in the United States was 84 percent of yearend capacity.

Significant production cutbacks in The United States and Italy and slight increases in most other countries were offset by large increases in production in West Germany and Japan; on a world basis, production of primary aluminum outpaced demand. The operating rate in the rest of the world, excluding the United States, was 82 percent of yearend capacity.

Total world aluminum production capacity in 1971 was 13,686,000 short tons, an increase of 14 percent over world capacity in 1970 resulting from expansions at existing plants and to installation of new plants. The increases built into existing, privately owned plants throughout the world amounted to 620,000 tons in 1971 compared with 42,000 tons for plants that were partly or fully government-owned. The increase in world capacity due to new, privately owned plants was 919,000 tons compared with 68,000 tons for new plants which were partly or fully owned by government.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Primary production	3,269	3,255	3,793	3,976	3,925
Value	$1,614,483	$1,639,621	$2,013,403	$2,190,087	$2,154,443
Price: Ingot, average cents per pound	25.0	25.6	27.2	28.7	29.0
Secondary recovery	698	817	901	781	814
Exports (crude and semicrude)	366	351	575	612	293
Imports for consumption (crude and semicrude)	539	793	558	468	690
Consumption, apparent	4,009	4,663	4,710	4,519	5,074
World: Production	8,343	8,839	9,885	10,630	11,339

Legislation and Government Programs. —The Bureau of Domestic Commerce (BDC), U.S. Department of Commerce, established aluminum set-asides each quarter during 1971 to meet the estimated requirements of the Department of Defense, Atomic Energy Commission, National Aeronautics and Space Administration, and related defense programs. The set-aside for the year was 315,000 short tons, down from 455,000 tons in 1970 and 600,000 tons in 1969. Part of the reduction was due to the fact that orders for large civilian aircraft were not defense-rated after June 30, 1971.

Shipments of aluminum ingot by the General Services Administration totaled 22 tons.

DOMESTIC PRODUCTION

Primary.—Cutbacks in production rates at primary aluminum plants continued in 1971 and affected about 16 percent of yearend capacity as some producers attempted to adjust to an oversupply situation which had persisted since mid-1970. Despite the excess supply three new alumina reduction plants, on which construction had started before the oversupply had developed, began production during the year, adding 215,000 tons per year to the capacity. In addition, nine of the older plants were expanded by 195,000 tons per year. The substantial cutbacks by some producers were partly offset by the new or expanded output of other producers, and total production for the year was only 51,000 tons less than that of 1970. Some new plants did not reach full production until the latter part of the year, and some of the older plants were not cut back until late in the year; total production was also about 16 percent less than yearend capacity.

According to the Aluminum Co. of America (Alcoa) annual report for 1971, the year end production capacities at six of the company's eight reduction plants were decreased by nearly 245,000 tons. The Intalco Aluminum Corp. (Intalco) was operating with 14,000 tons of its annual capacity shut down. American Metal Climax, Inc., which owns 50 percent of the Intalco plant, postponed construction of a new reduction plant at Astoria, Oreg. The Anaconda Aluminum Co. shut down about 17,500 tons of its annual reduction capacity at Columbia Falls, Mont., in 1970 and continued to operate at about 90 percent of rated capacity during 1971.

Phelps Dodge Aluminum Products, a fully owned subsidiary of the Phelps Dodge Corp. and Consolidated Aluminum Corp. (Conalco), owned by Swiss Aluminium Ltd. (Alusuisse), were merged early in the year. The new firm, which offered a full line of industrial aluminum mill products from 21 plants in the United States, including two alumina reduction plants, retained the name of Conalco and was 60-percent owned by Alusuisse and 40-percent owned by Phelps Dodge. The new company's 35,000-ton-per-year reduction plant at Lake Charles, La., was brought into production early in the year. One potline with 35,000 tons-per-year capacity at the company's New Johnsonville, Tenn., reduction plant had been shut down since September 1970.

The new 110,000-ton-per-year reduction plant of Harvey Aluminum Inc. at Goldendale, Wash., was scheduled to start production in mid-1971, but output was not started until November.

Kaiser Aluminum & Chemical Corp. closed a 40,000-ton-per-year aluminum potline at its Ravenswood, W. Va., reduction plant at the end of October. The company increased its capacity to produce synthetic cryolite and aluminum fluoride, raw materials for the production of aluminum. Synthetic cryolite capacity at the company's Chalmette, La., plant was raised from 30,000 tons per year to 50,000 tons per year, and the aluminum fluoride plant at Gramercy, La., was doubled to 60,000 tons per year.

Initial production of primary aluminum at the 70,000-ton-per-year reduction plant of Noranda Aluminum Inc. at New Madrid, Mo., was started in February. The new plant had 174 reduction cells, each utilizing 145,000 amperes, in two pot rooms. The plant is designed for eventual expansion to 210,000 tons per year capacity. Electrical power was scheduled to come from a new 600,000-kilowatt generating plant nearby, which will be operated by the Associated Electric Cooperative of Springfield, Mo. The first stage of the power plant was expected to be completed in April 1972. The reduction plant was to use the local power grid until the new power became available.

Revere Copper & Brass, Inc., through its subsidiary, Revere Aluminum Building Products, Inc., purchased U.S. Aluminum and Chemical Corp., a producer of aluminum siding and other aluminum building products.

Late in the year Reynolds Metals Co. announced the closing of the two remaining potlines at its reduction plant at Troutdale, Oreg. This action along with other cutbacks at other plants, reduced the total yearend capacity of the company by 250,000 tons per year, representing about 26 percent of its total year end capacity.

Shieldalloy Corp. and Metallurg Alloy Corp., both subsidiaries of Metallurg, Inc., began construction of a plant in Newfield, N.J., to produce aluminum master alloys for use in the primary and secondary aluminum industries.

Secondary.—Despite improvement in aluminum semifabricating and fabricating operations during the year, consumption of new purchased aluminum scrap, which is generated during such operations, increased only slightly. The low level of purchased

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

(Short tons)

Quarter	1970 Production	1970 Shipments	1971 Production	1971 Shipments
First	978,914	980,640	974,951	973,036
Second	997,183	976,816	993,853	1,020,896
Third	993,222	939,720	988,669	965,082
Fourth	1,006,829	981,744	967,750	928,415
Total	3,976,148	3,878,920	3,925,223	3,887,429

new scrap used was offset by a marked increase in consumption of old aluminum scrap, the supply of which is essentially independent of current semifabricating and fabricating operations. Total consumption of purchased aluminum scrap increased about 3 percent during the year.

Recovery of secondary aluminum, calculated from industry reports, was 813,000 short tons, 4 percent above the 1970 level. Recovery of all metallic constituents from aluminum base scrap increased 5 percent to 876,000 tons.

The Bureau of Mines estimated that full coverage of the industry would indicate a total scrap consumption of 1,210,000 short tons in 1971. Based on full recovery, aluminum recovery totaled 943,000 short tons in 1971. Metallic recovery was estimated to be 1,050,000 short tons in 1971.

Table 3.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1970	1971 [p]
New scrap:		
Aluminum-base	[1] 635,357	[2] 645,219
Copper-base	107	83
Zinc-base	96	97
Magnesium-base	283	289
Total	635,843	645,688
Old scrap:		
Aluminum-base	[1] 144,869	[2] 167,316
Copper-base	59	50
Zinc-base	554	621
Magnesium-base	94	66
Total	145,576	168,053
Grand total	781,419	813,741

Form of recovery	1970	1971 [p]
As metal	70,873	85,265
Aluminum alloys	698,415	717,761
In brass and bronze	817	469
In zinc-base alloys	5,164	4,134
In magnesium alloys	783	881
In chemical compounds	5,367	5,231
Total	781,419	813,741

[p] Preliminary.
[1] Aluminum alloys recovered from aluminum-base scrap in 1970, including all constituents, were 668,400 tons from new scrap and 164,008 tons from old scrap and sweated pig, a total of 832, 408 tons.
[2] Aluminum alloys recovered from aluminum-base scrap in 1971, including all constituents, were 695,281 tons from new scrap and 180,297 tons from old scrap and sweated pig, a total of 875,578 tons.

Data on secondary aluminum obtained through a Bureau of Mines canvass were combined for publication with data made available to the Bureau by the Aluminum Smelters Research Institute (ASRI). ASRI covered operations of its members, which represented about 75 percent of the secondary aluminum industry.

The aluminum beverage can recycling programs of the three largest producers of primary aluminum, several beverage producers and others were expanded during the year resulting in the estimated collection of about 15,000 tons of all aluminum cans compared to about 6,000 tons of aluminum cans collected in 1970.

Early in 1971 Vulcan Materials Co. announced a $3 million expansion of the Oak Creek, Wis., secondary aluminum smelter of its A & M Division. The A & M Division produced secondary aluminum alloy ingot at plants in Hot Springs, Ark., and Corona, Calif., as well as at Oak Creek, and operated an aluminum extrusion billet plant at Sandusky, Ohio.

Sitkin Smelting & Refining Co. announced the closing of its secondary aluminum smelter at Buffalo, N.Y., which had been acquired in 1969. Reportedly, the company will continue to make some aluminum products, including notched bar, at its main plant in Lewiston, Pa.

Culp Smelting & Refining Co., a subsidiary of Culp Iron & Metal Co., began producing deoxidizing grades of secondary aluminum at a plant at Attalla, Ala., in July.

Table 4.—Primary aluminum production capacity in the United States, by company

(Thousand short tons)

Company and plant	Capacity at yearend		Ownership
	1970	1971	
Aluminum Company of America (Alcoa):			Self 100 percent.
Alcoa, Tenn	200	200	
Badin, N.C	100	115	
Evansville (Warrick), Ind	175	275	
Massena, N.Y	125	130	
Point Comfort, Tex	175	185	
Rockdale, Tex	275	280	
Vancouver, Wash	100	115	
Wenatchee, Wash	175	175	
Total	1,325	1,475	
Anaconda Aluminum Co.: Columbia Falls, Mont	175	180	Olin Corp. 50 percent; Revere Copper & Brass, Inc. 50 percent.
Consolidated Aluminum Corp. (Conalco):			Swiss Aluminum Ltd. 60 percent. Phelps Dodge Corporation, 40 percent.
Lake Charles, La	--	35	
New Johnsonville, Tenn	140	140	
Total	140	175	
Eastalco Aluminum Co.: Frederick, Md	r 87	87	Howmet Corp. 100 percent.
Harvey Aluminum Inc.:			Martin Marietta Corp. 87.2 percent.
The Dalles, Oreg	r 90	90	
Goldendale, Wash	--	110	
Total	r 90	200	
Intalco Aluminum Corp.: Ferndale (Bellingham), Wash	260	260	American Metal Climax, Inc. 50 percent; Howmet Corp. 50 percent.
Kaiser Aluminum & Chemical Corp.:			Self 100 percent.
Chalmette, La	260	260	
Mead, Wash	206	206	
Ravenswood, W. Va	163	163	
Tacoma, Wash	81	81	
Total	710	710	
National-Southwire Aluminum Co.: Hawesville, Ky	180	180	National Steel Corp. 50 percent; Southwire Co. 50 percent.
Noranda Aluminum Inc.: New Madrid, Mo	--	70	Noranda Mines, Limited 100 percent.
Ormet Corp.: Hannibal, Ohio	240	240	Olin Corp. 50 percent; Revere Copper & Brass, Inc. 50 percent.
Revere Copper & Brass Inc.: Scottsboro, Ala	112	112	Self 100 percent.
Reynolds Metals Co.:			Self 100 percent.
Arkadelphia, Ark	63	63	
Corpus Christi (San Patricio), Tex	111	111	
Jones Mills, Ark	122	122	
Listerhill (Sheffield), Ala	221	221	
Longview, Wash	r 190	200	
Massena, N.Y	128	128	
Troutdale, Oreg	100	130	
Total	r 935	975	
Total United States	r 4,254	4,664	

r Revised.

Table 5.—Stocks, receipts, and consumption of new and old aluminum scrap and sweated pig in the United States in 1971 [1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption [2]	Stocks Dec. 31
Secondary smelters: [3]				
New scrap:				
Solids:				
Segregated, lowcopper (Cu maximum, 0.4 percent)	3,445	124,375	121,934	5,886
Segregated, highcopper	647	14,813	14,606	854
Mixed, lowcopper (Cu maximum, 0.4 percent)	2,654	73,298	72,996	2,956
Highzinc (7000 series type)	379	6,210	6,253	336
Mixed clips	1,791	45,446	45,306	1,931
Borings and turnings:				
Lowcopper (Cu maximum, 0.4 percent)	W	W	W	W
Zinc, under 0.5 percent	W	W	W	W
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	1,062	40,840	40,213	1,689
Foil, dross, skimmings, other	12,117	100,536	95,256	17,397
Total new scrap [4]	25,451	472,065	463,363	34,153
Old scrap (solids)	6,893	118,360	118,402	6,851
Sweated pig (purchased for own use)	10,616	53,064	58,144	5,536
Total all classes	42,960	643,489	639,909	46,540
Primary producers, foundries, fabricators, chemical plants:				
New scrap:				
Solids:				
Segregated, lowcopper (Cu maximum, 0.4 percent)	2,748	155,027	153,586	4,189
Segregated, highcopper	44	4,688	4,686	46
Mixed, lowcopper (Cu maximum, 0.4 percent)	4,871	91,800	77,418	19,253
Highzinc, (7000 series type)	133	2,824	2,927	30
Mixed clips	48	6,548	6,522	74
Borings and turnings:				
Lowcopper (Cu maximum, 0.4 percent)	W	W	W	W
Zinc, under 0.5 percent	W	W	W	W
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	618	23,000	23,317	301
Foil, dross, skimmings, other	2,849	46,774	46,651	2,972
Total new scrap [4]	11,432	333,428	317,899	26,961
Old scrap (solids)	204	19,491	19,528	167
Sweated pig (purchased for own use)	3,822	28,567	27,442	4,947
Total all classes	15,458	381,486	364,869	32,075
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated, lowcopper (Cu maximum, 0.4 percent)	6,193	279,402	275,520	10,075
Segregated, highcopper	691	19,501	19,292	900
Mixed, low-copper (Cu maximum, 0.4 percent)	7,525	165,098	150,414	22,209
Highzinc (7000 series type)	512	9,034	9,180	366
Mixed clips	1,839	51,994	51,828	2,005
Borings and turnings:				
Lowcopper (Cu maximum, 0.4 percent)	408	10,711	10,612	507
Zinc, under 0.5 percent	600	21,489	21,336	753
Zinc, 0.5 to 1.0 percent	2,469	37,114	37,643	1,940
Other	1,680	63,840	63,530	1,990
Foil, dross, skimmings, other	14,966	147,310	141,907	20,369
Total new scrap	36,883	805,493	781,262	61,114
Old scrap, (solids)	7,097	137,851	137,930	7,018
Sweated pig (purchased for own use)	14,438	81,631	85,586	10,483
Total all classes	58,418	1,024,975	1,004,778	78,615

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

Table 6.—Production and shipments of secondary aluminum alloys, by independent smelters [1]

(Short tons)

	1970		1971	
	Production [2]	Shipments [2]	Production [2]	Shipments [2]
Pure aluminum (Al minimum, 97.0 percent)	70,873	70,626	85,265	85,772
Aluminum-silicon:				
95/5 Al-Si, 356, etc. (maximum Cu 0.6 percent)	16,907	16,750	18,236	18,023
13 percent Si, 360, etc. (maximum Cu 0.6 percent)	46,331	45,712	43,962	44,477
Aluminum-silicon (Cu 0.6 to 2 percent)	5,889	5,483	5,313	5,647
No. 12 and variations	8,512	8,623	6,649	6,196
Aluminum-copper (maximum Si, 1.5 percent)	817	752	469	535
No. 319 and variations	49,679	48,788	46,882	47,590
Nos. 122, 138	1,012	1,015	1,339	1,335
AXS-679 and variations	308,875	304,204	322,106	326,692
Aluminum-silicon-copper-nickel	17,508	17,444	16,741	16,320
Deoxidizing and other destructive uses:				
Grades 1 and 2	17,260	17,305	15,771	15,415
Grades 3 and 4	10,336	10,306	8,314	8,270
Aluminum-base hardeners	4,765	5,058	4,282	4,276
Aluminum-magnesium	783	780	881	848
Aluminum-zinc	5,164	4,708	4,134	4,346
Miscellaneous	24,109	24,114	26,113	26,315
Total	588,820	581,668	606,457	612,057

[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 15,655 and 16,137 tons of primary aluminum in 1970 and 1971, respectively, in producing secondary aluminum-base alloys.
[2] No allowance was made for consumption or receipts by producing plants.

CONSUMPTION

Following a sharp decline in the use of aluminum in 1970, consumption, as measured by shipments of aluminum ingot and mill products to domestic industries, increased about 10 percent in 1971, rebounding to a level that was slightly above the record set in 1969. Total shipments of aluminum products including exports increased only 3 percent over the total for 1970.

The Aluminum Association reported the following distribution of end-use shipments of aluminum products:

Industry	Percent of total 1970	Percent of total 1971
Building and construction	22.3	26.6
Transportation	15.3	17.2
Containers and packaging	14.5	14.5
Electrical	13.3	13.7
Consumer durables	9.2	9.3
Machinery and equipment	6.0	6.2
Other markets	7.9	7.1
Export	11.5	5.4
Total	100.0	100.0

A lower than normal increase in the container and packaging industry of 3 percent was sufficient to make it the third largest aluminum market for the second consecutive year. Chiefly because of a large rise in housing starts during the year the building and construction market, with a 23-percent increase, had the largest gain. The rise in the number of housing starts as well as substitution of aluminum for copper in wire conductors contributed to a modest increase in shipments to the electrical industry. Slow demand in the rest of the world resulted in a sharp drop in exports, and declining military demand caused a decrease in demand in miscellaneous markets.

The year 1971 marked the first full year of the availability of an aluminum framing system for use in place of wood construction. The new system, consisting of aluminum columns, beams, joists, studs, plates, and integral doors and windows, was developed by Alcoa. The initial success of the system was attributed to the willingness of builders to pioneer major innovations to be able to use a readily available building material with a stable price and uniform quality. Utilizing up to 2,800 pounds of aluminum in some single family units, the framing system also appeared to be easily adapted to construction of modular and component parts by mass production methods.[2]

[2] American Metal Market. Alcoa Forecasts Dramatic Surge in Building Systems Production. V. 79, No. 19, Jan. 27, 1972, p. 9.

Table 7.—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
1967	3,136,136	+174,723	128,504	569,247	4,008,610
1968	3,403,055	+443,464	154,711	662,197	4,663,427
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	+373,693	167,316	645,219	5,073,657

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

Automobile manufacturers continued to use aluminum engine blocks in Chevrolet Vega models and for air conditioning units, engine pistons, etc., in these and other cars. The estimated average use of aluminum per car built in 1971 was 72 pounds. A new type of engine, a Wankel (rotary) engine (after its inventor), could threaten the future use of aluminum and other metals in automobile engines and radiators because of its small size relative to its horsepower rating. It appeared likely that the Wankel engine would be utilized in domestic automobiles by the mid-1970's.[3]

In contrast to a very strong growth trend in recent years, demand for aluminum in containers and packaging applications gained only about 3 percent in 1971. The principal aluminum market in this sector of the economy was in beverage cans, which accounted for an estimated 60 percent of the total. Can ends, twist-off caps for bottles, flexible and formed packaging containers made from aluminum foil for use in the food packaging industry, accounted for most of the remainder.

Electrical uses of aluminum, which include some non-conducting applications such as towers for high-voltage transmission lines, increased about 5 percent. However, shipments of insulated and covered aluminum wire and cable increased about 22 percent, indicating a dramatic growth of aluminum as a conductor. The use of aluminum instead of copper for electrical feeder lines in the John F. Kennedy Center for the Performing Arts in Washington, D.C., reportedly saved $200,000 in material costs.[4]

The possible hazards involved with some applications of aluminum as an electrical conductor were discussed in a report. The problem apparently stemmed from the difficulty in making proper electrical connections between aluminum and aluminum, and aluminum and other metals such as copper.[5]

[3] American Metal Market. Wankel (rotary) Engine a Threat to Automotive Metals Producers. V. 78, No. 139, July 22, 1971, pp. 8, 18.
Williams, D. N. When Will the Wankel Make It? Iron Age, v. 207, No. 8, Feb. 25, 1971, pp. 57–59.
[4] Metals Week. JFK Center Chooses Aluminum Conductors. V. 42, No. 41, Oct. 11, 1971, p. 5.
[5] Metals Week. Aluminum Fire Hazard Examined. V. 42, No. 49, Dec. 6, 1971, p. 29.

Table 8.—Net shipments of aluminum wrought [1] and cast products by producers

(Short tons)

	1970	1971 p
Wrought products:		
Sheet, plate, foil	2,123,669	2,280,958
Rolled and continuous cast rod and bar; wire	r 379,689	498,968
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing and rolled structural shapes	r 840,962	1,005,556
Powder, flake, paste	102,268	83,762
Forgings (including impacts)	60,194	49,117
Total	r 3,506,782	3,918,361
Castings:		
Sand	r 99,813	96,434
Permanent mold	175,048	174,271
Die	470,964	513,112
Others	7,412	4,762
Total	r [2] 753,237	[2] 788,579
Grand total	r 4,260,019	4,706,940

p Preliminary. r Revised.
[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 percent.

Table 9.—Distribution of wrought products

(Percent)

	1970	1971 p
Sheet, plate, foil:		
Nonheat-treatable	47.0	48.1
Heat-treatable	3.0	2.7
Foil	7.6	7.5
Rolled and continuous cast rod and bar; wire:		
Rod, bar, etc	1.9	1.3
Bare wire, conductor and nonconductor	1.3	1.2
Bare cable (including steel-reinforced)	6.8	6.1
Wire and cable, insulated or covered	3.5	4.0
Extruded products:		
Rod and bar	.8	.7
Pipe and tubing	2.4	2.4
Shapes [1]	19.1	20.3
Tubing:		
Drawn	1.1	1.1
Welded, nonheat-treatable [2]	1.2	1.2
Powder, flake, paste:		
Atomized	2.3	1.7
Flaked	(3)	(3)
Paste	.3	.3
Powder, n.e.c.	.1	.2
Forgings (including impacts)	1.6	1.2
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 percent.

STOCKS

Reflecting the oversupply condition of the industry, stocks of primary aluminum ingot at reduction plants continued to rise in 1971 reaching 179,050 short tons at yearend, compared with 140,203 tons at the end of 1970. All producers of primary aluminum do not report stocks of aluminum metal at their reduction plants. However, the BDC reported that the total metal inventory held by the aluminum industry, which apparently includes stocks of all metal forms at reduction and other processing plants, was 2,510 thousand tons at the end of 1971, compared with 2,193 thousand tons (revised) at the end of 1970.

PRICES

The price for 99.5 percent primary aluminum ingot, quoted in the American Metal Market, remained unchanged in 1971 at 29 cents per pound. Because of the excess supply of aluminum, however, substantial discounting continued during the year with some metal reportedly being sold for as low as 21 cents per pound. Quoted prices for secondary aluminum ingot also remained unchanged during the year.

FOREIGN TRADE

Owing to low world demand for aluminum, total U.S. exports of aluminum, crude and semicrude products, declined to 293,393 tons, 52 percent below the 1970 level. The largest decline was in exports of aluminum ingot, slabs, and crude, which dropped from 408,452 tons in 1970 to 112,295 tons in 1971. Japan, Belgium-Luxembourg, and West Germany were the principal destinations of the ingot, slab, and crude aluminum.

The 10-percent ad valorem surcharge imposed on all dutiable imports of aluminum from August 16, 1971, to December 20, 1971, had no noticeable effect on the quantity of aluminum imported during the year, and in contrast to the drop in aluminum exports, U.S. imports increased markedly. Canada and Norway were the chief sources, which were mainly in the form of metal, alloys, and crude. Possibly because of the low level of total shipments of aluminum ingot and mill products relative to domestic demand for aluminum metal products (the source of most of the aluminum base scrap that is purchased), the United States became a net importer of aluminum base scrap for the first time in many years.

Table 10.—U.S. exports of aluminum, by class

Class	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	408,452	$214,780	112,295	$58,040
Scrap	r 57,087	r 20,923	30,675	9,995
Plates, sheets, bars, etc	r 137,764	r 106,989	141,061	111,787
Castings and forgings	3,438	9,068	3,561	8,245
Semifabricated forms, n.e.c	4,843	9,302	5,801	9,443
Total	r 611,584	r 361,062	293,393	197,510
Manufactures:				
Foil and leaf	6,648	10,990	8,295	11,892
Powders and pastes	3,078	3,088	1,741	1,646
Wire and cable	r 18,109	r 15,399	13,585	10,709
Total	r 27,835	r 29,477	23,621	24,247
Grand total	r 639,419	r 390,539	317,014	221,757

r Revised.

Table 11.—U.S. exports of aluminum, by class and country

Country	1970						1971					
	Ingots, slabs, crude		Plates, sheets, bars, etc. [1]		Scrap		Ingots, slabs, crude		Plates, sheets, bars, etc. [1]		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	28,841	$16,004	647	$989	2	$1	10,180	$5,472	148	$294	--	--
Australia	83	53	r 1,274	r 1,408	--	--	137	86	898	1,107	3	$1
Belgium-Luxembourg	33,203	16,170	276	493	1,422	559	13,175	5,634	160	325	221	67
Brazil	16,803	9,103	363	399	1	1	2,847	1,543	1,334	1,258	--	--
Canada	9,415	7,651	79,027	59,339	6,349	2,416	9,166	5,439	93,787	68,379	6,449	2,411
Chile	1,991	1,006	100	170	18	7	1,421	754	498	385	--	--
Colombia	12	16	463	404	1	(2)	4	5	186	226	2	2
El Salvador	1,188	648	674	446	--	--	842	483	515	330	--	--
France	72,408	36,166	999	1,197	1,797	744	3,829	1,937	658	1,065	185	65
Germany, West	55,711	29,365	6,351	7,071	23,800	8,677	11,705	6,203	7,727	9,939	10,755	3,257
Ghana	36	51	1,302	974	--	--	147	234	2,054	1,424	--	--
Hong Kong	5,196	2,604	85	103	11	4	413	216	86	109	35	8
India	2,455	1,293	41	59	--	--	9,625	4,611	236	273	--	--
Iran	1,509	755	208	220	--	--	3,145	1,601	72	122	--	--
Israel	3,907	2,093	1,214	1,589	--	--	829	471	720	1,000	--	--
Italy	23,262	12,524	2,537	3,737	10,861	4,109	1,590	1,348	3,318	5,648	2,201	647
Jamaica	33	26	556	510	4	3	27	28	194	273	12	4
Japan	71,470	35,617	1,629	3,083	5,460	1,824	14,132	7,087	2,029	2,757	5,539	1,722
Korea, Republic of	3,184	1,903	94	124	356	118	411	216	156	209	815	269
Mexico	203	110	10,241	7,436	23	5	202	100	4,433	3,494	219	26
Netherlands	4,935	2,279	1,696	2,356	555	207	638	460	3,548	3,956	408	140
New Zealand	1,536	881	104	151	--	--	919	510	162	210	--	--
Pakistan	551	252	804	618	--	--	352	195	993	685	--	--
Panama	1,087	585	170	201	--	--	985	521	250	332	2	1
Peru	1,117	601	85	132	320	175	568	305	158	142	941	503
Philippines	6,698	3,780	78	199	74	37	7,183	3,690	50	147	68	28
South Africa, Republic of	4,225	2,382	6,532	4,761	--	--	359	204	3,437	3,054	--	--
Spain	11	5	109	167	665	191	561	250	55	98	825	176
Sweden	2,412	1,289	3,297	2,696	202	89	922	595	933	981	50	17
Switzerland	1,463	872	324	332	61	25	588	321	263	347	--	--
Taiwan	10,199	5,239	78	106	r 1,839	r 388	2,914	1,402	204	270	297	78
Thailand	6,526	3,233	73	141	1	(2)	6,601	2,395	37	50	--	--
United Kingdom	16,835	8,564	13,283	12,112	2,445	995	886	573	11,906	11,036	821	288
Venezuela	78	86	1,091	1,355	10	5	59	74	1,725	1,701	3	1
Vietnam, South	--	--	3,719	2,461	--	--	33	17	25	38	--	--
Other	19,869	11,574	6,521	7,820	r 809	343	4,900	3,060	7,468	7,811	824	284
Total	408,452	214,780	r 146,045	r 125,359	r 57,087	r 20,923	112,295	58,040	150,423	129,475	30,675	9,995

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

Table 12.—U.S. imports for consumption of aluminum, by class

Class	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	350,060	$164,227	554,208	$257,473
Circles and disks	9,284	6,434	8,041	5,404
Plates, sheets, etc. n.e.c.	59,137	39,294	55,756	35,211
Rods and bars	10,239	8,108	7,147	5,087
Pipes, tubes, etc	2,234	2,419	1,845	1,789
Scrap	36,779	12,979	62,840	21,504
Total	467,733	233,461	689,837	326,468
Manufactures:				
Foil	14,067	14,209	12,912	14,271
Leaf (5.5 by 5.5 inches)	(1)	27	(1)	47
Flakes and powders	164	193	1,403	1,527
Wire	946	928	622	633
Total	15,177	15,357	14,937	16,478
Grand total	482,910	248,818	704,774	342,946

1 1970: 1,787,500 leaves and 51,944,636 square inches; 1971: 2,932,166 leaves and 41,431,436 square inches.

Table 13.—U.S. imports for consumption of aluminum, by class and country

Country	1970						1971					
	Metal and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metal and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	60	$27	242	$190	--	--	119	$54	166	$116	--	--
Austria	2	1	2,203	1,708	--	--	--	--	1,657	1,219	--	--
Belgium-Luxembourg	26	16	27,720	17,637	--	--	20	7	26,069	15,633	--	--
Canada	327,024	153,144	6,171	5,396	30,002	$10,372	440,861	201,265	6,773	5,309	34,221	$12,053
France	3	8	13,869	9,216	480	196	2,162	1,105	12,337	8,330	292	123
Germany, West	2	2	2,249	2,254	550	212	2	5	728	736	9,792	3,357
Greece	--	--	86	56	--	--	--	--	19	11	--	--
Italy	1	8	4,442	3,120	--	--	2	7	3,679	2,553	(2)	1
Japan	452	231	14,296	9,773	110	51	511	229	13,352	8,356	--	--
Norway	20,040	9,536	1,105	704	--	--	53,901	25,704	3	2	3,665	1,310
Poland	1,650	691	--	--	--	--	1,294	511	32	17	--	--
Spain	11	5	1,973	1,219	--	--	1,831	757	2,256	1,303	384	152
Sweden	--	--	16	25	--	--	60	21	280	202	430	168
Switzerland	--	--	96	104	--	--	1	4	224	190	383	130
United Kingdom	360	355	122	184	3,459	1,514	6,729	3,722	210	235	8,021	2,906
Venezuela	--	--	8	5	--	--	--	--	--	--	--	--
Yugoslavia	--	--	5,683	4,278	--	--	220	85	4,465	2,972	--	--
Other	429	203	613	386	2,178	634	46,495	23,997	539	307	5,652	1,304
Total	350,060	164,227	80,894	56,255	36,779	12,979	554,208	257,473	72,789	47,491	62,840	21,504

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

WORLD REVIEW

World production in 1971 increased about 6 percent, however, for the second consecutive year consumption did not increase as fast as output. In an effort to stabilize the regional aluminum market, a consortium of nine European bankers granted a $45 million credit to create Alufinance and Trade Ltd. Alufinance, which will be located on the British Island of Jersey, will purchase surplus aluminum from certain European companies at a price reportedly below official producers prices. The producers will repurchase the aluminum, as needed, at the original sale price. Alufinance initially extended its services to Péchiney, Vereinigte Aluminium-Werke AG (VAW), Gebrueder Giulini, Holland Aluminium, Montecatini-Edison, Alusuisse, British Aluminium, and Vereinigte Metallwerke Ranshofen-Berndorf. By yearend Alufinance reportedly had acquired about 90,000 tons of primary aluminum.

Algeria.—Approval was given for construction of an aluminum reduction plant, and work on the site near the Hassi-R'Mel-Arzen natural gas deposits reportedly began.

Table 14.—Aluminum: World Production by country [1]

(Thousand short tons)

Country	1969	1970	1971 p
North America:			
Canada	r 1,079	1,072	1,105
Mexico	36	37	44
United States	3,793	3,976	3,925
South America:			
Brazil	r 62	49	88
Surinam [2]	59	61	66
Venezuela	r 19	25	26
Europe:			
Austria	99	99	100
Czechoslovakia	[3] 35	[3] 34	e 34
France	410	420	423
Germany, East e	r 60	r 65	70
Germany, West	290	341	471
Greece	90	96	128
Hungary	71	73	74
Iceland	14	42	45
Italy	156	161	132
Netherlands	80	83	129
Norway	560	584	583
Poland [4]	107	109	110
Romania [5]	99	112	e 121
Spain	r 117	127	140
Sweden	74	73	83
Switzerland	85	101	104
U.S.S.R. e	r 1,160	r 1,212	1,300
United Kingdom	37	44	131
Yugoslavia	53	53	51
Africa:			
Cameroon	52	58	56
Ghana	125	125	122
South Africa, Republic of	--	--	22
Asia:			
Bahrain	--	--	12
China, People's Republic of	130	140	150
India	r 136	178	196
Japan [6]	627	808	985
Korea, Republic of (South)	7	17	19
Taiwan	24	30	29
Oceania:			
Australia	139	225	246
New Zealand	--	--	19
Total	r 9,885	10,630	11,339

e Estimate. p Preliminary. r Revised.
[1] Output of primary unalloyed ingot unless otherwise specified.
[2] Exports.
[3] Series revised to exclude secondary output; revised figures are reported primary production.
[4] Includes secondary.
[5] Includes alloys.
[6] Includes super-purity aluminum as follows in tons: 1969—4,183; 1970—5,409; 1971—6,472.

Table 15.—World producers of primary aluminum

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1971	Ownership
NORTH AMERICA		
Canada:		
Aluminium Company of Canada, Ltd.:		Alcan Aluminium Ltd., 100 percent.
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., Baie Comeau, Quebec	175	Reynolds Metals Co., 100 percent.
Total Canada	1,210	
Mexico: Aluminio, S.A. de C.V., Vera Cruz	44	Aluminum Co. of America, 44 percent; private Mexican interests, 56 percent.
United States: (see table 4)	4,664	
Total North America	5,918	
SOUTH AMERICA		
Brazil:		
Aluminio Minas Gerais, S.A:		Alcan Aluminium Ltd. 100 percent.
Saramenha, Minas Gerais	31	
Arutü, Bahia	11	
Cia. Brasileira de Aluminio S.A. (C.B.A.), Sorocaba, Saõ Paulo	44	Industria Votorantim, Ltd., 80 percent; Government, 20 percent.
Companhia Mineira de Aluminio, S.A., Poços de Caldas, Minas Gerais	27	Aluminum Co. of America, 50 percent; Hanna Mining Co., 23.5 percent; Minas Gerais State, 26.5 percent.
Total Brazil	113	
Surinam: Suriname Aluminium Co. (Suraloc), Paranam	73	Aluminum Co. of America, 100 percent.
Venezuela: Aluminio del Caroni, S.A. (Alcasa), Matanzas	25	Reynolds Metals Co., 50 percent; Government, 50 percent.
Total South America	211	
EUROPE		
Austria:		
Salzburger Aluminium G.m.b.H. (SAG), Lend, Salzburg	13	Alusuisse, 100 percent.
Vereinigte Metallwerke Ranshofen-Berndorf, A.G. (VMRB), Ranshofen, Braunau-am-Inn	88	Government, 100 percent.
Total Austria	101	
Czechoslovakia: Ziar Aluminium Works, Ziar-on-Hron	72	Government, 100 percent.
France:		
Compagnie Péchiney:		Péchiney, 100 percent.
Auzat, Ariége	22	
Chedde, Haute-Savoie	9	
La Praz, Savoie	4	
L'Argentiére, Haute-Alpes	42	
La Saussaz, Savoie	13	
Nogueres, Basses-Pyrénées	123	
Rioupéroux-Isére	26	
St. Jean de Maurienne-Savoie	89	
Sabart-Ariege	26	
Société d'Electrochemie, d'Electrometallurgie et des Acierels Electriques d'Ugine (Ugine):		Ugine-Kuhlman S.A., 100 percent.
Lannemezan-Haute Pyrénées	58	
Venthon-Savoie	28	
Total France	440	
Germany, East: Electrochemisches Kombinat:		Government, 100 percent.
Bitterfeld	55	
Lautawerk	33	
Total Germany, East	88	
Germany, West:		
Aluminium-Hütte Rheinfelden G.m.b.H., Rheinfelden, Baden	75	Alusuisse, 99.85 percent.
Vereinigte Aluminium-Werke A.G. (VAW):		Government, 100 percent.
Erftwerke, Grevenbroich	40	
Innwerke, Toging	77	
Lippenwerke, Lunen	55	

Table 15.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1971	Ownership
EUROPE—Continued		
Germany, West—Continued		
Norf, Rheinwerke	154	
Gebrueder Giulini G.m.b.H., Ludwigshafen	24	Gebrueder Giulini G.m.b.H., 100 percent.
Kaiser-Preussag Aluminium G.m.b.H., Voerde	71	Kaiser, 50 percent; Preussag A.G., 50 percent.
Leichtmetall G.m.b.H., Essen	139	Metallgesellschaft A.G., 50 percent; Alusuisse, 50 percent.
Total Germany, West	635	
Greece: Aluminium de Grèce S.A. (ADG), Distomon	160	Péchiney, 72 percent; Ugine, 18 percent; Government, 10 percent.
Hungary: Magyarsoviet Bauxite Ipar:		Government, 100 percent.
Ajka	19	
Inota	33	
Tatabanya	17	
Total Hungary	69	
Iceland: Icelandic Aluminium Co., Hafnarfjordur	49	Alusuisse, 100 percent.
Italy:		
Alcan Alluminio Italiano S.p.A.: Borgo-Franco d'Ivrea	6	Alcan Aluminium Ltd., 100 percent.
Montecatini-Edison S.p.A.:		Government, 11 percent; Montecatini Edison, 89 percent.
Bolzano	66	
Fusina	40	
Mori	26	
Societa Alluminio Veneto per Azioni S.p.A. (SAVA):		Alusuisse, 93.75 percent.
Fusina	33	
Portó Marghera	31	
Total Italy	202	
Netherlands:		
Aluminium Delfzijl N.V. (Aldel), Delfzijl	106	Hoogovens, 50 percent; Alusuisse, 33 percent; Billiton, 17 percent.
Péchiney Nederland N.V., Vlissingen (Flushing)	94	Péchiney 100 percent.
Total Netherlands	200	
Norway:		
Alnor A/S (Alnor), Karmay Island	115	Harvey, 49 percent; Norsk Hydro, 51 percent.
A/S Ardal og Sunndal Verk (ASV):		Government, 50 percent; Alcan, 50 percent.
Ardal	194	
Høyanger	33	
Sunndalsora	132	
Det Norske Nitridaktieselskap (DNN):		Alcan, 50 percent; British Aluminium, 50 percent.
Eydehavn	14	
Tysseldal	30	
Mosjøen Aluminiumverk A/S (Mosal), Mosjøen	95	Alcoa, 50 percent; Elkem, 50 percent.
Søer-Norge Aluminium A/S (Soral), Husnes	76	Alusuisse, 100 percent.
Lista Aluminiumverk A/S (Elkem), Lista	56	Alcoa, 50 percent, Elkem, 50 percent.
Total Norway	745	
Poland: Ministry of Heavy Industry:		Government, 100 percent.
Konin Works (1)	61	
Skawina Works	61	
Total Poland	122	
Romania:		
Slatina	112	Government, 100 percent.
Tarnaveni	13	
Total Romania	125	
Spain:		
Aluminio de Galicia, S.A. (Alugasa): La Coruna	50	Péchiney, 66 percent; Endasa, 17 percent; Government, 17 percent.
Sabinanego, Huesca	14	
Empresa Nacional del Aluminio, S.A. (ENDASA):		Government, 54 percent; Alcan, 25 percent; Spanish interests, 21 percent.
Aviles	60	
Valladolid	26	
Total Spain	150	
Sweden:		
A/B Svenska Aluminiumkompaniet (Sako), Sundsvall, Kubikenborg	95	Svenska Metallverken, 79 percent; Alcan, 21 percent.

Table 15.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1971	Ownership
Switzerland:		
Swiss Aluminium Ltd. (Alusuisse):		Alusuisse, 100 percent.
Chippis	30	
Steg	51	
Usine d'Aluminium Martigny, S.A., Martigny	12	Self, 100 percent.
Total Switzerland	93	
United Kingdom:		
The British Aluminium Co., Ltd. (Baco):		Tube Investments, Ltd., 49 percent; Reynolds Metals Co., 48 percent.
Kinlochleven, Scotland	12	
Lochaber (Ft. William), Scotland	28	
Invergordon, Scotland	112	
Anglesey Aluminium Ltd.:		Rio Tinto-Zinc Corp. Ltd. 43 percent; Kaiser Aluminum & Chemical Corp., 30 percent; British Insulated Callenders Cables Ltd., 27 percent.
Holyhead, New Wales, Scotland	112	
Total United Kingdom	264	
U.S.S.R.:		Government, 100 percent.
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	
Yugoslavia: Yogoslovenisk:		Government, 100 percent.
Kidricevo, Slovenia	55	
Lozovac	7	
Razine	4	
Titograd	55	
Total Yugoslavia	121	
Total Europe	5,309	
AFRICA		
Cameroon: Compagnie Camerounaise de l'Aluminium Péchiney-Ugine (Alucam), Edea	61	Péchiney, 48 percent; Ugine, 12 percent; Cobeal, 10 percent; Comal Cie, 30 percent.
Ghana: Volta Aluminium Corp. (Valco): Tema	162	Kaiser, 90 percent; Reynolds, 10 percent.
South Africa, Republic of: Alusaf (PTY) Ltd. Richards Bay	55	Aluminium Investment Co., 66.66 percent; Light Metal Investments Co., 33.34 percent.
Total Africa	278	
ASIA		
Bahrain: Aluminium Bahrain (ALBA)	66	Kaiser Aluminium, General Cables, British Metals, 17 percent each; Western Metals, 8.5 percent; Bretton Investments, 9.5 percent; Electro-Kopper, 12 percent; Bahrain Government, 19 percent.
China, Peoples Republic of: Twenty locations	210	Government, 100 percent.
India:		
Aluminium Corp. of India Ltd. (Alucoin), Asansol, West Bengal	10	Self, 100 percent.
Hindustan Aluminium Corp. Ltd. (Hindalco), Rennkoot, Uttar Pradesh	88	Kaiser, 27 percent; Birla and Indian interests, 73 percent.
Indian Aluminium Co. Ltd. (Indal):		Alcan, 65 percent; Indian interests, 35 percent.
Belgaum, Bombay	48	
Alupuram, Kerala	20	
Hirakud, Orissa	24	

Table 15.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1971	Ownership
ASIA—Continued		
India—Continued		
Madras Aluminium Co. Ltd. (Malco), Mettur, Madras	15	Montecatini Edison, 27 percent; Madras State Government, 73 percent.
Total India	205	
Japan:		
Mitsubishi Chemical Industries, Ltd., Naoestu	173	Self, 100 percent.
Sakaide	50	
Nippon Light Metal Co. Ltd. (NKK):		Alcan, 50 percent; Japanese interests, 50 percent.
Kambara	124	
Hokkaido (Tomakomai)	144	
Niigata	62	
Showa Denko K. K.:		Self, 100 percent.
Chiba 1	150	
Kitakata	47	
Omachi	46	
Sumitomo Chemical Co., Ltd.:		Self, 100 percent.
Isoura	84	
Kikumoto	26	
Nagoya	55	
Toyama	92	
Mitsui Aluminium Industry Co., Omuta	41	Self, 100 percent.
Total Japan	1,094	
Korea, Republic of: Korean Aluminum Co. (South Korea, Han Kuk), Ulsan	18	Korean interests, 100 percent.
Taiwan: Taiwan Aluminium Corp. (Taialco), Kaohsiung, Takao	42	Government, 100 percent.
Total Asia	1,635	
OCEANIA		
Australia:		
Alcan Australia, Ltd., Kurri-Kurri	50	Alcan, 80 percent; other interests, 20 percent.
Alcoa of Australia Pty. Ltd., Point Henry (Geelong)	99	Alcoa, 51 percent; Australian interests, 49 percent.
Comalco Industries Pty. Ltd., Bell Bay, Tasmania	104	Kaiser, 50 percent; Conzinc Rio Tinto of Australia, Ltd., 50 percent.
Total Australia	253	
New Zealand: New Zealand Aluminium Smelters Ltd, Bluff	82	Comalco Industries, Pty. Ltd., 50 percent; Sumitomo Chemical Co., 25 percent; Showa Denko K.K., 25 percent.
Total Oceania	335	
Total world	13,686	

Arab Republic of Egypt.—In November, the Arab Republic of Egypt and the U.S.S.R. reached a final agreement for the Soviet Union to design, build, and equip a 110,000-ton-per-year aluminum smelter at Nag Hammadi. The $126.5 million smelter will use 2 billion kilowatt hours of electricity annually, about one-fourth of the Aswan High Dam's annual output. The smelter, which was to be constructed in coordination with the expansion of the Red Sea port of Safaga and the new Nile port near Nag Hammadi, will be completed in 1974. About one-fourth of the smelter's output will be used to fill Egypt's domestic requirements with the remainder to be exported.

Argentina.—Construction began on the $113 million Futaleufu hydroelectric power station in the Andes foothills that is to provide electrical energy to the proposed aluminum smelter at Puerto Madryn. The $139 million smelter was scheduled to begin operations in 1974 with an annual capacity of 140,000 to 150,000 tons. The smelter was to be owned by Aluor S. A., which is 51-percent owned by Fate S. A., 24-percent by Argentine stockholders, and the Government of Argentina owns the other 1 percent. The remaining 24 percent of Aluor shares was offered to a number of large primary aluminum producers but had not been accepted by the end of 1971. Alumina for the smelter was expected to be supplied from Australia by Alcoa. Reports indicated that from 1974 through 1980, 50 percent of the imported alumina will be paid for with aluminum. The National Development Bank was to provide a loan of $183 million for the smelter, including requirements for working capital. An 85,000-ton-per-year anode plant was also part of the project. The Argentine Government approved the project and this financing will come exclusively from Argentina's public and private sources.

Australia.—During the year, Alcan Australia Ltd., completed the expansion of its Kurri-Kurri smelter in New South Wales to 50,000 tons per year. A further expansion to 100,000 tons per year was temporarily deferred because of the cancellation of a long-term contract with Kobe Steel Ltd. of Japan. The contract, which was to help in the financing of the expansion, included a loan of $15 million and the consumption of $27 million worth of the smelter's production during a 10-year period.

Comalco also completed an expansion program which raised the capacity of its 81,000-ton-per-year smelter at Bell Bay, to 104,000 tons per year.

Due to the depressed world aluminum market and poor Australian export prices, two of Australia's three primary aluminum producers reported cutbacks in production capacities. Alcoa of Australia Ltd. cut back 15 percent in September, and during December Comalco announced a production cutback of about 7 percent.

Bahrain.—Aluminium Bahrain Ltd. (ALBA) began initial production on May 10, 1971, and was scheduled to reach full capacity by mid-1972. Aluminum produced at the smelter was estimated to cost 21 cents per pound, which was later reduced to 14.5 cents per pound. The low cost was attributed to the low cost of fuel; however, the plant reportedly is not equipped with air pollution control equipment, which also would result in low costs.

Brazil.—In December 1971, Aluminio Minas Gerais, a subsidiary of Alcan Aluminium Ltd. of Canada, brought its new 11,000-ton-per-year smelter at Aratú into operation. The Aratú smelter, which was to reach full production early in 1972, together with a slight increase in capacity at the Saramenha smelter, raised the company's total rated capacity to 42,000 tons per year.

Canada.—Canadian Reynolds Metals Co., a subsidiary of Reynolds Metals Co., and Alcan Aluminium Ltd., (Alcan) Canada's only primary aluminum producers reported curtailments of production during 1971, equal to 19 percent and 14 percent of capacity, respectively. The two companies, with a combined capacity of 1,210,000 tons per year, implemented the cutbacks in order to bring production into closer balance with demand.

Alcan, with the assistance of the Canadian Trade Commissioner in Peking, made its first sale to China since the early 1960's. The 5,500 metric ton order was delivered from the Kitimat smelter to China via a Chinese freighter. Alcan received an estimated $435 per metric ton of metal.

Germany, West.—Production of primary metal increased markedly over the previous year as a result of new smelter operations and expansions at existing plants. However, total consumption, showing another poor year, increased only 1.5 percent, compared with 1.9 percent in 1970.

Leichtmetall G.m.b.H. (LMG) completed construction at its new 139,000-ton per-year smelter at Essen. Reports indicated the smelter's first two potlines, representing 93,000 tons per year capacity, were to start production in 1971. The third potline was to remain idle until marketing conditions improved.

Vereinigte Aluminium-Werke A.G. (VAW) raised capacity at its Rheinwerke smelter to 154,000 tons per year. Due to existing conditions in the aluminum industry the company delayed startup of the new capacity. Construction was underway at VAW's new 66,000 ton-per-year smelter at Stade Industrial Park near Hamburg, which was due for completion in 1973.

Gebrueder Giulini G.m.b.H. continued work on an expansion planned to double capacity at its 24,000-ton-per-year smelter at Ludwigshafen. Pilot production was to begin on the new pots by yearend 1972, with full production to be reached in 1973.

Kaiser-Preussag Aluminium G.m.b.H.'s 71,000-ton-per-year Voerde smelter, which was officially inaugurated in May 1970, started initial production in 1971. A second stage designed to double capacity was scheduled for completion in 1973.

Reynolds Aluminium-Werke Hamburg G.m.b.H. began construction of its fully integrated aluminum complex at Hamburg, including a 110,000-ton-per-year reduction plant that was scheduled for completion by late 1973. The complex will include facilities to produce sheet, plate, cans, diecastings, and other finished products.

Ghana.—Volta Aluminium Corp. (Valco) completed work on a new potline at its Tema reduction plant increasing capacity from 121,000 to 162,000 tons per year. Valco and the Volta River Authority established the Valco Fund at a special signing ceremony in Accra, during October 1971. Contributions by Valco of $100,000 each year will be used for the education and scientific benefit of the people of Ghana. Responsibility for administering the Valco Fund will rest with the managing trustees, none of which represent Valco or the Volta River Authority.

Greece.—Reports indicated Alcoa, was discussing with the Government of Greece the possibility of establishing a $300 million alumina-aluminum complex in Greece. The complex would produce 331,000 tons per year of alumina, using domestic bauxite, and 165,000 tons per year of aluminum. Apparently the final decision will depend on the Public Power Corp.'s approval to provide power at a rate of 4.5 to 5 mills per kilowatt hour.

India.—Indian Aluminium Co. Ltd. (Indal) raised the capacity of its Belgaum smelter from 33,000 tons per year to 48,000 tons per year. A further expansion of 28,000 tons per year was planned but remained subject to government approval.

Hindustan Aluminium Corp. Ltd., (Hindalco), continued work on an expansion program aimed at raising capacity at its Rennkoot aluminum smelter to 132,000 tons per year. Capacity at the smelter was to be increased in two stages of 22,000 tons per year each, the first of which was due for completion in March 1972, followed by the second in 1973.

The Aluminium Corp. of India, Ltd., (Alucoin), announced plans to increase capacity at its Asansol smelter to 15,000 tons per year. The company also revealed plans to construct a new 33,000-ton-per-year smelter at Rayagada in Arissa. The smelter was to be built in two stages, the first of which was scheduled to begin operations in 1974.

The Madras Aluminium Co. Ltd. completed expansion of its Mettur smelter to 15,000 tons per year. A further expansion plan called for the smelter's capacity to be raised to 28,000 tons per year by 1974.

Two aluminum complexes were under construction during the year, the first of India's publicly owned projects in the aluminum industry. The two projects, one to be located at Korba, the other at Koyna, were to be constructed by Bharat Aluminium Co. (Balco). The Korba project was to include a 22,000-ton-per-year alumina plant, to be built with the assistance of Chemokomplex of Hungary, and a 110,000-ton-per-year aluminum smelter, built with Russian aid. The alumina plant was scheduled for completion in July 1972, and the smelter was to be on stream, in part, by 1973–74. The Koyna project included plans for a 55,000-ton-per-year aluminum smelter and facilities to mine local bauxite and extract alumina. The smelter was to be commissioned in 1973–74 and reach full capacity by 1974–75.

Italy.—Sicily was selected for the location of a new $642 million aluminum smelter complex owned equally by Montecatini-Edison, S.p.A., Ente Nationale Idrocarburi and Ente Participazione Finanziamento Industria Manifattura (EFIM). The smelter portion of the project will be capable of producing 165,000 tons per year of aluminum ingot of which 110,000 tons will be converted on site into semifabricated products. The complex will also include a coal-fired power plant, a 600- to 700-megawatt nuclear plant, and facilities to produce primary magnesium and phosphorus. The complex was expected to provide employment for 4,000 workers when completed in 1975.

Alluminio Sardo-ALSAR, owned by EFIM-BREDA (68 percent) and Montecatini-Edison (32 percent), was to begin partial production in 1972 at its new Porto Vesme smelter. The smelter will have an initial capacity of 110,000 tons per year.

Japan.—Showa Denko K. K. announced a reduction of production capacity by 7 percent, and Nippon Light Metal Co. Ltd. reportedly cut back production by 9 percent. Nippon announced it would implement further cutbacks.

Capacity at Nippon's Tomakomai smelter on Hokkaido Island was increased by the addition of a second potline capable of producing 80,000 tons per year. Total capacity at Nippon's three smelters was about 330,000 tons at yearend, with planned expansions to 410,000 tons per year by 1973. Completion of the expansions planned for Nippon's Niigata smelter were delayed until 1972.

In March 1971, Sumitomo Chemical Co., Ltd. (Sumitomo), completed construction of a 92,000-ton-per-year aluminum smelter at Toyama, costing $51.4 million. Expansion plans were underway during the year to raise capacity by an additional 31,000 tons per year at a cost of $43.8 million. Planned capacity should reach 185,000 tons per year by April 1973. Sumitomo announced it would scrap the low-efficiency (32,500 ampere) cells at its Kikumoto smelter, leaving an estimated 26,000-ton-per-year capacity. Capabilities to produce super-purity metal at the Kikumoto smelter was increased to 5,500 tons per year. Sumitomo reported it had developed improved manufacturing technology, which enables a purity of up to 99.999 percent. Sumitomo revealed plans to build a new smelter to be located at Mibukawa, due to start production in 1974. The 101,000-ton-per-year smelter will use 160,000 ampere cells.

Mitsui Aluminum completed the first potline of its new 41,000-ton-per-year smelter at Omuta. A second potline, designed to double capacity was delayed until April 1972. Local government officials on the Island of Kyushu halted Mitsui's plans to construct a smelter there owing to environmental and economic reasons. Mitsui was considering constructing the planned $112 million smelter at another location. As originally planned, the 165,000-ton-per-year smelter was to be completed by 1975.

Alcoa cancelled plans to construct a 77,000-ton-per-year aluminum smelter on Okinawa. A spokesman for the Okinawa Aluminium Co., a joint venture of Mitsubishi Chemical Industries, Mitsui Aluminium, Nippon Light Metal, Showa Denko K. K., and Sumitomo Chemical, indicated that it was going ahead with plans to build by 1974 a 55,000-ton-per-year aluminum smelter and a thermal power plant on Okinawa.

Mitsubishi Chemical Industries, Ltd., completed installation of the first stage of its new 99,000-ton-per-year smelter at Sakaide. Startup of the 50,000-ton-per-year stage, which was originally scheduled for August 1971, began in October 1971.

Kobe Steel Works, Ltd., announced a plan to install a 110,000-ton-per-year aluminum smelter with construction due to begin in 1972. No location was reported. Sumitomo and Kobe Steel requested deferment of aluminum shipments from Alcan Aluminium Ltd. in order to cope with the existing slump in demand. Mitsubishi requested Alcoa to defer or cancel shipments of 4,000 tons of a 15,000-ton contract, agreed upon for delivery during the 1971–72 fiscal year. Alcan agreed to delay shipments scheduled for delivery by 55,000 tons.

Sumitomo Metal Industries and Sumitomo Light Metal Company revealed plans to form a joint company with shareholdings of 30 percent and 70 percent, respectively, for the purpose of building and operating a 33,000-ton-per-year smelter at Sakate. The smelter, which will cost an estimated Y30 million to Y50 million is scheduled to startup in October 1975, with capacity to reach 220,000 tons per year by 1978. Technical assistance was to be provided by Compagnie Péchiney, and the alumina was to be imported from Australia.

Mexico.—Marubeni Iida and Metalurgica Mexicana Peñoles SA announced plans to establish a $3 million aluminum fluoride plant at Torreon, with holdings of 40 percent and 60 percent, respectively. Shipments, due to start in 1974, will be aimed at the Japanese aluminum industry, which consumes an estimated 44,000 tons per year.

Netherlands.—Péchiney Nederland NV's Vlissingen smelter was officially opened in October 1971. Construction, which will increase capacity to 187,000 tons per year by 1973, was expected to be delayed. Reportedly, Aluminium Française will receive 85 percent of the smelter's output, and a subsidiary of Hunter-Douglas, will receive the remainder.

New Guinea.—A study was initiated to determine the feasibility of constructing a series of dams on the Purari River, to generate inexpensive electrical power for an aluminum smelter to be located at Papua. The proposed project was to be linked to the Ramu hydro project already under construction in the eastern highlands. The project also will include a deep water port on the Gulf of Carpentaria and a copper smelter.

New Zealand.—New Zealand Aluminium Smelters Ltd's. Bluff smelter, which poured its first aluminum in April, was officially opened in November 1971. Expansion of the smelter to 121,000 tons per year, originally due for completion in 1972, was delayed indefinitely at the opening ceremony due to existing economic conditions in the aluminum industry. Additional expansion problems were anticipated because of resistance by conservationists to the raising of the water level of Lake Manapouri, which would be necessary to increase hydroelectric power output for the smelter.

Norway.—A/S Ardal og Sunndal Verk (ASV) announced the completion of the first stage of its modernization program, which called for the rebuilding of Ardal's two oldest potlines and increase capacity by about 58,000 tons per year.

In June 1971 Lista Aluminiumverk's 56,000-ton-per-year smelter at Farsund was officially inaugurated. The new smelter, jointly owned by Alcoa and Elkem started actual production in January on a single line of 88 pots. The $46 million smelter uses an Alcoa process (see Technology) to remove close to 100 percent of the fluorine in the off-gases.

Norsk Hydro completed expansions of its Karmay Island smelter at year end 1971, raising capacity to 115,000 tons per year. Plans for a new 165,000-ton-per-year smelter at Glomfjord were under evaluation by Norsk Hydro. The project would require government approval and would be built in several stages.

Poland.—Production of aluminum fluoride was started at a new plant at Lubon near Poyman late in the year. Capacity was not reported, but the plant was expected to satisfy 40 percent of the domestic requirements by 1972 and might be expanded to meet the total domestic demand by 1974.

South Africa, Republic of.—Alusaf (Pty) Ltd.'s aluminum reduction plant at Richard's Bay, which began operating at full capacity in June, was officially opened in October. The 55,000-ton-per-year smelter used imported alumina from Europe throughout 1971. Starting in 1972, Alusaf will import alumina from Australia under the terms of a 20-year contract. The $84 million smelter was designed for an ultimate capacity of 330,000 tons per year.

Taiwan.—During the year, the State-owned Taiwan Aluminium Corp. (Talco) increased capacity at its only aluminum smelter to 42,000 tons per year. Further expansions, under a 4-year plan to begin in 1971, called for an increase to 77,000 tons per year by 1975.

United Kingdom.—Startup at Alcan (U.K.) Ltd.'s 132,000-ton-per-year aluminum smelter at Lynemouth was delayed due to disputes between contractors and trade unions involving the construction of a coal-fired power plant, which will supply power for the smelter. Startup was rescheduled for early in 1972.

British Aluminium Co. Ltd.'s (Baco) new $91.8 million aluminum smelter at Invergordon started production on its first potline but delayed startup of its second potline, which was due on stream in September 1971. Due to the delayed startup, rescheduled for 1972, and cutbacks in production at the Fort William smelter, Baco's output was about 21,000 tons short of that expected for 1971. Baco reported it intended to cut back about 10 percent of its entire labor force, about 1,000 workers, by mid-1972. Most of the layoff was to come from the closing of two rolling mills near Neath, Glamorgan.

On May 4, 1971, the Aluminium Powder Co., Ltd. (ALPOCO), started production at its 5,500-ton-per-year aluminum powder plant at Holyhead. The new plant, which is the largest of its kind in Europe, uses the atomizing process to manufacture aluminum powder. The plant uses molten aluminum provided by Anglesey Aluminium Ltd.'s new 112,000-ton-per-year smelter near Holyhead.

The Anglesey smelter was officially opened on June 25, 1971. The smelter's 308 pots consume about 240 megawatts of electrical power from the Wylfa Power Station, part of the national grid. The smelter has an ultimate design capacity of 280,000 tons per year.

U.S.S.R.—A Péchiney delegation was received in Moscow for negotiations concerning Péchiney's interest in supplying technology, engineering, and expertise for the building of a $500 million aluminum complex in central Siberia. Preliminary studies for the 441,000 to 551,000-ton-per-year aluminum smelter were completed, and the agreement provided for machinery and equipment to be supplied by other French firms. The complex would be built near the Syano-Shushenskaga Dam to insure availability of the large amounts of electrical power required to produce aluminum. The 640,000-kilowatt hydroelectric complex is to be completed in 1977.

Venezuela.—Aluminio del Caroni, S.A. (Alcasa), Venezuela's only primary aluminum producer, announced plans to double capacity at its Matanzas smelter to 50,000 tons per year. Alcasa, which is jointly owned by Corporación Venezolana de Guayana and Reynolds Metals Co., will finance the $24 million expansion with the aid of a $12 million loan from the Inter-American Development Bank.

Yugoslavia.—During the last quarter of 1971, initial production began at the Péchiney built aluminum smelter at Titograd. The new smelter has an annual capacity of 55,000 tons per year.

TECHNOLOGY

Considerable concern has been expressed in recent years by both industry and government representatives over a more effective utilization of secondary materials. In the metal industries secondary materials fall into two categories. New or prompt industrial scrap is scrap metal, dross, or slag that is generated in the production of semifabricated or fabricated aluminum products and includes such items as clippings, lathe turnings, and sheet trimmings. Such scrap may reenter the production cycle several times in a year. Old or obsolete scrap is metal that has been put into use in a variety of forms and returned to the production cycle in the form of wrecked aircraft or automobiles, worn out carburetors, and electrical conductors. Some old aluminum scrap may be in use 30 years before it is discarded, but some items like cans are discarded within a few months after being produced. In the aluminum industry another term, "sweated pig," is used to describe scrap metal (usually old scrap) that has been melted to separate it from the metals with higher melting points and to facilitate handling. Normally, sweated pig has to be further processed before it can be reused. The quantity of metal put into use in finished parts is believed to be at least equivalent to the amount of scrap that is generated in production.

Available data on the recovery and reuse of new scrap include only material that has been purchased, treated on toll, or imported, which possibly represents over one-half of the total new scrap generated. New scrap is generated by relatively few firms, and its composition is usually known. Consequently, 80 to 90 percent of all of the new scrap that is generated is recovered and reused in some form. Data on old scrap also includes only material that is purchased, treated on toll, or imported. However, it is believed that such reported data represent most of the old scrap that is recycled.

On this basis it is interesting to note that of the nearly 53 million tons of primary aluminum metal and old scrap that was put into use in crude form in the United States between 1940 and 1971, only about 3.6 million tons, or less than 7 percent, was old scrap. Assuming that only one-half of the crude metal was put into use in finished products, only 13 percent has been recovered as old scrap. Even on the assumptions that some finished products containing aluminum are exported, some are still in use and a large proportion of the aluminum put into use since 1940 was put there in recent years. It is apparent that recovery and reuse of aluminum from old scrap does not approach the efficiency of the recovery from new scrap.

In recent years the Bureau of Mines has emphasized research to increase the recovery of aluminum and other metals from secondary material. The Bureau operated a 1,000-pound-per-hour pilot plant for recovering old aluminum scrap and other metals and materials from municipal incinerator residues and estimated the investment and operating cost for plants of various sizes. The estimated value of the products produced from the residues was $15.76 per ton of residue treated. The Bureau estimated that satisfactory profits could be made if the value of the product was at least $10 per ton of residue. Capital costs ranged from $1.4 million for a plant capable of treating 250 tons of residue per 8-hour day to $1.7 million for a plant to treat 1,000 tons of residue in a 24-hour day.[6]

Under the current production and use system, most aluminum products that have worn out, broken, or otherwise become obsolete and are discarded apparently cannot be collected economically from the large number of consumers. Moreover, the aluminum parts in some finished end products are often contaminated with other materials such as plastics, oils, or lacquers, or they cannot be economically separated from adjoining parts made from other materials.

Although independent secondary aluminum smelters traditionally have recovered

[6] Henn, J. J., and F. A. Peters. Cost Evaluation of a Metal and Mineral Recovery Process for Treating Municipal Incinerator Residues. BuMines Inf. Circ. 8533, 1971, 41 pp.

most of the aluminum from old scrap that has been recycled, considerable effort by major primary producers and others was underway in 1971 to improve the collection and recycle of used aluminum cans.[7]

Adequate control of fluoride emissions from alumina reduction cells has been a major problem facing the aluminum industry for many years. Early attempts to recover and reuse the fluorine in cell off-gases and the efficiency, investment, and operating costs of several alternative systems, which have been developed through industry research programs, were discussed in a report.[8]

Emissions from an alumina reduction cell are largely carbon dioxide and some carbon monoxide, but they also contain gaseous hydrogen fluoride and particulates containing fluorine and alumina. According to the report, about one-half of the fluorine from the pots using prebaked anodes is in a gaseous form, and the rest is in a solid form.

The first control devices were water spray washers installed in roof vents of potlines to remove gaseous fluorides from the outgoing gases. These crude systems were gradually improved to remove as much as 65 percent of the fluorides evolved. Later methods incorporated more efficient gas collection systems, such as hooded cells. Following these developments, centrifugal and other mechanical systems and electrostatic precipitators to remove particulate matter more effectively came into use. The gases, essentially free of solids, were then passed through a water spray. With careful operation and good maintenance, this system removed 80 to 87 percent of the fluorides exhausted from the cells.

In most of the systems developed, the solid materials from the cell could easily be recycled into the reduction pots. However, the recovery and reuse of fluorides from wet systems was difficult and prohibitively expensive. To overcome these difficulties Alcoa researchers developed a dry process whereby the cell off-gases are passed through alumina, which absorbs most of the gaseous fluorides and entrains most of the solid particles. The alumina was then used as part of the normal feed to the cell thus recycling most of the fluoride and alumina from the off-gas. This process reportedly removed 99 percent of the fluoride that passed through the system. In a properly operated, well-hooded cell using prebaked anodes, 95 percent of the gases evolving from the cell reportedly were collected, resulting in an overall fluoride removal and recycle efficiency of up to 94 percent.

The first commercial installation of this dry system was at Alcoa's Badin, N. C., reduction plant in 1967. Since that time the company has installed 123 reactors at eight reduction plants, including three plants on vertical spike, soderberg-type cells. An additional 59 reactors were being designed or were under construction. According to the report, costs of fume control equipment were about one-eighth of the total invested capital in a reduction plant.

Lithium carbonate, which reportedly increases efficiency and reduces fluorine emissions from alumina reduction cells (by 20 to 30 percent for hydrogen fluoride gas emissions)[9], became available in pellet form during the year. The pellets, one-half inch in length and one-half inch in diameter, were priced at 50 cents per pound, delivered, for 500,000-pound minimum annual orders, and reportedly eliminated most losses of lithium from dusting. The aluminum industry continued rather large scale experiments with the long-term use of lithium.

The design and operation of two new alumina reduction plants were described.[10] The technology for the reduction plant of Aluminium Bahrain was provided by Montecatini-Edison S.p.A. of Italy. Prebaked anodes are used in the pots, which are about 30 feet in length, 10 feet in width and 5 feet deep. Each of the four pot rooms (two of which were completed) is about 2,100 feet in length, 75 feet wide, and 60 feet high and houses 114 pots arranged in two rows. Power is supplied by

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[7] American Metal Market. Sharp Acceleration Noted on Efforts to Recover All-Aluminum Beverage Cans. V. 78, No. 219, Nov. 16, 1971, p. 12.

[8] Andrews, Raynal W., Jr. Fluoride Recovery From Aluminum Reduction Cells. Proc. of a symp. on Technology for the Future to Control Industrial and Urban Wastes. Univ. of Mo.-Rolla. Continuing Education Series. 1971. pp. 113–115; available for consultation at Univ. of Missouri.

[9] Mizoguchi, K., and K. Yuhki. Appraisal of the Operation of Horizontal-Stud Cells With the Addition of Lithium Fluoride. Pres. at 100th Ann. Meeting, Light Metals Comm., Extractive Met. Div. The Met. Soc., AIME Proc., New York, Mar. 1-4, pp. 175–187.

[10] Metal Bulletin Monthly. A Second Look at ALBA:1. No. 11, November 1971, pp. 31–36.

——. Alcan at Lynemouth. No. 11, November 1971, pp. 10–12.

a 250-megawatt power station, which uses natural gas turbines. The facilities include an anode preparation and baking plant. All raw materials are imported, and berthing and unloading facilities were built on an island that was partially constructed from material excavated from the plant site. A water desalination plant also was constructed for plant use. The report indicated that at this plant fluorine and other gases from the pots are merely discharged into the atmosphere where prevailing winds blow them offshore over the Persian Gulf.

The new alumina reduction plant near Lynemouth, England, was designed by Alcan. Individual pots, 30 feet long and 14 feet wide, use prebaked anodes and were completely hooded to facilitate fume collection and recovery. In the first potline, gas cleaning is done by a system designed by Alcan that utilizes a wet scrubber with an efficiency of greater than 98 percent removal of the gaseous fluoride. The efficiency of this system in removing particulate fluorides was not reported but was said to be dependent on the number of gas scrubbing stages and the pressure drop across them. The wet scrubber effluent was discharged into the sea. Off-gases that escape into the pot room when the hoods were opened for servicing were discharged through covered stacks that were 250 feet high and 22 feet in diameter.

The Lynemouth smelter also was comprised of four pot rooms, each with about 84 pots. The cathode shell was heavily insulated. Busbar connections were organized in order to offset the various magnetic currents that disrupt the stability of metal pad. Power utilization of under 7 kilowatt hours per pound of metal was reported.

Antimony

By Charlie Wyche [1]

The domestic antimony industry in 1971 experienced a reversal of the upward trend in production of primary antimony initiated in 1967; the short supply of the past few years also ended. In the first 9 months of 1971 domestic sales were slow, as the acute scarcity of antimony in late 1969 and early 1970 plus the unusually high price which resulted, cost antimony several of its markets. Imports of antimony declined 27 percent during the year with decreases principally in the form of ores and oxide. Domestic mine production was 9 percent below the 1970 figure; smelter production and industrial consumption were also down. A firmer tone developed in the fourth quarter, which produced increased activity throughout the industry; however, this failed to offset the depressed market that prevailed during the three preceding quarters.

The price for RMM brand antimony metal, in bulk, f.o.b. Laredo, Tex., dropped 41 percent to 57 cents per pound during the year. The price of ore on the world market also trended downward. The European price range of lump ore, 60 percent antimony, declined from $12.50 to $15.40 per short ton unit in January to $8.64 to $10 at yearend. In addition to the sluggish domestic economy, price weakness was attributed to more active marketing by the People's Republic of China, one of the world's largest producers.

Legislation and Government Programs.—Effective January 1, 1971, "The General Modification of Tariff Schedules of the United States," Federal Register Document 67–14749, filed on December 18, 1967, reduced the import duty on antimony metal, TSUS No. 632.02, from 1.4 cents to 1.2 cents per pound, and another reduction is scheduled for 1972.

Under Public Law 92–105, enacted August 11, 1971, the General Services Administration (GSA) was authorized to dispose of approximately 6,000 short tons of excess antimony from the national and the supplemental stockpiles. The total inventory of antimony in the national and supplemental stockpiles as of January 1, 1971, was 46,746 short tons. The stockpile objective established April 8, 1970, was 40,700 short tons. No stockpile disposals were made in 1971.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient antimony statistics

(Short tons)

	1967	1968	1969	1970	1971
United States:					
Production:					
Primary:					
Mine	892	856	938	1,130	1,025
Smelter [1]	12,466	12,489	13,203	13,381	11,374
Secondary	23,664	23,699	23,840	21,424	20,917
Exports of ore, metal and alloys	82	109	207	543	1,023
Imports, general (antimony content)	17,419	17,343	17,032	18,654	13,595
Consumption [1]	17,350	18,520	17,843	13,937	13,707
Price: New York, average cents per pound	45.75	45.75	57.57	144.19	71.18
World: Production	63,565	67,628	73,001	75,618	70,161

[1] Includes primary antimony content of antimonial lead produced at primary lead refineries.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic production from antimony ores and concentrates and coproduct antimony concentrates from silver mine production declined 9 percent to 1,025 short tons in 1971. In addition 828 tons of byproduct antimony was recovered at primary lead smelters from domestic lead ores. Most of this antimony was not recovered directly but was consumed in the production of antimonial lead.

Sunshine Mining Co.'s new and larger electrolytic plant was the predominant source of antimony, accounting for 83 percent of total mine production. This fully equipped plant is situated on the Sunshine mine property in the Coeur d'Alene mine district, near Kellogg, Idaho. Production capacity was increased to about 2,500 short tons of antimony metal per year. Antimony was recovered from tetrahedrite concentrates mined by Sunshine and from antimony-bearing ores obtained from other companies.

The U.S. Antimony Corp. continued development of its Stibnite mine in Montana. More than 700 feet of drifting and raising was completed during the year to provide access to ore reserves. Work began on a refinery to produce a high-purity metal from the sulfide concentrates. Concentrate shipments on a regular basis began in September. By the end of November production was up to 60 tons of concentrates, or more than 33 tons of contained metal per month. The overall mill recovery was increased from less than 40 percent to more than 75 percent.

The only other source of domestic mine production was a small tonnage of antimony in concentrates produced at a mine in Nevada. This material was consigned to the Laredo, Tex., smelter of NL Industries, Inc.

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate (Quantity)	Antimony	
		Produced	Shipped
1967	5,402	892	828
1968	5,263	856	941
1969	5,707	938	943
1970	6,681	1,130	1,029
1971	4,721	1,025	1,073

SMELTER PRODUCTION

Primary.—Primary smelter production of antimony was 11,374 short tons, 15 percent less than that of 1970. Foreign antimony ore and concentrates supplied 83 percent of the primary feed material for smelter production. In addition 9 percent came from domestic mine ore, chiefly as a coproduct of silver ores, and 8 percent as a byproduct of domestic lead ores. Most of the byproduct antimony recovered at primary lead smelters was consumed at the smelter in the manufacturing of antimonial lead; the remainder was processed to oxide or recycled in residues.

Primary smelter output consisted of the following: metal, 34 percent; oxide, 55 percent; antimonial lead, 10 percent; and sulfide and residues, 1 percent. Antimony metal was produced by NL Industries, Inc., at Laredo, Tex., and Sunshine Mining Co., Big Creek, Idaho. McGean Chemical Co., Harshaw Chemical Co., and M & T Chemicals Inc. were the principal producers of antimony oxide. Byproduct antimonial lead was produced by Bunker Hill Co., American Smelting and Refining Co., St. Joe Minerals Corp., and U.S. Smelting Lead Refinery, Inc. McGean Chemical Co. and Hummel Chemical Co. produced antimony sulfide.

Secondary.—Secondary antimony recovered from secondary sources decreased from 21,424 tons in 1970 to 20,917 tons in 1971. Of this total, 20,150 tons was recovered by secondary smelters, 59 tons by primary smelters, and manufacturers and foundries recovered the remaining 708 tons. Antimony obtained from old scrap represented 84 percent of the total secondary production and was divided as follows: Batteries, 69 percent; type metal, 15 percent; babbitt, 5 percent; and miscellaneous material, 11 percent. New scrap consisting of residues and drosses resulting from manufacturing and casting, amounted to 3,342 tons, or 16 percent of the total. Processed secondary antimony is usually consumed commercially as antimonial lead. Because the antimony content in secondary sources is normally insufficient to meet the commercial specifications of antimonial lead alloys, 2,850 tons of primary antimony was required to augment the secondary antimony during 1971, compared with 2,465 tons in 1970.

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	
1967	4,002	6,612	71	249	1,532	12,466
1968	3,617	6,518	133	417	1,804	12,489
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

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1970	1971	Form of recovery	1970	1971
New scrap:			In antimonial lead [1]	16,002	15,839
Lead-base	2,761	3,269	In other lead alloys	5,412	5,067
Tin-base	48	73	In tin-base alloys	10	11
Total	2,809	3,342	Total	21,424	20,917
			Value (millions)	$61.8	$29.8
Old scrap:					
Lead-base	18,596	17,550			
Tin-base	19	25			
Total	18,615	17,575			
Grand total	21,424	20,917			

[1] Includes 203 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1970 and 59 tons in 1971.

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
1967	18,608	983	549	185	1,717	9.2
1968	28,363	1,300	504	203	2,007	7.1
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

[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

Domestic consumption of primary and secondary antimony in 1971 totaled 34,624 tons, a decline of nearly 2 percent from the 35,361 tons consumed in 1970. Primary antimony comprised 40 percent of the total (13,707 tons), and secondary metal was 60 percent (20,917 tons). Nearly all of the secondary antimony was consumed in the manufacture of antimonial lead and other hard-lead alloys.

Total consumption of primary antimony decreased in 1971 about 2 percent compared with that of 1970. However, requirements for metal products did show a slight increase. The quantity of antimony used in nonmetal products dropped nearly 300 tons, resulting mainly from a decline for use in flameproofing chemicals and compounds. Increases were reported for ceramics and glass, plastics, and rubber products. Of the nearly 800 tons classified under "Other" nonmetal products, about 52 percent was used as sodium antimonate. This antimony compound is used as an opacifier in enamel frits, to add hardness and increase acid resistance. Approximately 23 percent was consumed as antimony chloride (penta- and trichloride), and the remaining 25 percent was used in other industrial applications.

Table 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1967	312	5,666	9,514	77	249	1,532	17,350
1968	299	6,561	9,363	75	418	1,804	18,520
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

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1967	1968	1969	1970	1971
METAL PRODUCTS					
Ammunition	209	156	115	102	67
Antimonial lead	5,539	6,817	6,723	5,246	5,430
Bearing metal and bearings	653	755	758	481	515
Cable covering	141	178	55	38	36
Castings	54	46	33	16	20
Collapsible tubes and foil	31	50	56	35	22
Sheet and pipe	118	105	105	77	74
Solder	184	255	242	286	178
Type metal	382	423	541	220	177
Other	223	258	137	73	102
Total	7,534	9,043	8,765	6,574	6,621
NONMETAL PRODUCTS					
Ammunition primers	30	33	37	27	23
Fireworks	43	37	30	17	4
Flameproofing chemicals and compounds	3,454	2,774	2,096	r 1,774	1,524
Ceramics and glass	1,884	2,037	2,108	1,820	1,840
Pigments	665	859	722	610	592
Plastics	1,785	2,318	2,558	1,667	1,810
Rubber products	948	440	433	519	525
Other	1,007	979	1,094	r 929	768
Total	9,816	9,477	9,078	7,363	7,086
Grand total	17,350	18,520	17,843	13,937	13,707

r Revised.

STOCKS

Industrial stocks of primary antimony declined 2 percent to 8,637 tons at yearend. Although ore and concentrate stocks were the highest in 20 years, all other stocks were below the 1970 level. Government stocks of antimony metal totaled 46,746 tons at the close of 1971. Of the total inventory, the strategic stockpile contained 24,716 tons and the supplemental stockpile contained 22,030 tons.

Table 8.—Industry stocks of primary antimony in the United States, December 31
(Short tons, antimony content)

Stocks	1967	1968	1969	1970	1971
Ore and concentrate	2,469	2,791	2,227	2,973	3,582
Metal	1,719	1,323	1,273	1,598	1,367
Oxide	2,704	1,921	2,053	2,932	2,697
Sulfide	80	127	108	39	22
Residues and slags	916	199	307	948	647
Antimonial lead [1]	462	265	371	357	322
Total	8,350	6,626	6,339	8,847	8,637

[1] Inventories from primary sources at primary lead refineries only.

PRICES

The oversupply of primary antimony metal in both the United States and foreign areas, coupled with weak demand, was reflected in declining prices of domestic and imported antimony materials. The domestic price of antimony metal, 99.5 percent RMM brand, f.o.b., Laredo, Tex., was 96 cents per pound at the beginning of 1971. In March the price was reduced to 79 cents, in May to 68 cents, and in July to 57 cents per pound, remaining unchanged to yearend. Until November the price of the "Lone Star" brand (99.8 percent) was 1 cent per pound more than the RMM brand. In November, however, NL Industries, Inc., raised the price of "Lone Star" to 68 cents, creating an 11-cents per pound spread between the two brands. Antimony oxide was $1 per pound in carload lots in January but was reduced to 77 cents by yearend.

The European price of lump ore also continued the downward trend. The quoted price of 60 percent lump ore at New York was $12.50 to $15.40 per short ton unit at the beginning of the year. The price was quoted in the $11.34 to $14.06 range in April and in the range of $8.64 to $10 at midyear through December. The dealer price for imported metal, duty paid, New York, fell from 95 cents per pound at the beginning of the year to 52 cents in July but ended the year at 57 cents.

Table 9.—Antimony price ranges in 1971

Type of antimony	Price, per pound
Domestic metal [1]	$0.57–0.96
Foreign metal [2]	.52– .95
Antimony trioxide [3]	.77–1.00

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in Metals Week.

FOREIGN TRADE

Antimony exports—alloys, metal, scrap, and waste—totaled 1,023 tons, about twice that of 1970. The total value of the exported material, however, was $760,879, an increase of only one-third compared with that of 1970. Of the 21 countries that imported metal, scrap, waste, and alloys, France, West Germany, Belgium, and Japan, in declining order of receipts, accounted for over 78 percent of the total. The quantity of antimony oxide exported dropped to 142 tons, which was considerably below the 435 tons exported in 1970; oxide exports were valued at $200,576. Consignments were made to 15 countries. Canada was the leading importer with 107 tons, followed by Mexico with 20 tons. The balance was divided among 13 other countries.

General imports of antimony in all forms decreased from 18,654 tons in 1970 to 13,595 tons in 1971. Imports in the two largest categories, ore and oxide, decreased 30 percent and 34 percent, respectively. The decline in gross weight of 12,300 tons as ore and concentrates resulted from large cutbacks in receipts from the Republic of South Africa, Mexico, Bolivia, and Guatemala. Increased shipments from Mozambique, Chile, and the United Kingdom failed to offset decreases from the major suppliers. Japan, Mexico, and Yugoslavia were the major suppliers of imported metal (64 percent). The United Kingdom, France, and Belgium-Luxembourg were the major suppliers of oxide (85 percent).

An additional 270 tons of alloy containing 83 percent or more of antimony by weight was imported, 76 percent of which came from the United Kingdom and Mexico; 32 tons came from Turkey; and 11 tons was received from Thailand; 32 tons of antimony sulfide was supplied by Belgium-Luxembourg; 22 tons of antimony tartrate was received from Japan. Total value of these materials was $344,843.

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

Country	1970			1971		
	Short tons (gross weight)	Short tons (antimony content)	Value (thousands)	Short tons (gross weight)	Short tons (antimony content)	Value (thousands)
Antimony ore:						
Australia	--	--	--	54	36	$41
Bolivia	3,565	2,162	$4,415	2,610	1,593	2,131
Canada	21	7	8	22	10	9
Chile	96	42	70	489	311	537
Colombia	13	5	7	--	--	--
Ecuador	30	14	21	--	--	--
Guatemala	2,502	1,244	254	1,230	615	134
Honduras	981	367	151	296	118	44
Mexico	16,799	3,666	1,840	9,540	2,314	847
Morocco	112	50	124	229	103	63
Mozambique	--	--	--	679	402	478
Peru	14	6	10	69	34	16
South Africa, Republic of	10,242	6,239	5,789	6,400	3,826	4,273
Thailand	35	14	38	143	92	100
United Kingdom	5	4	6	341	165	114
Total	34,415	13,820	12,733	22,102	9,619	8,787
Antimony metal including needle or liquated [1]:						
Argentina	74	--	75	--	--	--
Belgium-Luxembourg	83	--	408	175	--	231
Bolivia	24	--	21	10	--	9
Canada	1	--	31	(2)	--	26
Chile	10	--	43	--	--	--
China, Peoples Republic of	--	--	--	16	--	17
Czechoslovakia	--	--	--	2	--	2
France	45	--	248	65	--	87
Germany, West	(2)	--	17	11	--	14
Italy	58	--	181	17	--	18
Japan	95	--	191	649	--	796
Malaysia Republic	--	--	--	17	--	17
Mexico	377	--	565	233	--	149
Netherlands	34	--	67	11	--	7
Spain	18	--	65	11	--	13
Taiwan	--	--	--	63	--	68
Thailand	39	--	93	77	--	101
Turkey	33	--	213	32	--	28
United Kingdom	317	--	942	88	--	136
Yugoslavia	100	--	387	193	--	242
Total	1,308	(3)	3,547	1,670	(3)	1,961
Antimony oxide:						
Belgium-Luxembourg	258	--	1,031	439	--	569
Canada	--	--	--	1	--	1
France	984	--	2,669	692	--	1,047
Germany, West	62	--	217	50	--	59
Japan	75	--	304	330	--	552
Netherlands	--	--	--	47	--	66
Switzerland	(2)	--	(2)	--	--	--
United Kingdom	2,877	--	5,802	1,232	--	2,023
Total	4,256	(3)	10,023	2,791	(3)	4,317

[1] Includes needle or liquated (value in thousands) 1970—Belgium-Luxembourg 3 tons ($8), United Kingdom 15 tons ($46); 1971—Belgium-Luxembourg 32 tons ($47). Does not include alloy containing 83 percent or more of antimony.

[2] Less than ½ unit.

[3] Content not reported.

Table 11.—U.S. imports for consumption of antimony

Year	Antimony ore			Needle or liquated		Antimony metal [1]		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)						
1969	24,158	12,098	$5,248	62	$51	980	$888	4,715	$3,852
1970	34,415	13,820	12,733	18	54	1,290	3,493	4,256	10,023
1971	22,102	9,619	8,787	32	47	1,638	1,914	2,791	4,317

[1] Does not include alloy containing 83 percent or more of antimony; 1969—Mexico 200 short tons ($185,533), Peru 95 short tons ($72,706), United Kingdom 100 short tons ($83,928), Turkey 16 short tons ($19,548); 1970—United Kingdom 179 short tons ($378,740), Turkey 18 short tons ($50,411), Japan 13 short tons ($31,346); United Kingdom 120 short tons ($120,093), Turkey 32 short tons ($29,022), Japan 22 short tons ($18,453), Mexico 85 short tons ($113,319), Thailand 11 short tons ($10,356).

WORLD REVIEW

The antimony industry in 1971 was characterized by an oversupply situation resulting from lack of consumer demand and from expanded free-world production brought on by high prices in the previous year. More active marketing by the People's Republic of China also contributed to driving the free antimony market prices down. The Chinese were willing sellers of antimony at the fall Canton Fair, and estimates of the tonnage involved ranged from 1,500 to over 4,000 tons.

Supply exceeded demand in all major consuming countries and industrial stocks were large here and abroad. Huge unsold stocks of antimony ore were built up by Consolidated Murchison Goldfields and Development Co. Ltd., Republic of South Africa, and in Bolivia. The Japanese also had a surplus. U.S.S.R., which is one of the largest buyers, was reported to have had such a surplus that it was exporting antimony to its satellite countries instead of importing.

Although prices dropped sharply in 1971, they were still above the May 1969 levels when the upward surge started. As a result, antimony producers around the world continued to build new facilities and expand existing ones. Increased production rates compared with those of 1970 were reported for eight foreign countries.

The Republic of South Africa and Japan expanded their antimony production facilities. In Australia, Silver Valley Minerals was studying the feasibility of erecting a smelter for the production of antimony metal and antimony trioxide. Its location was to be close to Hillgrove, New South Wales, where reserves of over 400,000 tons of stibnite were recently indicated. Although Australia is an important producer of antimony ore with an annual output of some 800,000 tons, it has only one small regulus producer. The Eleanora mine in New South Wales was officially opened in November, and the Smith's Lode was being developed. Australia's Antimony Corp. N.L. reported that extensive geological work in the Taylor's Arm district of New South Wales encountered further mineralization and found lode extensions in the Purgatory Creek and Flemings Ridge areas. In April, an agreement for the construction of an antimony smelter in Bolivia by a Czechoslovakian firm was finalized. The smelter will have an annual capacity of 5,500 tons of metallic antimony and 1,100 tons of antimony alloys.

In Canada, Consolidated Durham Mines and Resources Ltd. began full production at the Lake George Mine near Fredericton, New Brunswick. The Lake George Mine is designed to process 400 tons of ore per day and is expected to become the second largest producer of antimony concentrates in the Western World. Proven ore reserves now stand at 190,000 tons, grading between 5 and 6 percent antimony.

The Indian Government proposed building a second antimony smelter either at Tundoo in Bihar or at Udaipur in Rajasthan. The smelter was to have an initial capacity of 1,500 tons per year. India produced 600 tons of antimony in 1971 (all from imported ores and concentrates), and needed approximately 1,200 tons. Mineral Resources (N.Z.) Ltd. was investigating its antimony prospect at Endeavour Inlet, New Zealand. The company reported that it will establish grade and continuity of the ore to its lowest existing levels. Furthermore, old tailing dumps that contained a moderate grade of antimony, were being assessed.

Table 12.—World production (content of ore except where otherwise indicated) by country

(Short tons)

Country	1969	1970	1971 p
North America:			
Canada [1]	410	363	165
Guatemala	110	288	e 300
Honduras	125	378	160
Mexico [2]	3,555	4,925	e 3,500
United States	938	1,130	1,025
South America:			
Argentina	--	(3)	(3)
Bolivia [4]	14,481	12,970	12,861
Peru (recoverable) [2]	676	660	e 660
Europe:			
Austria (recoverable)	687	672	515
Czechoslovakia e	660	660	660
Italy	1,415	1,432	1,405
Portugal	1	--	--
Spain	133	88	e 130
U.S.S.R. e	7,300	7,400	7,600
Yugoslavia [5]	2,278	3,197	e 2,900
Africa:			
Algeria e	65	170	165
Morocco	1,551	2,175	2,116
South Africa, Republic of	20,080	19,147	15,704
Asia:			
Burma	66	72	141
China, Peoples' Republic of e	13,000	13,000	13,000
Japan	6	7	3
Korea, South	33	--	--
Pakistan e	--	33	55
Malaysia (Sarawak)	r 95	198	e 200
Thailand	827	2,598	2,529
Turkey	3,495	3,053	e 3,100
Oceania: Australia [6]	1,014	1,002	1,267
Total	r 73,001	75,618	70,161

e Estimate. p Preliminary. r Revised.
[1] Antimony content of smelter products.
[2] Includes antimony content of antimonial lead.
[3] Less than ½ unit.
[4] Data for 1969 represent exports by small and medium mines only (actual output data not available and no data for output or exports by COMIBOL); data for 1970 are the sum of exports by small and medium mines and COMIBOL output; data for 1971 reportedly represent total exports.
[5] Series revised to reflect mine production rather than metal output.
[6] Antimony content of antimony concentrates, lead concentrates and lead-zinc concentrates.

TECHNOLOGY

At College Park, Md., the U.S. Bureau of Mines developed a method for removing antimony from secondary lead by forming an insoluble aluminum-antimony intermetallic compound.[2] Optimum conditions for the formation of the aluminum-antimony compound in a lead alloy containing 2 percent antimony were established. These variables and their optimum conditions for antimony removal are: (1) Inert gas protective covering, (2) 820° C reaction temperature and 350° C filtration temperature, (3) 1.38 molar ratio of aluminum to antimony, (4) stirring for 15 minutes between 50 and 100 revolutions per minute, and (5) woven glass cloth filter medium. Tests performed under these conditions provided an overall recovery of 90 percent of the lead containing as low as 0.9 percent antimony.

Two recent British patents involving antimony were issued. One patent described a stagewise, fluidized-bed process in which ore is preroasted using a separate supply of a free oxygen-containing gas to volatilize the bulk of the antimony.[3] The pre-

[2] Amey, E. B., D. Montagna, D. A. Wilson and J. M. Marchello. Removal of Antimony from Lead—Two Percent Antimony Alloy. Secondary Raw Materials, v. 9, No. 5, May 1971, pp 71–74.
[3] Fabrik, A. G. (assigned to Badische Anilin & Soda). British Pat. 1,232,218, May 19, 1971.

roasted material is then fully roasted in a second stage with a separate supply of a free oxygen-containing gas. In the other patent, a process for fire refining of molten copper sulfide ores to produce high-grade copper while recovering antimony and other metals present in commercial amounts is described.[4]

The Electrochemical Branch, Naval Research Laboratory, in Washington, D.C., published a paper in which crystallization of $PbSO_4$ on anodes of lead-antimony alloys was evaluated.[5] The morphologies of crystals of $PbSO_4$ depositing on 5-percent antimonial lead alloy in 1.25 specific gravity H_2SO_4 were examined by electron microscopy. The crystals formed on open circuit stand and during discharge of PbO_2 coatings, developed by electrochemical cycling, were examined. Well-developed prisms, dendrites, and hopper crystals were observed. The discharge of the antimonial coatings appeared to be limited by the crystal growth rate.

The result of the investigations of the aluminum-antimony system[6] and the constitutions and solidification microstructures of some pure and impure lead-antimony-tin-arsenic alloys[7] were reported.

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[4] Queneau, P. E., and C. E. O'Neill (assigned to International Nickel Co.). British Pat. 1,218,-167, Jan. 6, 1971.

[5] Burbank, J. Crystallization of $PbSO_4$ on Anodes of Lead-Antimony Alloy. J. Electrochem. Soc., v. 118, No. 4, April 1971, pp. 525–530.

[6] Lyttel, J. E., P. V. Dembawski, and L. S. Castleman. Irregular Growth of AlSb in Solid Aluminum-Solid Antimony Diffusion Couples. Met. Trans., v. 2, No. 1, January 1971, pp. 303–304.

[7] Kerr, H. W. The Constitutions and Solidification Microstructures of Some Pure and Impure Lead-Antimony-Tin-Arsenic Alloys. J. Inst. of Metals, v. 99, August 1971, pp. 238–242.

Asbestos

By Robert A. Clifton [1]

Shipments of asbestos in the United States increased 4 percent to a record high in 1971. The abatement of the tight money market and easing of interest rates aided the home building industry and increased the demand for asbestos. Imports were 5 percent above 1970 levels.

The free world's largest producer, Canada, increased shipments to its largest market, the United States, but overall shipments were only 98 percent of the 1970 total.

Legislation and Government Programs.—Despite efforts to have it removed, asbestos was retained on the list of hazardous air pollutants, and the Environmental Protection Agency proposed operating techniques as standards. In 1971 the General Services Administration (GSA) reduced government inventories by disposing of 2,724 short tons of amosite, 5,875 tons of crocidolite, and 1,611 tons of chrysotile. The strategic grades of asbestos were removed by legislative act from the Rhodesian Sanctions.

[1] Chemist, Division of Nonmetallic Minerals.

Table 1.—Salient asbestos statistics

	1967	1968	1969	1970	1971
United States:					
Production (sales) short tons	123,189	120,690	125,936	125,314	130,882
Value thousand	$11,102	$10,406	$10,648	$10,696	$12,174
Exports and reexports (unmanufactured) short tons	47,718	41,236	36,173	46,585	53,678
Value thousands	$6,025	$4,679	$4,979	$6,996	$7,863
Exports and reexports of asbestos products (value) thousands	$23,767	$24,527	$28,183	$25,391	$31,419
Imports for consumption (unmanufactured) short tons	645,112	737,909	694,558	649,402	681,367
Value thousands	$65,743	$72,930	$76,422	$75,146	$80,090
Consumption, apparent [1] short tons	720,583	817,363	784,321	728,131	758,571
World: Production do	3,207,259	3,315,301	3,599,123	3,846,475	3,947,996

[1] Measured by quantity produced, plus imports, minus exports.

Table 2.—Stockpile objective and Government inventories as of December 31, 1971

(Short tons)

Mineral	Stockpile objective	Inventories			
		National	Supplemental	Defense Production Act	Total
Amosite	18,400	11,705	47,933	--	59,638
Chrysotile	13,700	6,079	6,572	242	12,893
Subspecification	--	20	1,688	242	1,950
Crocidolite	None	1,554	35,368	--	36,922

Environmental Impact.—The inclusion of asbestos on the list of hazardous air pollutants is beginning to effect the industry. One application, sprayed insulation, has been outlawed in several cities and States, and would be banned under proposed Environmental Protection Agency (EPA) regulations. There have been no serious losses of markets yet, except for talc that contains tremolite, but new markets are extremely slow in opening up.

The manufacturer not now having asbestos among his necessary raw materials is reluctant to purchase it because of very strict inspection and regulation of the working areas by the Labor Department Office of Safety and Health Administration (OSHA), and of plant effluents by EPA.

In 1971 asbestos workers in mines and mills were protected under the Metal and Nonmetal Health and Safety Act administered by the Bureau of Mines. The Bureau's inspectors were changing over from measuring all particulate matter using a particle impingement method and reporting in million particles per cubic foot, to using a membrane filter and microscopy method, and reporting in fibers longer than 5 microns per milliliter. The acceptable Threshold Limit Value (TLV) was five fibers per milliliter greater than 5 microns.

EPA was proposing regulations that would give it jurisdiction over any possible emission source to the ambient air. This would include all activity at the mine site and mill that occurs in the open, such as drilling, blasting, loading, hauling, etc. EPA stated that there is no suitable technique available for measuring asbestos emissions in ambient air; in lieu of specific standards, EPA proposed establishment of restrictions on operating techniques.

OSHA is using the membrane filter technique to check on the working conditions of the people using asbestos in product manufacture and applications. In 1971 its TLV was five fibers per milliliter greater than 5 microns. The National Institute for Occupational Safety and Health proposed a level of two fibers per milliliter greater than 5 microns.

The Clean Air Act gives the States jurisdiction over emissions of hazardous air pollutants, provided their regulations equal or exceed those proposed by EPA.

DOMESTIC PRODUCTION

U.S. mines produced 4 percent more asbestos in 1971 than in 1970. The value increased 14 percent. Four States produced asbestos; California, with 67 percent, was the leader, followed in order by Vermont, Arizona, and North Carolina.

Although 1971 saw the entire West Coast in the economic doldrums, the California segment of the asbestos industry continued to grow. The 10 percent increase in production to 87,144 tons was led by Pacific Asbestos Corp.'s mine in Calaveras County. The largest producing County was Fresno, with Coalinga Asbestos Co. and Atlas Asbestos Corp. mines. Union Carbide Corp. had very significant production in San Benito County. The State's increased production realized a $1,444,190 increase in value.

GAF Corp.'s mine in Orleans County, Vt., showed an apparent production decrease of 5 percent without an attendant loss in value. With only Jaquays Mining Corp.'s mine in Gila County operating in 1971, Arizona production decreased 11 percent. With a new production site in Transylvania County to go with their other two in Yancey and Jackson Counties, the production in North Carolina of Powhatan Mining Co. increased 11 percent. 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	do	Coalinga	Do.
Pacific Asbestos Corp	Calaveras	Pacific Asbestos	Do.
Union Carbide Corp	San Benito	Joe No. 5	Do.
North Carolina:			
Powhatan Mining Co	Yancey	Burnsville	Anthophyllite.
Do	Jackson	Boot Hill	Do.
Do	Transylvania	Rainey Knob	Do.
Vermont: GAF Corp	Orleans	Lowell	Chrysotile.

CONSUMPTION AND USES

There were literally thousands of direct and indirect uses for asbestos, but the major portion went to a few applications. Chief among these were asbestos cement building materials and asbestos cement pipe, which together used an estimated 70 percent of world production.[2] The domestic consumption picture differs somewhat: According to a survey done for a member of the Asbestos Information Association/North America in 1971, asbestos cement pipe and building products consumed 25 percent; floor tile, 18 percent; felts and papers, 14 percent; friction products, 10 percent; textiles, 3 percent; packing and gaskets, 3 percent; sprayed insulation, 2 percent; and miscellaneous 25 percent.

The upward trend of the building and construction industries resulted in an apparent consumption in 1971 that was 4 percent higher than that of 1970. Most of the asbestos consumed was chrysotile, which accounted for 97 percent of domestic consumption; amosite, crocidolite, and anthophyllite accounted for the remainder.

[2] Industrial Minerals (London). No. 28, January 1970, p. 12.

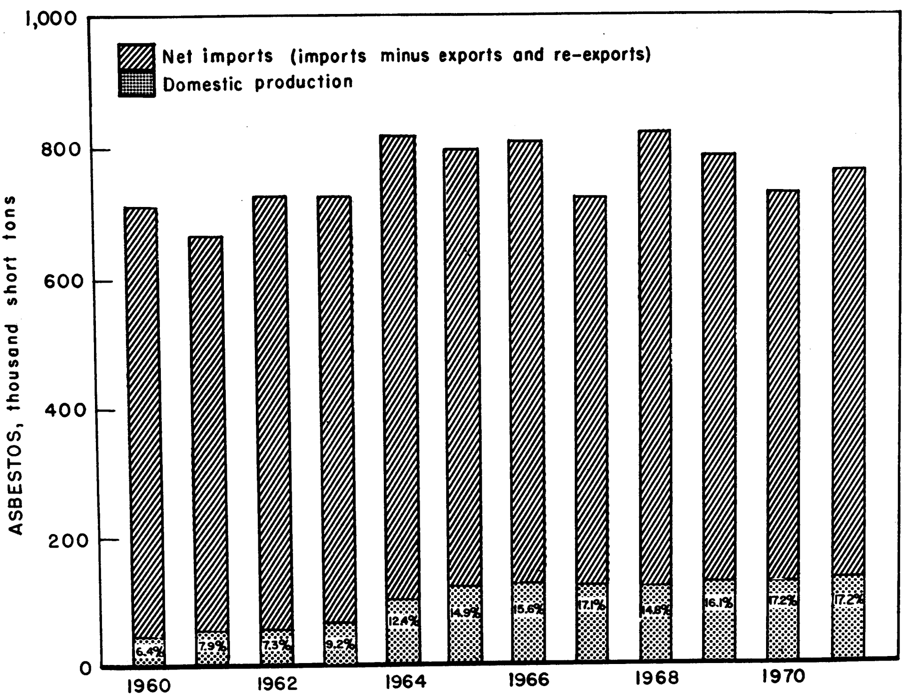

Figure 1.—Domestic consumption of asbestos.

PRICES [3]

Quoted prices for Quebec asbestos were increased 4 to 6 percent effective July 1, 1971. The increases were not abnormal in an inflationary economy, but the price of British Columbia and Arizona asbestos remained unchanged.

Prices for Arizona chrysotile asbestos have remained unchanged since August 1, 1968. Quotations, f.o.b. Globe, were as follows:

Grade	Description	Per short ton
Group No. 1	Crude	$1,410–1,650
Group No. 2	do	700– 950
AAA		800
Group No. 3	Nonferrous filtering and spinning.	425– 700
Group No. 4	Nonferrous plastic and filtering.	400– 500
Group No. 5	Plastic and filtering	385– 425
Group No. 6	Refuse or shorts	250
Group No. 7	do	65– 90

As of July 1, 1971, Vermont chrysotile asbestos, f.o.b. Morrisville, was priced as follows:

Grade	Description	Per short ton
Group No. 4	Shingle fiber	$220.00
Group No. 5	Paper fiber	159.50–187.50
Group No. 6	Waste, stucco or plaster fiber.	116.00
Group No. 7	Shorts and floats	43.50– 97.00

Quotations for Canadian (Quebec) chrysotile, f.o.b. mine, were as follows, as of July 1, 1971:

Grade	Description	Per short ton
Group No. 1	Crude	Can $1,615
Group No. 2	do	875
Group No. 3	Spinning fiber	412– 675
Group No. 4	Shingle fiber	227– 383
Group No. 5	Paper fiber	164– 195
Group No. 6	Waste, stucco or plaster.	120
Group No. 7	Refuse or shorts	52– 100

Prices for British Columbia, Canada, chrysotile asbestos have remained unchanged since January 1, 1971. Quotations, f.o.b. Vancouver, were as follows:

Grade	Description	Per short ton
AAA	Nonferrous spinning fiber.	Can$877
AA	do	697
A	do	529
AC	Asbestos cement fiber.	380
AK	Shingle fiber	263
CP	do	248
AS	do	228
CT	do	223
AX	do	208
CY	do	147
AY	do	147

Private negotiated sales are the African asbestos producers' modus operandi. As this rules out market quotations, the following are averages, regardless of grade, of the values of South African imports calculated from U.S. Department of Commerce Data:

Type	Per short ton		
	1969	1970	1971 [1]
Amosite	$153	$160	$164
Crocidolite	189	196	212
Chrysotile	192	198	120

[1] First 6-month data on exports, Department of Mines, Johannesburg.

Figure 2, drawn from calculations on pertinent data,[4] depicts dramatically that the increased demand and greater price increases have gone to the asbestos used in cement products (groups 5, 7).

[3] Asbestos. V. 53, No. 4, October 1971, p. 44.
[4] Industrial Minerals (London). No. 28, January 1970, pp. 9–29.

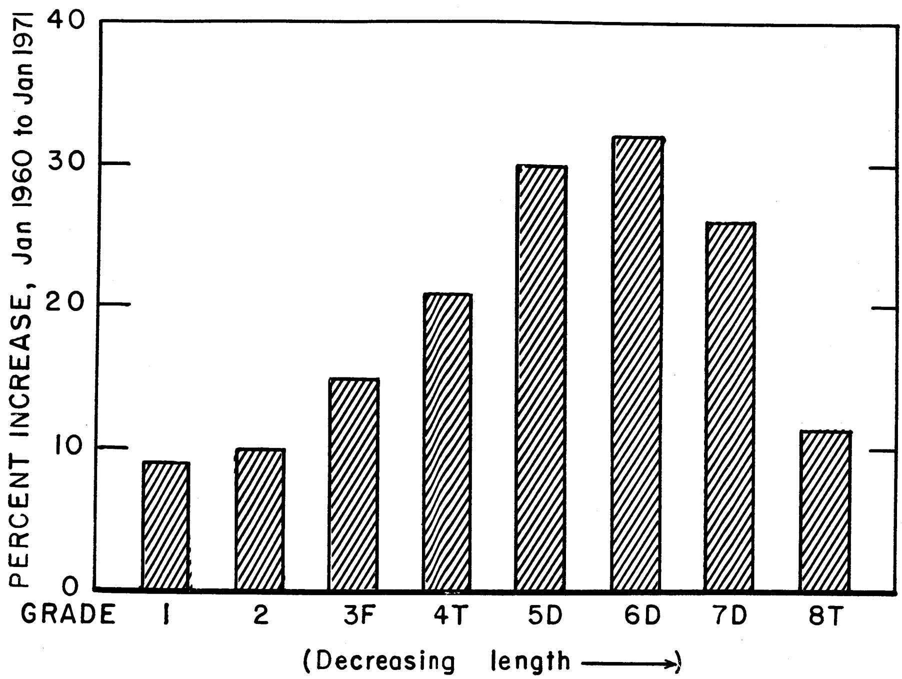

Figure 2.—Price increase by grade.

FOREIGN TRADE

The value of exports of asbestos products manufactured in the United States increased 24 percent over the value of those exported in 1970. Five of the nearly 100 countries buying these products accounted for better than half of the foreign sales. They are Canada (35 percent), West Germany (9 percent), United Kingdom (4 percent), Venezuela (3 percent), and Australia (3 percent).

In 1971 the United States imported 83 percent of its asbestos needs. This equaled the 1970 percentage, in spite of increased demand. Canada provided 95 percent of the imports, the Republic of South Africa provided 4 percent, and seven other countries, the remainder. Chrysotile, with 96 percent, dominated the imported types. There was a 7-percent increase in the dollar value of imported fibers. The Rhodesian values in table 4 do not reflect the recent lifting of the 1967 embargo, but were deliveries resulting from pre-1967 sales.

Table 3.—U.S. exports and reexports of asbestos and asbestos products

Product	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
EXPORTS				
Unmanufactured:				
Crude and spinning fibers......short tons..	4,300	$930	6,830	$1,376
Nonspinning fibers......do....	12,477	1,961	21,257	3,453
Waste and refuse......do....	21,458	2,449	24,115	2,742
Total......do....	38,235	5,340	52,202	7,571
Products:				
Gaskets and packing......do....	2,546	6,964	2,299	7,698
Brake linings......do....	3,787	5,576	5,253	7,174
Clutch facings, including linings......number..	2,557,694	1,926	1,920,176	1,572
Textiles and yarn......short tons..	3,733	2,368	6,673	3,397
Shingles and clapboard......do....	8,356	1,659	12,696	2,580
Articles of asbestos cement......do....	3,440	1,202	9,603	3,080
Manufactures, n.e.c......	NA	5,605	NA	5,897
Total......	--	25,300	--	31,398
REEXPORTS				
Unmanufactured:				
Crude and spinning fibers......short tons..	7,441	1,511	1,141	229
Nonspinning fibers......do....	799	138	335	63
Waste and refuse......do....	110	7	--	--
Total......do....	8,350	1,656	1,476	292
Products:				
Gaskets and packing......do....	15	21	1	5
Brake linings......do....	6	8	6	10
Clutch facings, including linings......number..	5,196	5	422	1
Textiles and yarn......short tons..	43	19	--	--
Shingles and clapboard......do....	42	13	--	--
Articles of asbestos cement......do....	76	22	--	--
Manufactures, n.e.c......	NA	3	NA	5
Total......	--	91	--	21

NA Not available.

Table 4.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber)		Textile fiber		All other		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1970								
Canada	80	$4	15,398	$5,657	597,832	$64,104	613,310	$69,765
Finland	--	--	--	--	4,141	276	4,141	276
Germany, West	--	--	--	--	65	11	65	11
India	--	--	--	--	5	(1)	5	(1)
Italy	--	--	2	3	2	1	4	4
Mexico	--	--	--	--	100	20	100	20
Mozambique	--	--	--	--	70	8	70	8
Norway	--	--	--	--	132	10	132	10
Portugal	--	--	--	--	231	16	231	16
Rhodesia, Southern	--	--	--	--	200	101	200	101
South Africa, Republic of	23,788	4,158	85	18	2,855	568	26,728	4,744
Southern Africa, n.e.c.	110	22	--	--	--	--	110	22
United Kingdom	90	19	211	36	5	1	306	56
Yugoslavia	--	--	1,488	43	2,512	70	4,000	113
Total	24,068	4,203	17,184	5,757	608,150	65,186	649,402	75,146
1971								
Canada	240	96	11,620	5,306	636,782	69,577	648,642	74,979
Finland	--	--	--	--	4,182	342	4,182	342
Italy	2	4	--	--	--	--	2	4
Mexico	--	--	18	8	40	3	58	11
Mozambique	203	43	--	--	157	31	360	74
South Africa, Republic of	23,188	4,104	1	(1)	1,822	399	25,011	4,503
Swaziland [2]	160	46	--	--	230	59	390	105
United Kingdom	--	--	--	--	109	3	109	3
Yugoslavia	--	--	--	--	2,613	69	2,613	69
Total	23,793	4,293	11,639	5,314	645,935	70,483	681,367	80,090

[1] Less than ½ unit.
[2] Effective Jan. 1, 1971, formerly Southern Africa, n.e.c.

Table 5.—U.S. imports for consumption of asbestos from specified countries, by grades

(Short tons)

Grade	1970			1971	
	Canada	Southern Rhodesia	Republic of South Africa	Canada	Republic of South Africa
Chrysotile:					
Crudes	80	--	591	188	1,655
Spinning fibers	15,398	--	85	11,620	1
All other	597,832	200	2,855	636,782	1,822
Crocidolite (blue)	--	--	8,936	52	6,953
Amosite	--	--	14,261	--	14,580
Total	613,310	200	26,728	648,642	25,011

WORLD REVIEW

World consumption, viewed on an annual basis, can be misleading. Temporary factors, such as a world monetary realinement or the impending expansion of the European Common Market, can give data that are in apparent disagreement with well-established trends. The past year is a perfect example of this. The world's largest producer and exporter, Canada, had a 2-percent decline in shipments at a time when world demand and capacity were nearing equality. Worldwide demand, however, should continue to rise until limited by production capacity.

Analysis of the world production over the last 20 years shows an average annual growth rate of a little over 2 percent. Projecting this rate to the year 2000 would call for a cumulative production of 163 million tons, or approximately half of the known reserves. An average growth rate of 6 percent (it is now about 5 percent) would exhaust the known reserves by the year 2000.

The asbestos industry is at or very near the point where supply and demand are equal. Any significant increase in demand will reveal shortages that may be only apparent because supply distribution across the ideological political boundaries or United Nations embargo lines is still difficult.

It seems evident that, in spite of a large increase in exploration, the opening of several new major mines, and the renovation of others, there will be at least a few years in the seventies when demand will exceed supply. The effect of such a situation on asbestos prices should be interesting because the only real fluctuations in the remarkably stable asbestos prices have been those occasioned by inflationary trends in the general economy.

Australia.—Chrysotile Corp. of Australia Pty. Ltd., Woodsreef Mines Ltd. subsidiary, prepared for its December 17 commissioning date. A 5-year, 200,000-ton contract with a Japanese firm was obtained.

Active exploration of chrysotile deposits at Beaconsfield and Noddy Creek, Tasmania, as well as at Marlborough, Queensland, was underway.

Brazil.—The Government, through Metas e Bases (Goals and Bases Program), was investing $9.2 million in a priority asbestos mining project. The goal is a 1973 annual production of 24,800 tons of asbestos. Mineração de Amianto S.A. was increasing production at its Cana Brava deposit, Uruaçu, Goiás. The company has indicated that its production may reach 30,000 short tons per year by 1972.

Canada.—Despite the first decrease in production since 1967 (2 percent), to 1,634,662 short tons, the Canadian asbestos industry gave every indication of vitality and confidence in an expanding market. Some of the areas of exploration, development and/or expansion are as follows:

(1) Abitibi Asbestos Mining Co. Ltd. has determined that its Amos, Quebec, property has sufficient reserves to operate

Table 6.—Asbestos: World production, by country [1]

(Short tons)

Country	1969	1970	1971 p
North America:			
Canada (sales)	r 1,576,876	1,661,644	1,634,662
United States (sold or used by producers)	125,936	125,314	130,882
South America:			
Argentina	359	39	e 40
Brazil e	r 14,000	18,000	22,000
Europe:			
Bulgaria	3,100	3,307	e 3,300
Finland [2]	r 15,487	15,019	e 15,000
France e	550	550	550
Italy	124,039	130,644	131,692
Portugal	224	223	e 220
U.S.S.R. e	r 1,060,000	1,175,000	1,270,000
Yugoslavia	12,634	13,342	17,011
Africa:			
Mozambique	868	251	e 250
Rhodesia, Southern e	88,000	88,000	88,000
South Africa, Republic of	284,588	316,822	351,963
Swaziland	r 43,077	36,439	39,114
United Arab Republic	--	[3] 495	e 500
Asia:			
China, People's Republic of e	r 175,000	190,000	175,000
Cyprus	23,927	28,247	[4] 24,925
India	10,734	10,840	12,122
Japan	r 23,141	23,451	e 24,000
Korea, Republic of	6,515	1,513	--
Philippines	r 50	1,337	e 1,300
Taiwan	3,396	3,133	2,565
Turkey	5,698	1,857	e 1,900
Oceania: Australia	r 924	1,008	e 1,000
Total	r 3,599,123	3,846,475	3,947,996

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] Includes vermiculite.

[4] Exports.

for 25 years at a 130-ton-per-day ore rate. Methods of financing production have yet to be ascertained.

(2) Abitibi was also engaged in diamond drilling at an optioned asbestos property near Timmins, Ontario.

(3) Allied Mining Corp. Ltd. optioned the Asbestos Lloyd Mines Ltd. claims in Midlothian Township, Ontario, and added others to cover a deposit of an indicated 120 million tons of 9-percent ore. An operation of 150,000 to 200,000 tons per year is envisioned.

(4) Asbestos Corp. Ltd. was preparing their Ungava Peninsula property for full production in 1972. They anticipate shipping 300,000 tons per year of ore to West Germany to produce 100,000 tons per year of fibers. Since completion of the $2.5 million shaft at the Penhale Mine, Quebec, more than 2,000 feet of laterals have been dug for ore body confirmation. The world's largest underground asbestos mine could result, having an 8,200-ton-per-day production rate.

(5) The Garrison Township, Ontario, deposit of Canadian Johns–Manville Co., Ltd. is now of proven commercial potential, but is on standby status pending need. The $75 million relocation and reconstruction project at the Jeffrey mine continued; completion is expected in 1973.

Colombia.—The asbestos deposit at Campomento has proven reserves of 280,000 tons of ore and probably another 420,000 tons. Nicolet Industries was building a mill and expects to be in production in 1973 at a possible 60,000 tons of fiber per year rate.

Greece.—Cerro Corp. says that preliminary reports indicate marketable fibers can be produced from the 50-million-ton Zindanion deposit. A 1975 operation of 50,000 tons per year of fiber is proposed.

India.—Johns–Manville Corporation is assisting an Indian company toward development of two deposits.

Mexico.—The Ciudad Victoria deposit soon to be brought into production by the government-owned Companía Nacional de Asbestos, S.A. has an outlined ore body of 6 million tons with 10 percent recoverable fibers.

Tests continued at the Oxaca deposit, partially owned by Freeport Minerals Co. The drilling work so far has shown better than 80 million tons of ore of medium and short fibers.

Table 7.—Canada: Shipments [1] of asbestos, by grades

(Short tons)

Grade	1967	1968	1969	1970	1971
Quebec milled group:					
3 (spinning) [2]	25,391	32,248	29,291	24,648	21,272
4 (shingle)	336,568	335,807	326,146	r 340,112	320,052
5 (paper)	185,450	193,446	204,208	223,535	199,569
6 (stucco)	244,021	255,648	242,126	261,564	234,720
7 (refuse)	490,087	542,124	539,413	515,872	565,162
8 (sand)	7,149	3,037	2,023	1,793	1,545
Newfoundland, Ontario, and British Columbia	154,345	147,389	233,669	294,120	292,342
Total	1,443,011	1,509,699	1,576,876	r 1,661,644	1,634,662

r Revised.
[1] Includes tonnage for own use.
[2] Includes crude No. 1, No. 2, and other.

Source: Dominion Bureau of Statistics.

Barite

By Frank B. Fulkerson [1]

Domestic barite sold or used in 1971 totaled 825,000 tons, down 3 percent from 1970 production. Sales of ground and crushed material produced from domestic and imported barite decreased also. Imports of crude barite declined 31 percent to 484,000 tons, the lowest since 1955. A temporary surcharge placed on these imports was probably the principal factor causing the sharp drop.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Barite (primary):					
Mine or plant production	944	NA	NA	NA	NA
Sold or used by producers	962	[1] 927	1,077	854	825
Value	$11,604	[1] $13,706	$15,753	$12,800	$13,491
Imports for consumption	532	663	614	706	484
Value	$4,655	$5,666	$5,549	$6,314	$4,468
Consumption [2]	1,371	NA	NA	NA	NA
Ground and crushed sold by producers	1,144	1,266	1,537	1,388	1,330
Value	$28,754	$30,563	$37,297	$34,294	$34,020
Barium chemicals sold by producers	113	136	130	105	83
Value	$16,283	$18,811	$19,101	$16,961	$15,488
World: Production	3,933	3,769	4,238	4,134	4,153

NA Not available.
[1] Data not comparable to previous years.
[2] Includes some witherite.

Table 2.—Barite (primary) sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1970		1971	
	Quantity	Value	Quantity	Value
Alaska	134	$835	102	$1,075
Arkansas	168	3,721	W	W
California	W	W	W	W
Georgia	W	W	W	W
Missouri	230	3,555	232	3,606
Nevada	192	1,455	192	1,490
Tennessee	19	286	21	342
Undistributed	112	2,949	278	6,978
Total [1]	854	12,800	825	13,491

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

Barite was mined in seven States in 1971. Production in Alaska, Arkansas, Georgia, Missouri, and Nevada accounted for the bulk of the total output. Missouri continued as the largest barite producer and supplied 28 percent of the national tonnage.

Ground and crushed barite was produced in 11 States; sales were down 4 percent from 1970. Leading producing States were Arkansas and Missouri (from domestic barite) and Louisiana and Texas (from imported barite). Ground and crushed barite was also produced in Alaska, California, Georgia, Missouri, Nevada, Tennessee, and Utah.

[1] Industry economist, Division of Nonmetallic Minerals.

CONSUMPTION AND USES

About 77 percent of the ground and crushed barite produced in the United States was used as a weighting agent in oil- and gas-well drilling muds. Barite sales for this use were less than in 1970 because of decreased drilling activity. A 21,000-ton increase was recorded for other uses combined, which included applications in the glass, paint, rubber, and barium chemicals industries.

Major producers of barium chemicals from barite included the following: Chemetron Corp., Huntington, W. Va.; Chemical Products Corp., Cartersville, Ga.; The Great Western Sugar Co., Johnstown, Colo.; Inorganic Chemicals Division, FMC Corp., Modesto, Calif.; Mallinckrodt Chemical Works, St. Louis, Mo.; PPG Industries, Chemical Division, New Martinsville, W. Va.; and Sherwin Williams Chemicals, Coffeyville, Kans.

PPG Industries announced it would close the barium plant at its New Martinsville, W. Va., complex at the end of 1971 and go out of the barium chemicals business.[2] The facilities were constructed in 1962 and produced principally television-grade and ceramic-grade barium carbonate. The company said that conversion by tube manufacturers from barium carbonate to strontium carbonate for color television tubes and greater imports of black-and-white television sets drastically reduced the demand for domestic barium carbonate. Other factors cited for the shutdown were excessive industry expansion, lack of growth for ceramic-grade barium carbonate in the brick and tile industry, and depressed markets for barium chloride, used in the manufacture of barium sulfate, sodium, dyestuffs, printing inks, and heat-treating salts for tool steels.

[2] Chemical Age. PPG Withdraws From Barium Chemicals Business. V. 103, No. 2726, Oct. 15, 1971, p. 16.

Table 3.—Ground and crushed barite sold, by use [1]

Use [2]	1969		1970		1971	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Barium chemicals [3]	177,570	11	146,038	10	140,843	10
Glass	72,706	5	49,642	4	(4)	--
Filler or extender:						
Paint	52,306	3	43,919	3	43,439	3
Rubber	14,177	1	25,489	2	(4)	--
Other filler	(4)	--	(4)	--	22,430	2
Well drilling	1,235,229	77	1,118,973	79	1,044,367	77
Other uses	52,754	3	24,565	2	104,318	8
Total	1,604,742	100	1,408,626	100	1,355,397	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 [1] in the United States in 1971
(Short tons)

Chemical	Plants	Produced	Sold by producers	
			Quantity	Value
Barium carbonate	5	59,630	46,211	$5,871,000
Other barium chemicals [2]	(3)	48,413	36,746	9,617,000
Total [4]	7	108,043	82,957	15,488,000

[1] Only data reported by barium chemical plants that consume barite are included.
[2] Includes black ash, blanc fixe, chloride, hydroxide, oxide, peroxide, sulfide, and other compounds for which separate data may not be revealed.
[3] Black ash, 1 plant; blanc fixe, 2; chloride 3; oxide, 1; peroxide, 1; and sulfide, 1.
[4] A plant producing more than 1 product is counted only once in arriving at total.

PRICES

Prices of crude and ground barite generally are negotiated between buyer and seller. Prices of barite published in trade journals serve as a general guide and do not necessarily reflect actual transactions.

Quoted prices for drilling-mud-grade crude and ground barite increased in 1971.

Table 5.—Price quotations for crude and ground barite in 1971

Item	Price per ton
Chemical and glass grade, f.o.b. shipping point, carload lots, short ton:	
Hand picked, 95 percent $BaSO_4$, 1 percent iron	$22.50–$24.50
Water ground, 99.5 percent $BaSO_4$, 325 mesh, 50-pound bags	55–78
Drilling-mud grade:	
Ground, 83–93 percent $BaSO_4$, 3–12 percent iron, specific gravity 4.20–4.30, f.o.b. shipping point, carload lots, short ton	31–44
Crude, bulk, imported, specific gravity 4.20–4.30, c.i.f. gulf ports, short ton	17–22

Source: Engineering and Mining Journal.

FOREIGN TRADE

Imports of crude barite for consumption in 1971 totaled 484,000 tons, a decrease of 31 percent from imports in 1970 and the lowest annual total in 16 years. Sources cited the following reasons for the sharp drop in imports: The 10-percent ad valorem surcharge that was imposed on all dutiable imports, including crude barite, from August 16, 1971, to December 20, 1971; a decline in U.S. oil- and gas-well drilling activity; uncertainty that developed about economic conditions and caused barite grinders to reduce inventories; and a dock workers' strike that shut down gulf coast ports for about 6 weeks. Peru was the principal source of imports, followed by Ireland, Mexico, and Canada. The imported barite entered the United States through the following customs districts: New Orleans, La., 57 percent; Laredo, Tex., 21 percent; Port Arthur, Tex., 16 percent; and Houston and El Paso, Tex., 6 percent.

Principal countries receiving natural barium sulfate and carbonate exports (mostly ground barite) from the United States were Canada, Singapore, Indonesia, and the Philippines. The exports dropped from 63,000 tons in 1970 to 24,000 tons in 1971 after new barite-grinding mills in the Far East came into production.

Table 6.—U.S. exports of natural barium sulfate and carbonate

Country	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	--	--	20	$2
Bermuda	26	$1	--	--
Brazil	94	3	237	9
Canada	7,143	265	8,449	325
Colombia	--	--	200	7
Dominican Republic	50	2	--	--
El Salvador	59	2	--	--
Indonesia	17,415	216	5,385	193
Japan	391	13	--	--
Liberia	114	5	--	--
Malagasy Republic	--	--	252	9
Malaysia	920	31	--	--
Mexico	16	1	22	2
Nicaragua	1,301	46	--	--
Peru	53	2	90	3
Philippines	--	--	1,055	40
Romania	282	49	--	--
Saudi Arabia	3,975	149	--	--
Senegal	250	9	--	--
Singapore	29,670	997	7,570	159
South Africa, Republic of	321	16	--	--
Spain	38	1	--	--
Surinam	15	1	116	4
United Kingdom	68	2	--	--
Venezuela	337	15	380	17
Total	62,538	1,826	23,776	770

Table 7.—U.S. exports of lithopone

	Short tons	Value (thousands)
1969	1,086	$300
1970	1,541	523
1971	545	425

Table 8.—U.S. imports for consumption of barite, by country

(Thousand short tons and thousand dollars)

Country	1970		1971	
	Quantity	Value	Quantity	Value
Crude barite:				
Canada	88	$748	71	$601
Greece	56	553	50	491
Ireland	203	1,540	107	810
Italy	29	416	23	319
Mexico	132	1,108	99	887
Morocco	28	319	23	273
Peru	170	1,630	111	1,087
Total	706	6,314	484	4,468
Ground barite:				
Canada	1	36	(1)	3
Colombia	--	--	(1)	5
France	(1)	10	(1)	12
Mexico	--	--	(1)	2
Total	1	46	(1)	22

[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	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	261	$40	2,705	$399	1,083	$118	37	$2
1970	87	19	2,866	495	1,558	166	--	--
1971	81	13	3,522	576	1,446	167	--	--

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	1,035	$144	887	$70	944	$381
1970	786	118	1,416	117	525	258
1971	832	139	1,120	91	799	313

Table 10.—U.S. imports for consumption of crude, unground, and crushed or ground witherite

Year	Crude, unground		Crushed or ground	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	392	$15	67	$7
1970	--	--	182	35
1971	417	22	94	20

WORLD REVIEW

Algeria.—A barite-grinding plant was being constructed at Khenchla by ALFLUID for la Société Nationale de Recherche et d'Exploitation Minière (SONAREM). The plant was to have initial capacity to grind 50,000 metric tons of barite per year. The barite was to come from the Mizab mine. ALFLUID is owned jointly by the U.S. firm Davis Mud & Chemical Co. and Société Nationale pour la Recherche, la Production, la Transport, la Transformation et la Commercialisation des Hydrocarbures (SONATRACH).

Australia.—South Australian Barytes Ltd., Australia's largest barite producer, was producing about 35,000 tons per year, of which approximately 25,000 tons was exported, principally to Brunei and Papua. The company operated two mines in the Flinders Ranges. Most of the processing operations were to be transferred from the original mill at Quorn to a new mill at Wyndam, which was to have 90,000 tons per year capacity.[3]

Greece.—Under Foreign Investment Law 2687, the Ministry of National Economy approved a $2.3 million investment by the local firm Silver Ore and Barytes Co. for geological and mineral research, expansion of barite and perlite mining operations, and establishment of a plant for processing perlite and beneficiating barite.

Indonesia.—The barite plant of P.T. Dresser Magcobar Indonesia, a subsidiary of Dresser Industries, Ltd., of the United States, was inaugurated late in 1971. The plant, located on Batam Island, about 10 miles south of Singapore, has a production capacity of about 45,000 tons per year of ground barite for drilling mud. Barite was being imported from Thailand for processing, packaging, and distribution. Excess production over domestic needs was slated for export to Thailand, Malaysia, and other Asian countries. As of November 1971, Indonesia was importing about 30,000 tons of ground barite per year from the United States and Australia.[4]

Italy.—Industria Chimica Carlo Laviosa S.p.A planned to build a barite plant at the port of San Antioco in Sardinia. Plans outlined an annual production of over 60,000 tons of processed barite. Laviosa was expected to place special emphasis on barite for the varnish and paper industries on the Italian mainland. Italy still imports sizable quantitites of barite for these industries even though it is a large barite-producing country.[5]

IMC Drilling Mud, Inc., of the United States sold its barite operations in Sardinia to the government-controlled Azienda Minerali Metallici Italiane S.p.A (AMMI).

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[3] Industrial Minerals (London). No. 47, August 1971, p. 24.
[4] Bureau of Mines. Mineral Trade Notes. V. 69, No. 2, February 1972, p. 9.
[5] Industrial Minerals (London). No. 51, December 1971, p. 26.

Table 11.—Barite: World production by country

(Short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada	143,230	147,251	137,000
Mexico	195,022	351,738	308,362
United States [2]	1,077,208	854,132	825,000
South America:			
Argentina	29,751	27,425	[e] 28,000
Brazil	51,800	28,200	[e] 47,100
Chile	8,828	1,700	1,413
Colombia	13,494	7,519	6,382
Peru	164,067	143,295	[e] 143,000
Europe:			
Austria	780	347	870
Czechoslovakia [e]	7,700	8,300	8,300
France	104,719	115,742	[e] 116,000
Germany, East [e]	33,000	33,000	33,000
Germany, West	482,232	454,798	450,693
Greece [3]	91,647	59,707	108,980
Ireland	176,926	[e] 177,000	[e] 177,000
Italy	268,213	239,555	222,144
Poland [e]	55,000	55,000	61,000
Portugal	119	474	1,025
Romania [e]	110,000	128,400	128,000
Spain	70,130	93,219	[e] 94,000
U.S.S.R.[e]	310,000	314,000	330,000
United Kingdom [4]	[r] 21,280	[e] 21,000	[e] 21,000
Yugoslavia	89,850	87,886	[e] 88,100
Africa:			
Algeria [5]	57,000	56,927	[e] 57,300
Arab Republic of Egypt (formerly United Arab Republic)	--	237	[e] 220
Kenya	480	493	819
Morocco	95,835	93,421	93,117
South Africa, Republic of	3,872	3,219	3,265
Swaziland	629	373	159
Asia:			
Burma, Union of	10,696	14,840	25,312
China, People's Republic of [e]	154,000	165,000	154,000
India	57,094	79,281	67,918
Iran	64,616	66,380	[e] 66,000
Japan	68,506	72,674	63,809
Korea, North [e]	132,000	132,000	132,000
Pakistan	7,936	2,060	3,265
Thailand	--	18,177	70,040
Turkey	36,458	32,013	[e] 32,000
Oceania: Australia	44,309	47,193	[e] 47,000
Total	[r] 4,238,427	4,133,976	4,152,593

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Bulgaria, Philippines, and Southern Rhodesia also produce barite, but available information is inadequate to make reliable estimates of output levels.

[2] Sold or used by producers.

[3] Barite concentrates; total crude output reported as follows in short tons: 1969—260,097; 1970—151,000 (estimate); 1971—138,899.

[4] Includes witherite.

[5] Ground barite; total crude output reported as follows in short tons: 1969—45,258; 1970—80,906; 1971—81,000 (estimate).

TECHNOLOGY

A patent was issued on the use of barite as a weighting agent in the dry-ballasting of waterborne vessels. The empty holds are filled with particles of barite that were coated with stearic acid or some other hydrophobic agent. The coated barite can be mixed with an optimum proportion of a clay for adjusting the bulk density of the ballast mass and a desiccant.[6]

A patent was issued on a process to remove calcitic impurities from barite. Crushed ore is roasted under controlled conditions so as not to form insoluble calcium compounds, and the calcine was leached with an aqueous solution of ammonium chloride. Values remain as insoluble matter in a chemical and physical state said to be very favorable for further processing.[7]

[6] Sydow, C. H., Jr., and O. W. Van Dyke (assigned to Dresser Industries, Inc.). Ballast. U.S. Pat. 3,559,609, Feb. 2, 1971.

[7] Ground, E. R. (assigned to Continental Ore Corp.). Beneficiation and Concentration. U.S. Pat. 3,586,480, June 22, 1971.

A British patent was issued that covered a method to obtain a barite product of improved whiteness for use as a filler or pigment. In this process, barite is wet-ground to a fineness of minus 40 microns in the presence of sodium pyrophosphate as a dispersant, the minus 10-micron particles are collected as product in overflow from a grading vessel, and the minus 40-, plus 10-micron material is collected as underflow and either recycled or, when high in impurities, sent to waste.[8]

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[8] Deutsche Baryt-Industrie Dr. Rudolf Alberti & Co. K.G. Comminution and Sizing. British Pat. 1,230,467, May 5, 1971.

Bauxite

By Horace F. Kurtz [1]

World bauxite production increased 10 percent to 62 million long tons in 1971, double the output of 8 years earlier. The large number and size of new bauxite and alumina production facilities under construction or planned throughout the world indicated continued strong growth of these industries in the 1970's. In the last 3 years, Australia, which has more than doubled its production of bauxite and alumina, has been the area of greatest growth.

Bauxite production in the United States remained near the 2-million-ton level in 1971. Bauxite consumption and calcined alumina production and imports decreased slightly because of a decline in requirements for producing primary aluminum.

Legislation and Government Programs.—Public Law 92-151 removed the duties on all U.S. imports of bauxite and alumina.

Excess bauxite and fused aluminum oxide in the Government stockpile were available for commercial sale or exchange for other commodities needed to meet stockpile objectives. During 1971, 2,446,000 tons of Surinam-type bauxite were sold for $26.2 million.

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Production, crude ore (dry equivalent)	1,654	1,665	1,843	2,082	1,988
Value	$19,079	$23,752	$25,725	$30,070	$28,543
Exports (as shipped)	2	7	5	3	34
Imports for consumption [1]	11,594	10,976	12,160	12,620	12,326
Consumption (dry equivalent)	14,503	14,097	15,580	15,673	15,619
World: Production	43,889	45,256	51,008	56,260	61,981

[1] Includes bauxite imported for Government account. Import figures for Jamaica, Haiti, and 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 declined 4.5 percent to just under 2 million long tons (dry equivalent) in 1971. About 90 percent of the bauxite was produced in Arkansas and most of the remainder, in Alabama.

In Arkansas, Aluminum Co. of America (Alcoa), Reynolds Mining Corp., American Cyanamid Co., and A. P. Green Refractories Co. mined in Saline County, and Reynolds and American Cyanamid produced in Pulaski County. Bauxite processing plants were operated in Arkansas by American Cyanamid, A. P. Green, Norton Co., Porocel Corp., and Stauffer Chemical Co.

Bauxite production in Alabama, largely for use in refractories, was increased in 1971 and came entirely from Barbour and Henry Counties. The producers included Eufaula Bauxite Mining Co., A. P. Green Refractories Co., Harbison-Walker Refractories Co., and Wilson-Snead Mining Co. Drying or calcining facilities were operated by all four companies.

American Cyanamid Co., the only bauxite producer in Georgia, operated two mines in Sumter County.

[1] Industry economist, Division of Nonferrous Metals.

The eight alumina plants in the continental United States and the plant in the Virgin Islands produced a total of 7.21 million short tons of alumina, an increase of 1 percent from 1970. Alcoa completed expansion of its plant at Point Comfort, Tex., and Harvey Aluminum, Inc., continued to modify and expand its facilities on St. Croix, V.I. The total production included 6.55 million tons of calcined alumina, 599,000 tons of commercial alumina trihydrate, and 69,000 tons of tabular, activated, and other alumina. The production of alumina trihydrate increased 44 percent. Calcined alumina production declined, however, because of reduced requirements for primary aluminum production.

Shipments of alumina and aluminum oxide products totaled 7.18 million tons, compared with 7.11 million tons (revised) in 1970. The total value of shipments was $501 million. Approximately 6.35 million tons was shipped to the aluminum industry. The chemical industry was the second largest recipient, and most of the rest of the alumina was shipped to producers of abrasives, ceramics, and refractories.

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:						
1967	108	83	$810	85	84	$1,236
1968	110	83	694	74	69	898
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
Arkansas:						
1967	1,943	1,571	18,269	2,022	1,742	21,343
1968	1,961	1,582	23,058	1,962	1,680	25,349
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
Total United States:[3]						
1967	2,051	1,654	19,079	2,107	1,826	22,579
1968	2,071	1,665	23,752	2,036	1,749	26,247
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

[1] Computed from selling prices and values assigned by producers and from estimates of the Bureau of Mines.
[2] Includes data for 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 recovered	Dry equivalent
1967	223	123	167
1968	210	108	152
1969	288	162	218
1970	428	259	343
1971	444	250	357

[1] Dried, calcined, and activated bauxite.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (percent)	1967	1968	1969	1970	1971
Less than 8	4	15	15	19	4
From 8 to 15	73	53	55	54	65
More than 15	23	32	30	27	31

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 r	6,670	478	7,148	7,001
1971	6,545	668	7,213	7,002
Shipments:				
1970 r	6,631	476	7,106	6,961
1971	6,525	659	7,184	6,975

r Revised.
[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, 1971 [1]
(Thousand short tons per year)

Company and plant	Capacity
Aluminum Co. of America:	
Bauxite, Ark	375
Mobile, Ala	1,025
Point Comfort, Tex	1,350
Total	2,750
Harvey Aluminum, Inc.: St. Croix, V.I	350
Kaiser Aluminum & Chemical Corp:	
Baton Rouge, La	1,025
Gramercy, La	800
Total	1,825
Ormet Corp.: Burnside, La	580
Reynolds Metals Co.:	
Hurricane Creek, Ark	840
Corpus Christi, Tex	1,380
Total	2,220
Grand total	7,725

[1] Capacity may vary depending upon the bauxite being used.

CONSUMPTION AND USES

Bauxite consumption in the United States remained virtually unchanged at 15.6 million long tons (dry basis) per year during the period 1969 through 1971. Nearly 88 percent of the bauxite consumed in 1971 was imported ore.

Approximately 94 percent of the total bauxite consumption was used to make alumina and related products. An average of 2.1 long dry tons of bauxite was used to produce 1 short ton (calcined basis) of alumina. The two alumina plants in Arkansas consumed mainly domestic bauxite; the other alumina plants used only imported ore.

The manufacture of high-alumina refractories was the second largest use of bauxite. Most of this material was calcined bauxite and 81 percent was imported, largely from Guyana.

The use of bauxite to make abrasives decreased in 1971, reflecting lower demand by the manufacturing industries that use these products. All of the bauxite used in the manufacture of abrasives was imported calcined bauxite. Data on the abrasives industry included bauxite fused and crushed in Canada since much of this material is made into abrasive wheels and coated products in the United States. The production and uses of aluminous abrasives was described.[2]

The chemical industry increased its consumption of bauxite by 4 percent to 319,000 tons. Other consumers of bauxite, in descending order of magnitude, included the cement, oil and gas, and steel industries, and municipal waterworks.

[2] Industrial Minerals. Abrasives: Uses Widening But Improved Quality Moderating Demand. No. 46, July 1971, pp. 9–24.

Table 7.—Bauxite consumed in the United States, by industry

(Thousand long tons, dry equivalent)

Year and industry	Domestic	Foreign	Total [1]
1970:			
Alumina	1,718	12,936	14,653
Abrasive [2]	--	r 280	r 280
Chemical	[3] 161	[3] 208	307
Refractory	60	310	370
Other	W	W	63
Total [1] [2]	1,940	r 13,733	r 15,673
1971:			
Alumina	1,665	12,968	14,633
Abrasive [2]	--	207	207
Chemical	[3] 175	[3] 223	319
Refractory	71	309	380
Other	W	W	79
Total [1] [2]	1,911	13,707	15,619

r Revised. 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.

[3] Includes other uses.

Consumption of calcined alumina by the 30 primary aluminum plants in the United States in 1971 totaled 7.5 million short tons. Alumina consumption data for other uses were not available. Among the growing new uses were the use of hydrated alumina in plastics and as a fire retardant in carpet backing; high-purity alumina is used in substrates for miniature electronic components.

Table 8.—Crude and processed bauxite consumed in the United States in 1971

(Thousand long tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total [1]
Crude	1,691	7,010	8,701
Dried	15	6,182	6,197
Activated	31	--	31
Calcined	174	516	690
Total [1]	1,911	13,707	15,619

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

Table 9.—Production and shipments of selected aluminum salts in the United States in 1970

(Thousand short tons and thousand dollars)

Item	Number of producing plants	Production	Total shipments including interplant transfers: Quantity	Total shipments including interplant transfers: Value (thousands)
Aluminum sulfate:				
Commercial (17 percent Al_2O_3)	64	1,202	1,128	$46,662
Municipal (17 percent Al_2O_3)	3	6	XX	XX
Iron-free (17 percent Al_2O_3)	21	71	46	2,773
Aluminum chloride:				
Liquid (32° Bé), Crystal (32° Bé)	5	23	10	861
Anhydrous (100 percent $AlCl_3$)	5	31	32	8,890
Aluminum fluoride, technical	5	136	135	26,795
Aluminum hydroxide, trihydrate (100 percent $Al_2O_3.3H_2O$)	7	364	330	26,936
Other inorganic aluminum compounds [1]	XX	XX	XX	23,122
Total	XX	XX	XX	136,039

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

Government stocks of bauxite were reduced 5 percent between December 31, 1970, and the end of 1971. Although 2,466,000 long tons of Surinam-type bauxite in the Government stockpile were sold, only 761,000 tons were shipped. An additional disposal of 110,000 tons of bauxite was made from a stockpile accumulated during World War II. Stocks of bauxite at mines, processing plants, and consumers were increased an estimated 14 percent by yearend.

Inventories of alumina and related products at plants producing alumina and primary aluminum increased 21,000 tons to 1,082,000 short tons during the year.

Table 10.—Stocks of bauxite in the United States [1]

(Thousand long tons, dry equivalent)

Sector	Dec. 31, 1970 [r]	Dec. 31, 1971
Producers and processors	966	999
Consumers	2,263	2,677
Government [2]	18,020	17,149
Total	21,249	20,825

[r] Revised.

[1] Domestic and foreign bauxite; crude, dried, calcined, activated; all grades.

[2] Includes bauxite stockpiled during World War II (1,001,000 tons Dec. 31, 1970, 891,000 tons Dec. 31, 1971), plus bauxite in defense material inventories (National Stockpile, Supplemental Stockpile, Defense Production Act).

PRICES

Market prices for crude (undried) and dried bauxite produced in the United States were not published because most of the bauxite was produced by companies for their own use. The average value of crude domestic bauxite shipments, f.o.b. mine or plant, was estimated by the Bureau of Mines at $11.82 per long ton in 1971. The average value of domestic dried and calcined shipments were estimated at $16.46 and $26.41 per ton, respectively. Bauxite values among producers varied widely. The average value of imported dried or partly dried bauxite consumed at domestic alumina plants was estimated at $14.95 per long dry ton. During 1971, the Engineering and Mining Journal published the following prices on special grades of bauxite, f.o.b. cars, Atlantic ports, per long ton:

January through October	
Imported, calcined, crushed:	
Abrasive grade, 87.25 percent minimum Al_2O_3, penalties for SiO_2 content over 7 percent	$44.00
Refractory grade:	47.50
87.75 percent minimum Al_2O_3	51.00
88 percent minimum Al_2O_3, super calcined	
November through December	
Imported, calcined, crushed, f.o.b. Mobile, Ala.:	52.73
Guyana RAC (refractory grade)	56.93
Guyana RASC (super calcined)	

The average value of calcined alumina shipments, as determined from producers reports, was $67.04 per short ton, compared with $67.60 per ton (revised) in 1970. The average value of shipments of alumina trihydrate was $77.80 per ton. The average value of imported alumina classified as alumina for use in making aluminum was $58.07 per ton at port of shipment; the average value of alumina exports from the United States and the Virgin Islands was $69.60 per ton.

Table 11.—Market quotations on alumina and aluminum compounds

(In bags, carlots, f.o.b. works)

Compounds		Jan. 1, 1971	Dec. 30, 1971
Alumina, calcined	per pound	$0.0585	$0.06
Alumina, hydrated, heavy	do	0.0420–.0435	0.0445–.0455
Alumina, activated, granular	do	.1365	.1365
Aluminum sulfate, commercial, ground, freight equalized, 17 percent Al_2O_3	per ton	62.25	62.25
Aluminum sulfate, iron-free, freight equalized	do	83.05–87.05	87.05

Source: Oil, Paint and Drug 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 1970	Average value, port of shipment 1971
Exports: Bauxite and bauxite concentrate	$74.74	$45.02
Imports:		
Crude and dried:		
Australia	(2)	10.68
Brazil	--	8.57
Dominican Republic [3]	16.88	16.58
Greece	10.14	8.41
Guinea	r 4.80	4.93
Guyana	9.84	11.20
Haiti [3]	10.02	9.86
Jamaica [3]	12.99	12.76
Netherlands	r 9.00	--
Surinam	10.59	11.12
Venezuela	9.30	--
Average	r 12.39	12.46
Calcined:		
Canada	r 19.62	34.12
Guinea	--	90.28
Guyana	34.77	39.85
Mexico	--	64.05
Surinam	32.63	34.87
Trinidad and Tobago	11.97	39.21
Venezuela	35.20	--
Average	34.59	39.33

r Revised.

[1] Excludes bauxite into the Virgin Islands from foreign countries 1970: Australia $4.91, Guinea $4.51, 1971: Australia $5.54, Papua (New Guinea) $4.31, Guinea $4.34.

[2] Revised to none.

[3] Dry equivalent tons adjusted by the Bureau of Mines used in computation.

Note: Bauxite is not subject to an ad valorem rate of duty, and the average values reported 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 classified as "bauxite and concentrates of aluminum excluding alumina" totaled 34,000 long tons. Fifty-three percent, with an average value of $28.21 per ton, port of shipment, went to West Germany, and 27 percent, valued at $67.66 per ton, was shipped to Canada.

Alumina exports from the United States declined 3 percent to 1,024,000 short tons, valued at $71.8 million. By country, 412,000 tons were shipped to the U.S.S.R., 269,000 tons to Canada, 109,000 tons to Ghana, 80,000 tons to Mexico, 60,000 tons to Hungary, and the remaining 94,000 tons to 57 other countries. Additional shipments of 115,000 tons to Norway and 65,000 tons to the U.S.S.R. were made from the Virgin Islands.

Exports of aluminum hydroxide decreased 17 percent to 34,000 short tons, valued at $4.5 million. Shipments to Mexico and Sweden accounted for 77 percent of the total. Aluminum sulfate exports, nearly half of which was sent to Venezuela, totaled 17,000 tons and was valued at $569,000. Exports of artificial corundum amounted to 16,000 tons valued at $6.8 million. Canada was the largest recipient. Exports classified as "other aluminum compounds" totaled 47,000 tons and were valued at $12.5 million.

Legislation suspending the duties on crude and dried bauxite, calcined bauxite, and alumina imported for use in making aluminum expired on July 15. Public Law 92–151, signed into law November 5, permanently removed the duties on these commodities. The measure contained a retroactive provision that eliminated the duties on imports after July 15. The law also removed the duty on aluminum hydroxide and alumina for uses other than making aluminum, which had been 0.15 cent per pound.

Imports of crude, dried, and partially dried bauxite into the United States (excluding the Virgin Islands) declined 2 percent to 12.3 million long tons. Receipts from Jamaica were increased slightly and provided 62 percent of the total. Surinam

Table 13.—U.S. imports for consumption of bauxite (crude and dried), by country [1]

(Thousand long tons and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	--	--	--	--	139	$1,485
Dominican Republic	918	$14,738	910	$15,363	912	15,119
Greece	22	178	58	588	34	286
Guyana	333	3,048	317	3,118	271	3,034
Haiti	599	8,119	617	6,183	502	4,951
Jamaica	7,132	109,461	7,503	97,500	7,583	96,767
Surinam	2,816	27,070	2,923	30,969	2,870	31,923
Venezuela	318	2,899	276	2,560	--	--
Other countries	22	126	16	81	15	74
Total	12,160	165,639	12,620	156,362	12,326	153,639

[1] Official Bureau of the Census data for Jamaican, Haitian, and Dominican Republic bauxite have been converted to dry equivalent by deducting free moisture for Jamaican 16 percent, Haitian 12.5 percent, and 17.7 percent for Dominican Republic, in 1969 and 1970; 1971 Jamaican is 15.4 percent, Haitian 13.0 percent, and Dominican Republic, 16.8 percent. Other imports, which are virtually all dried, are on as-shipped basis.

Note: Excludes bauxite imported into the Virgin Islands from foreign countries: 1969—Australia 69,000 tons; Guinea 435,000: 1970—Australia 235,000 tons; Guinea, 506,000 tons; 1971—Australia 393,000; Papua (New Guinea) 30,000 tons; Guinea, 588,000 tons.

Table 14.—U.S. imports for consumption of bauxite (calcined) by country

(Thousand long tons and thousand dollars)

Country	1967	1968	1969	1970	1971
	Quantity	Quantity	Quantity	Quantity	Quantity
Guyana	157	177	175	237	247
Surinam	48	30	25	16	30
Trinidad and Tobago	9	--	--	1	15
Other countries	(1)	(1)	(1)	2	(1)
Total	214	207	200	256	292
Value	$6,283	$6,309	$6,017	$8,852	$11,487

[1] Less than ½ unit.

Table 15.—U.S. imports for consumption of alumina for use in producing aluminum, by country

(Thousand short tons and thousand dollars)

Country	1970		1971	
	Quantity	Value	Quantity	Value
Australia	1,185	$66,278	1,241	$66,634
France	37	1,902	83	4,732
Germany, West	18	1,403	1	98
Greece	27	1,230	63	3,951
Guyana	38	2,379	13	929
Jamaica	868	55,866	458	30,681
Japan	36	3,357	68	4,918
Surinam	346	20,122	463	26,852
Other countries	--	--	1	46
Total	2,555	152,537	2,391	138,841

Note: Shipments from the Virgin Islands to the United States 1970: 118,957 short tons ($9,549,662); 1971: 119,978 short tons ($9,315,987).

supplied 23 percent of the imports; Dominican Republic, 7 percent; Haiti, 4 percent; Guyana, 2 percent; and Australia, 1 percent. An additional 1,011,000 tons was imported into the Virgin Islands, largely from Guinea and Australia. Imports of calcined bauxite increased 14 percent to 292,000 tons (calcined basis) and came mainly from Guyana.

Imports of alumina for use in making aluminum declined 6 percent. Almost all of the decrease was attributable to reduced shipments from Jamaica. Australia provided 52 percent of the total, and Surinam and Jamaica each provided 19 percent. Imports of aluminum hydroxide and alumina for other uses decreased to 20,000 tons, of which Canada supplied 87 percent.

WORLD REVIEW

World bauxite production increased 10 percent in 1971, the third consecutive year of increases of at least 10 percent. The greatest expansion was in Australia, where production was increased over 3 million long tons. Large increases were also recorded in Surinam, Greece, and Jamaica. Three countries, Jamaica, Australia, and Surinam, accounted for half of the world's bauxite output.

World production of alumina increased 8 percent to 24.6 million short tons. The largest gains were made in Australia and Japan. The United States produced 29 percent of the total and remained the largest producer.

Australia.—Alcoa of Australia (W.A.) N.L. continued to mine bauxite in the Jarrahdale area of the Darling Range and to produce alumina at its plant at Kwinana. Construction of Alcoa's second alumina plant in Western Australia, located at Pinjarra, was expected to be completed by the middle of 1972. The initial capacity of this plant was reduced from a previously reported 550,000 short tons per year to 460,000 short tons. It will receive bauxite from another deposit in the Darling Range.

Bauxite production and shipments by Comalco Industries Pty., Ltd., at Weipa on the Cape York Peninsula, Queensland, again rose sharply and totaled over 7 million tons. Comalco continued discussions with numerous companies concerning the formation of a consortium to erect a large

Table 16.—Bauxite: World production by country

(Thousand long tons)

Country [1]	1969	1970	1971 p
North America:			
Dominican Republic [2]	1,076	1,050	1,291
Haiti [3]	654	621	633
Jamaica	10,333	11,820	12,565
United States [2]	1,843	2,082	1,988
South America:			
Brazil	343	492	e 492
Guyana [2]	4,238	e 4,079	e 3,757
Surinam	5,364	e 5,257	e 6,162
Europe:			
France	r 2,753	3,003	3,066
Germany, West	3	3	--
Greece	r 1,807	2,242	3,039
Hungary	1,904	1,990	2,057
Italy	216	221	188
Romania e	49	299	300
Spain	r 2	2	e 2
U.S.S.R. e [4]	r 4,100	4,200	4,400
Yugoslavia	2,094	2,066	1,928
Africa:			
Ghana	r 242	344	324
Guinea	2,420	e 2,600	e 2,600
Mozambique	4	7	e 6
Sierra Leone	447	433	581
Asia:			
China, People's Republic of e [5]	r 440	490	540
India	r 1,067	1,338	1,414
Indonesia	753	1,210	1,218
Malaysia (West Malaysia)	1,056	1,121	962
Pakistan	2	1	(6)
Turkey	r 2	50	125
Oceania: Australia	r 7,796	9,239	12,343
Total	r 51,008	56,260	61,981

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, but no information on bauxite mining activities, if any, are available since 1965. Fiji may have initiated bauxite production in 1971, but no output figures have been released.

[2] Dry bauxite equivalent of crude ore.

[3] Dry bauxite equivalent of ore processed by drying plant.

[4] Excludes materials other than bauxite used for the production of alumina, estimated as follows, in thousand long tons (1969 and 1970 figures revised from previous edition): Nepheline concentrates (25 to 30 percent aluminum): 1969—295; 1970—390; 1971—490; alunite ore (16 to 18 percent aluminum) 1969—100; 1970—195; 1971—295.

[5] Diasporic bauxite for production of aluminum only; excludes 98,000 to 195,000 tons of production for refractory applications.

[6] Less than ½ unit.

Table 17.—Alumina: World production, by country

(Thousand short tons)

Country [1]	1969	1970	1971 p
North America:			
Canada	1,107	1,218	e 1,220
Jamaica (exports)	1,274	1,862	1,997
United States	7,334	7,148	7,213
South America:			
Brazil	96	131	e 200
Guyana	334	336	336
Surinam e	1,066	1,100	1,100
Europe:			
Czechoslovakia e	80	80	80
France	1,219	1,246	e 1,310
Germany, East	59	60	e 60
Germany, West	749	835	911
Greece	331	344	514
Hungary	450	486	e 500
Italy	r 315	346	289
Norway	12	3	--
Romania e	187	231	231
United Kingdom	112	118	e 120
U.S.S.R. e	r 1,800	2,000	2,200
Yugoslavia	134	138	e 138
Africa: Guinea	631	672	e 680
Asia:			
China, People's Republic of e	r 250	280	300
India e	294	360	400
Japan	1,173	1,416	1,767
Taiwan	r 48	46	47
Oceania: Australia	r 2,129	2,357	2,944
Total	r 21,184	22,813	24,557

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: 1969—30,058; 1970—30,354; 1971—30,011.

alumina plant at Weipa. The Queensland Alumina Ltd., plant at Gladstone, Queensland, which receives all of its bauxite from Weipa, became the world's largest alumina plant with completion of the second phase of its expansion in June. Annual capacity was set at 1.43 million short tons, but the plant has consistently operated above rated capacity. A third expansion of the plant to a capacity of 2.24 million short tons was scheduled for completion in mid-1972 but will probably be delayed.

Nabalco Pty. Ltd., managed by its principal shareholder, Swiss Aluminium (Alusuisse), began mining and shipping bauxite from its deposits at Gove, Northern Territory. Production of over 1 million tons was reported for 1971. Construction of an alumina plant at Gove continued. The first stage, which will have an annual capacity of 560,000 tons of alumina, was scheduled for completion in mid-1972, and a similar second stage was to be completed a year later.

Amax Pacific Aluminum through its subsidiary, Kimberley Alumina Pty., Ltd., is the manager of a project to mine bauxite in the North Kimberley District of Western Australia and to produce alumina at Port Warrender on the Admiralty Gulf. The alumina plant is to be completed late in 1974 and to have an initial annual capacity of over 1 million tons. Participation in the international consortium supporting the project changed during 1971 and at yearend included American Metal Climax, Inc. (AMAX), Holland Aluminium N.V., and four Japanese companies. Estimates of the capital costs of the venture ranged from $330 to $390 million.

Pacminex, Pty., owned jointly by Colonial Sugar Refining Co., Ltd., and Hanwright Partnership, submitted a proposal for a bauxite and alumina complex to the Government of Western Australia for approval. The bauxite would be mined about 50 miles north of Perth, and an alumina plant with an eventual capacity of over 1 million tons per year would be built at Upper Swan in the northern suburbs of Perth.

Alwest Pty., Ltd., a subsidiary of News, Ltd., reported that it had proved bauxite reserves in the Darling Range of 200 million tons averaging 32 percent alumina. The company was studying the feasibility of building an alumina plant near Bunbury, Western Australia, in a joint venture with Broken Hill Pty. Co. Ltd.

Table 18.—World producers of alumina

(Thousand short tons)

Country, company, and plant location	Capacity, yearend 1971	Ownership
NORTH AMERICA		
Canada: Aluminum Co. of Canada, Ltd., Arvida	1,355	Alcan Aluminium Ltd. 100 percent.
United States: (See table 6)	7,725	
Jamaica:		
Alcan Jamaica Ltd.		Alcan Aluminium Ltd. 100 percent.
Ewarton	613	
Kirkvine	613	
Alumina Partners of Jamaica, Ltd.: Nain, St. Elizabeth	950	Reynolds Metals Co. 36.8 percent, The Anaconda Company 36.8 percent, Kaiser Aluminum and Chemical Corp. 26.4 percent.
Revere Jamaica Alumina Ltd.: Maggotty	220	Revere Copper and Brass Inc. 100 percent.
Total North America	11,476	
SOUTH AMERICA		
Brazil:		
Aluminio Minas Gerais, S.A. Saramenha, Minas Gerais	52	Alcan Aluminium Ltd. 100 percent.
Cia. Brasileira de Aluminio S.A. Sorocaba, São Paulo	55	Industria Votorantim, Ltd. 80 percent, Government, 20 percent.
Cia. Mineira de Aluminio Poços de Caldas, Minas Gerais	55	Aluminum Co. of America, 50 percent, Hanna Mining Co. 23.5 percent, Brazilian interests 26.5 percent.
Guyana: Guyana Bauxite Co., MacKenzie	385	Government 100 percent.
Surinam: Surinam Aluminum Co., Paranam	1,323	Aluminum Co. of America, 100 percent.
Total South America	1,870	
EUROPE		
Czechoslovakia: Ziar, Banskobystricky	110	Government 100 percent.
France:		
Compagnie Péchiney:		Péchiney 100 percent.
Gardanne	720	
Salindres	290	
Ugine-Kuhlman S.A.: La Barasse	330	Ugine-Kuhlman 100 percent.
Germany, East: V.E.B., Lautawerke	70	Government 100 percent.
Germany, West:		
Gebrueder Giulini G.m.b.H, Ludwigshafen	143	Gebrueder Giulini G.m.b.H. 100 percent.
Martinswerk G.m.b.H. fur Chemische und Metallurgische Produktion, Bergheim/Erft	441	Alusuisse 99.2 percent.
Vereinigte Aluminium-Werke A.G.:		Government 100 percent.
Lippenwerke, Lunen	375	
Nabreverk, Schwandorf	230	
Greece: Aluminium de Grèce S.A., Distomon	529	Péchiney 72 percent, Ugine 18 percent, Government 10 percent.
Hungary: Almasfuzito, Mason Magyarovar, Ajka	e 580	Government 100 percent.
Italy: Montecatini-Edison S.p.A., Porto Marghera	231	Montecatini-Edison 89 percent, Government 11 percent.
Romania: Romanian Aluminium, Oradea	231	Government 100 percent.
United Kingdom: The British Aluminium Co., Ltd.:		Tube Investments, Ltd. 52 percent, Reynolds Metals Co. 48 percent.
Burntisland	110	
Newport	55	
U.S.S.R. (including Asia): Achinsk, Bogsitogorsk, Kirovabad, Pikalevo, Volkhov-Tikhiun, Zaporozhye, Kamensk-Uralsky, Krasnoturinsk, Pavlodar, Sumgait, Volgograd	e 3,300	Government 100 percent
Yugoslavia:		Government 100 percent.
Titograd	220	
Kidricevo	154	
Total Europe	8,119	

Table 18.—World producers of alumina—Continued

(Thousand short tons)

Country, company, and plant location	Capacity, yearend 1971	Ownership
AFRICA		
Guinea: FRIA Kimbo	772	Olin Mathieson 48.5 percent, Péchiney-Ugine 26.5 percent, British Aluminium 10 percent, Alusuisse 10 percent, Vereinigte Aluminium 5 percent.
Total Africa	772	
ASIA		
China, People's Republic of: Kweyang, Weinan, Nanting, Fushun, Antung, Kunming, Yangshuan, Sian	e 330	Government 100 percent.
India:		
Aluminium Corp. of India Ltd., Jaykagnagar, West Bengal	28	Aluminium Corp. of India, 100 percent.
Hindustan Aluminium Corp. Ltd., Rennkott, Uttar Pradesh	182	Kaiser 27 percent, Birla and Indian interests 73 percent.
Indian Aluminium Co. Ltd.:		Alcan 65 percent, Government 35 percent.
Muri, Bihar	79	
Belgaum, Mysore	83	
Madras Aluminium Co. Ltd., Coimbatore, Madras	55	Montecatini-Edison 27 percent, Madras State Government 73 percent.
Japan:		
Nippon Light Metal Co. Ltd., Shimizu	562	Alcan 50 percent, Japanese interests 50 percent.
Showa Denko K.K., Yokohama	600	Showa Denko 100 percent.
Sumitomo Chemical Co., Ltd., Kikumoto	675	Sumitomo Chemical Co. 100 percent.
Taiwan: Taiwan Aluminium Corp., Kaohsiung, Takao	85	Government 100 percent.
Total Asia	2,679	
OCEANIA		
Australia:		
Comalco Ltd., Bell Bay, Tasmania	65	Comalco Ltd. Conzinc Riotinto of Australia, Ltd. 45 percent, Kaiser 45 percent, public 10 percent, 100 percent.
Queensland Alumina Ltd., Gladstone	1,430	Kaiser 37.3 percent, Alcan 22 percent, Péchiney 20 percent, Comalco 11.3 percent, Conzinc Riotinto of Australia 9.4 percent.
Alcoa of Australia (W.A.) N.L., Kwinana	1,380	Alcoa of Australia, Ltd. (Aluminum Co. of America 51 percent, Australian interests 49 percent) 100 percent.
Total Oceania	2,875	
Total World	27,791	

e Estimate.

Tipperary Land and Exploration Corp., which is associated with Holland Aluminium and Péchiney in a project to develop bauxite deposits in the Aurukun area south of Weipa, Queensland, reported that it had reserves of 600 million tons containing 50 percent alumina. The feasibility of constructing and financing a large alumina plant was being investigated. Closer to Weipa, Austral-Pacific Mining Corp. Ltd. and Secmin Ltd., in a joint venture, reported confirmation of commercial-grade bauxite in two areas.

Brazil.—Bauxite deposits, discovered near the confluence of the Trombetas and the Amazon Rivers in the State of Pará, contained reserves estimated at from 250 million to 1 billion tons. The deposits were within 20 miles of the Trombetas River where the ore could be loaded on ocean-going freighters. Mineração Rio do Norte S.A., an Alcan Aluminium Ltd. subsidiary, continued development work on its concessions and began construction of an access road and port facilities. Eventually, the project will include facilities for mining, crushing, washing, drying, and loading 2 to 3 million tons of bauxite per year. The installation will include a new town for about 7,000 people and a small adjacent airfield.

Costa Rica.—Two contracts were awarded to begin infrastructure work on the $119 million bauxite-alumina complex to be built by the Aluminum Co. of America. The first phase of the project involved the construction of a port and a road by the Costa Rican Government, which was seeking the necessary financing abroad. The entire complex is expected to be completed by 1977.

France.—Construction of the alumina plant of Alumine de Flandres at Dunkirk, which originally was scheduled to begin in September 1971, was deferred indefinitely. The plant was to have been completed in 1974 with 1.1-million-ton capacity. Although the postponement was attributed to poor market conditions, the possibility that bauxite from the Boké deposit in Guinea might not be available as a raw material could have been another factor.

French Guiana.—An agreement that includes further exploration of bauxite deposits on concessions held by the Compagnie Minière Alcoa de Guyane (CMAG) was approved by the French Government. CMAG is owned by Alcoa (75 percent) and Péchiney Co. of France (25 percent). CMAG holds three concessions: Kaw, in the Kaw Mountains, about 7,400 acres; Observatoire, in the Roura Mountains northwest of the Kaw group, about 32,100 acres; and Cayenne on Mahury Mountain, just east of the capital city, about 17,000 acres. All three deposits are near the capital city of Cayenne and not far from the sea.

The French Bureau of Geological and Mineral Research estimated that the three concessions contain about 25 million tons of bauxite, composed of 47 percent alumina and 2 percent silica. If CMAG finds bauxite reserves of over 100 million tons, the company has agreed to construct an alumina plant in French Guiana. Otherwise, some other company may build a plant or the material may be processed at Paranam, Surinam. Development of the bauxite mining operations alone is expected to cost more than $16 million over a 3-year period, and create 500 jobs.

Ghana.—The Ministry of Lands and Mineral Resources announced the granting of prospecting rights for the development of bauxite deposits at Kibi in the Eastern Region and Nyanihini in the Ashanti Region. One of the two companies granted prospecting rights was Volta Aluminium Co. Ltd. (Valco), which is owned 90 percent by Kaiser Aluminum and Chemical Corp. and 10 percent by Reynolds Metals Co. Valco is the only company in Ghana with aluminum smelting capacity. Reserves at Kibi were estimated at 120 million tons. Engineers International Corp., an international consortium, also obtained prospecting rights and reportedly was interested in the Nyanihini deposit. This deposit reportedly has proven reserves of 150 million tons of bauxite.

Greece.—The Ministry of Commerce reported that bauxite exports totaled 951,634 tons in 1971. The export quota for 1971 was 1,295,000 tons, of which 450,000 tons went to the European Economic Community, 450,000 tons to the U.S.S.R., 125,000 tons to Great Britain, 75,000 tons to the United States, 60,000 tons to Spain, 55,000 tons to Sweden, 50,000 tons to Czechoslovakia, and 20,000 tons to Japan.

Reynolds International in cooperation with Bauxite Parnasse Mining Co. notified the Government of Greece of its intent to invest in a $100 million alumina plant that will have an initial annual capacity of 275,000 tons. Bauxite Parnasse was expected to provide the bauxite ore, a plant site near Stea on the Gulf of Corinth, and possibly some equity capital. Péchiney, through its subsidiary Aluminium de Grèce, S.A., completed expansions at its alumina facilities.

Guinea.—Guinea Bauxite Co. (CBG), owned by an international consortium, Halco Mining, Inc. (51 percent), and by the Government of Guinea (49 percent) continued to construct production facilities and infrastructure for the large Boké bauxite project. The first bauxite exports were scheduled for January 1973. The International Bank for Reconstruction and Development approved an additional loan of $9 million to CBG to expand production capacity to 9 million tons per year, double the capacity originally planned.

In February, Alusuisse and the Government of Guinea signed an agreement to become equal partners in the development of the bauxite deposits near Tougué and created Société Mixte Guineé-Alusuisse (SOMIGA) for this purpose. The agreement includes provisions for construction of ore drying facilities, a town, a rail spur, and port facilities. Alusuisse reportedly agreed to provide $2 million for initial prospecting and infrastructure feasibility studies, which were to be completed in 2 years. High-grade bauxite is believed to occur in the Tougué area, and estimates of reserves as high as 2 billion tons have been reported. Production of as much as 8 million tons per year was contemplated.

Another agreement, signed in April, provided for prospecting and exploiting the bauxite near Dabola in central Guinea. For this joint venture, the Government (51 percent) and the Yugoslavian firm Energoproject (49 percent) formed the company, Société des Bauxites de Dabola (SBD). Feasibility studies for the project will include consideration of a 300,000-ton-per-year alumina plant.

The Government was reported to have signed an agreement late in 1970 with the U.S.S.R. for the development of bauxite deposits in the Kindia region. The agreement was believed to be a joint venture providing necessary infrastructure, similar to agreements covering the projects at Boké, Tougué, and Dabola.

Guyana.—The Government of Guyana completely nationalized the operations of Demerara Bauxite Co. Limited (DEMBA) a subsidiary of Alcan Aluminium Ltd. Discussions about a 51-percent Government participation in DEMBA had begun in December 1970. Announcement that nationalization was to take place was made February 23, but the effective date was not until July 15, 1971. Guyana agreed to pay Alcan nearly $54 million, plus interest, over a maximum period of 20 years. DEMBA workers struck in April for 2 weeks because of uncertainty about the vesting of their pension fund and pay raises they considered overdue.

The Guyana Bauxite Co. (Guybau) was created by the Government of Guyana to acquire the assets and operate the facilities formerly owned by DEMBA. Guybau appointed Gerald Metals Ltd. of London as sole sales agent for the final 6 months of 1971. Later in the year Guybau announced the signing of a 3-year contract, starting in 1972, with Philipp Brothers A. G. of Zug, Switzerland, a wholly owned subsidiary of Philipp Brothers, a division of Englehard Minerals and Chemicals Corp. of New York.

In spite of the normal problems occurring with nationalization, Guybau reportedly maintained production of calcined refractory bauxite and alumina at near 1970 levels. Production of metallurgical bauxite was less than that of the previous year.

Guybau increased the size of individual shipments of alumina by bulk carrier to 11,550 short tons in November and December. Vessels with very shallow drafts were used to cross the bar at the mouth of the Demerara River. Companies formerly shipped cargoes of 4,000 to 6,000 tons, which were transshipped at Trinidad.

India.—The Government-owned Bharat Aluminium Co. expected to complete construction of a new alumina plant at Korba in Madhya Pradesh in the latter part of 1972. The plant will have an annual capacity of 220,000 short tons and will use bauxite from deposits at Amarkantak and Phutkaphar.

Indonesia.—Exports of bauxite increased about 5 percent to 1,218,000 long tons. The Government-owned bauxite company announced that it had agreed to supply 1 million long tons of bauxite per year to Japanese customers. Three Japanese aluminum producers, Showa Denko K.K., Nippon Light Metal Co., and Sumitomo Chemical Co., have submitted a feasibility study to the Government for the construction of a 440,000-ton-per-year alumina plant on Bintan Island. The same group has also proposed construction of an aluminum smelter on nearby Sumatra.

Italy.—Società Alluminio Veneto per Azioni SpA. (SAVA) closed its 140,000-ton-per-year alumina plant at Porto Marghera, near Venice, in October. Labor difficulties, which reduced 1971 production to 60 percent of capacity, were cited as a cause. Alusuisse owned 93.5 percent of SAVA.

Construction of the 660,000-ton-per-year alumina plant for Eurallumina S.p.A. on the west coast of Sardinia proceeded on schedule. Raw material for the new plant was scheduled from the Weipa, Australia, deposit. The shareholdings in Eurallumina S.p.A. at yearend were as follows: Alsar S.p.A., 41.67 percent; Montecatini-Edison S.p.A. 20.83 percent; Comalco, 20 percent;

and Metallgesellschaft A.G., 17.5 percent. Alusuisse withdrew its participation in Eurallumina by yearend.

Jamaica.—The bauxite-alumina companies in Jamaica made up of Alcoa Minerals of Jamaica, Inc. (Alcoa), Alcan Jamaica, Ltd. (Alcan), Kaiser Bauxite Co. (Kaiser), Anaconda Jamaica, Inc. (Anaconda), Reynolds Jamaica Mines Ltd. (Reynolds), and Revere Jamaica Alumina, Ltd. (Revere Jamaica), contributed a second installment as part of an overall grant of $780,000 to support the Jamaican Government program to build and equip trade training schools.

At midyear the Government of Jamaica announced that three U.S. mining companies had agreed to pay income taxes based on an imputed profit of $5 per long ton of bauxite exported. A retroactive clause increased former taxes for the three companies by $11.3 million.

Revere Jamaica started operating its new 220,000-ton-per-year alumina plant, the output of which will be shipped to its affiliated Scottsboro, Ala., smelter.

Alumina Partners of Jamaica, Ltd. (Alpart), jointly owned by Kaiser, Reynolds, and Anaconda, were more than three-fourths through with construction to expand their facilities. The new plant, at Nain in St. Elizabeth's Parish, will have a capacity of 1.3 million tons of alumina.

Alcoa's new alumina plant in Clarendon Parish also was nearing completion. This installation will consist initially of two units, each having a rated capacity of 220,000 short tons of alumina per year. With the completion of planned plant expansions, Jamaica should have an annual alumina production capacity of over 3 million tons by 1973.

Japan.—Australia, Indonesia, and Malaysia continued to provide most of the bauxite for the three alumina producers, Nippon Light Metal Co., Showa Denko K.K., and Sumitomo Chemical Co. In December, Showa Denko and Sumitomo reached agreement to increase bauxite purchases from Comalco, Ltd., of Australia in 1972 by 10 percent above the 2 million tons purchased in 1971. To further the exploration and development of overseas sources of aluminum raw materials, the five primary aluminum producers have formed the company, Japan Aluminum Resources Development Corp. (Aldeco).

The three alumina producers reportedly sold 187,000 tons of bagged alumina to the U.S.S.R. in 1971. Nippon Light Metal Co. also reported in October that it agreed to supply 150,000 tons of alumina to Comalco over a 1-year period. The construction of two new alumina plants was continued in 1971. Nippon Light Metal Co.'s plant at Tomakomai, Hokkaido, and Mitsui Alumina's plant at Wakamatsu, Kyushu, were both expected to begin production in 1972.

Malagasy Republic.—Péchiney and the Government signed an agreement to form a joint operation to study bauxite deposits at Manantenina in the south of Madagascar. The deposits were estimated at 70 million tons.

Malaysia.—Bauxite was produced by Southeast Asia Bauxites Ltd., an Alcan subsidiary, and by Ramunia Bauxite Co. Most of the output was exported to Japan.

Solomon Islands (British).—Mitsui Mining and Smelting Co. of Japan concluded an agreement with the Government to mine bauxite on Rennell Island. Reserves of 36 million tons had been proven previously, and the ore was reported to be very low in silica. If sufficient additional reserves can be proven, plans call for eventual production at the 1-million-ton-per-year level.

Conzinc Riotinto of Australia Ltd. continued exploration in the Solomons and announced an estimated 20 million tons of bauxite reserves on Wagina Island. Buku Minerals NL reported discoveries of bauxitic material in two areas on New Georgia Island totaling 11 million tons.

Surinam.—Bauxite exports increased 5 percent in 1971, and exports of alumina increased 31 percent.

The Surinam Parliament in August ratified agreements with Reynolds Metals Co. to develop bauxite deposits in the Bakhuys Mountains and in the Coppename River area, thus formalizing the statement of intent signed in July 1970. The Bakhuys project provides for 50–50 participation between a Surinam Government corporation and Reynolds in the exploration for and mining of bauxite, the production of alumina, and, if a power source is ultimately developed, the construction of reduction facilities. The Government will be expected to provide power, a railroad for transportation of ore to the Corantijn River, and ship-handling facilities.

The Coppename concession at present is entirely under the control of Reynolds, but the Surinam Government has the option of acquiring up to 50 percent in the future.

U.S.S.R.—Prospecting and exploration for bauxite reportedly was carried out on a large scale. In Kazakhstan, new bauxite ore bodies were discovered at Belinski and Aiatski, and new reserves were proved at Krasnooctiabrski. This considerably improved the raw materials base of the Pavlodarski alumina plant. Also, drilling produced new reserves at greater depth and considerably added to ore reserves for operation of the Uralski and Bogoslovski aluminum plants. In the Severooniezhski region, a new large bauxite mine was being developed at Iksinski. High-grade lateritic bauxites, with 50 to 53 percent aluminum content and 1.5 to 3 percent silica, reportedly were found in Western Siberia in the Krasnoyarski region. Laterites were found in the Belgorodski district in Ukraine and at Timan.[3]

The U.S.S.R. also was reported to be seeking major contracts with several Australian and Japanese firms to buy additional supplies of bauxite and alumina. The material would be used to supply new aluminum production facilities in Eastern Siberia near new hydroelectric projects.

Yugoslavia.—The new Titograd alumina-aluminum complex in Montenegro started operations in November with a rated capacity of 220,000 short tons per year of alumina. The Boris Kidric alumina plant at Razine in Croatia, which has been operating at about 80 percent of its 11,000-ton-per-year capacity, reportedly will be closed down.

An alumina-aluminum complex similar in size to the Titograd complex was under construction at Mostar, in Bosnia-Hercegovina. Another 220,000-ton-per-year alumina plant was to be constructed at Obravac near the coast in Croatia to process Dalmatian bauxite. Also planned was an alumina plant to use the high-grade bauxite near Vlasenica, Bosnia-Hercegovina, where reserves of 100 million tons have recently been proved.

TECHNOLOGY

Bulk sampling of ferruginous bauxite deposits in Columbia County, Oreg., carried out by the Reynolds Metals Co. in 1970, provided an opportunity to study the geology of the deposits.[4] The 20- to 40-foot-deep test pits exposed ore (defined in the report as material having no more than 10 percent silica and no less than 30 percent alumina) containing three distinguishable textural zones, referred to in descending order as pisolitic, nodular, and fine-grained. The uppermost pisolitic layer tended to have the highest silica content, but a large proportion was said to be free silica.

The Eufala bauxite-kaolin district in southeastern Alabama, which has been an important commercial source of special grades of bauxite for many years, was investigated by the Geological Survey of Alabama in an attempt to outline the district and extend bauxite reserves. The Bureau of Mines and the University of Alabama assisted in the study which indicated that prospecting in the area for concealed deposits that were covered by later sediments was extremely difficult. However, it was concluded that some geologic features could be recognized and used as guides to increase the probabilities of finding ore deposits with less drilling. Moreover, kaolinitic clays tended to surround the bauxite deposits and could serve as an aid in prospecting.[5]

Detailed investigations of the ferruginous bauxite deposits on Kauai and Maui, Hawaii, confirmed the presence of large quantities of potential aluminum resources on the islands.[6]

[3] Univ. of Utah. Expansion of Russian Mineral Resources. Itermet Bull., v. I, No. 2, October 1971, pp. 15–16.

[4] Jackson, Ronald L. Description of the Bauxite Ore Profile in Columbia County, Oregon. Ore Bin, v. 33, No. 12, December 1971, pp. 223–229.

[5] Clarke, Otis M., Jr. Ore Controls in Eufala Bauxite-Kaolin District. Pres. at 100th Ann. Meeting of the Soc. of Min. Eng., AIME, New York, N.Y., Feb. 26–Mar. 4, 1971, SME preprint No. 71–H–21, 1971, 4 pp.

[6] Patterson, Sam H. Investigations of Ferruginous Bauxite and Other Mineral Resources on Kauai and Reconnaissance of Ferruginous Bauxite Deposits on Maui, Hawaii. U.S. Geol. Survey Prof. Paper 656, 1971, 74 pp.

A process for producing alumina from alunite, which reportedly was to be used commercially, was described.[7] The alunite, a basic sulfate, occurs in the State of Guanajuato, Mexico, in a deposit that contains from 25 to 50 percent alunite, equivalent to 15 percent alumina and 4.3 percent potassium sulfate. At a pilot plant operation capable of processing 5 tons of ore per 24 hours, potassium was dissolved for 10 to 35 minutes in a weak basic solution such as aqueous ammonia and recovered for fertilizer use. The residue, containing the alumina, was treated successively with a weak acid and strong acid, forming a basic aluminum salt and alumina trihydrate, which was filtered and calcined. Aluminum recoveries at the pilot plant reportedly ranged between 90 and 92 percent.

The commercial plant to be built at Salamanca, Guanajuato, will treat 33,000 tons of ore per year and produce 5,500 tons of ammonium sulfate, 2,500 tons of potassium sulfate, and about 4,400 tons of alumina for conversion to aluminum salts. Investment costs for the commercial plant were set at $800,000.

The process developed at Guanajuato was expected to be tested for possible use in producing metallurgical-grade alumina from an alunite deposit in Utah, which was under joint development by Earth Sciences, Inc., Colorado Mines, Inc., and National-Southwire Aluminum Co., a domestic producer of primary aluminum.[8] The resulting alumina reportedly was to be tested at National-Southwire's alumina reduction plant at Hawesville, Ky.

The Bureau of Mines continued research on the recovery of aluminum and sodium from oil shale containing dawsonite and nahcolite. Although the alumina content of the shale being tested was low compared with that in clays and other potential sources of alumina, laboratory tests at the Bureau's College Park Metallurgy Research Center, College Park, Md., have shown that most of the alumina in the shale is readily soluble in hot water.

Reports on the mineralogy of Jamaican bauxites, pilot plant tests to develop optimum process parameters for treating various bauxites, calcination of alumina trihydrate, and other reports related to bauxite processing were presented at the 100th annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, in New York.[9]

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[7] Chemical Week. Alumina Plans to Roll With Rock. V. 108, No. 23, June 9, 1971, p. 44.
Metals Week. Alunite: A Viable Route to Alumina? V. 42, No. 27, July 5, 1971, pp. 6–7.
Parkinson, G. Low-Grade Alunite Yields Alumina and Fertilizers Too. Chem. Eng., v. 78, No. 9, Apr. 19, 1971, pp. 83–85.

[8] American Metal Market. Continue Search for Ingot Material. V. 79, No. 43, Mar. 3, 1972, p. 9.

[9] American Institute of Mining, Metallurgical, and Petroleum Engineers. Proceeding of Symposia, 100th AIME Annual Meeting, Light Metals Committee, Extractive Metallurgy Division. The Metallurgical Soc., AIMF, New York, N.Y., Mar. 1–4, 1971, pp. 3–120.

Beryllium

By Robert A. Whitman [1]

The beryllium industry took several steps to consolidate earnings, diversify, and improve manufacturing capability. A new ore body of bertrandite was opened in Utah. The market for beryl, both domestic and foreign, continued to decline. Increased capability for fabrication should promote increased utilization by industry.

Legislation and Government Programs.—Government yearend stocks of beryl, beryllium-copper master alloy, and beryllium metal are shown in table 2. Government inventories of beryl decreased 224 short tons during 1971, as a result of sales from both the national and supplemental stockpile.

National emission standards for hazardous air pollutants were published in the Federal Register, v. 36, No. 234, dated December 7, 1971. These included standards proposed for beryllium.

Public Law 92–44, approved July 2, 1971, extended the existing suspension of duties for metal scrap, including beryllium, until close of business June 30, 1973.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient beryllium mineral statistics

	1967	1968	1969	1970	1971 p
United States:					
Beryl, approximately 11 percent BeO:					
Shipped from mines ---short tons--	W	168	W	W	W
Imports ---do---	9,511	3,822	6,422	4,942	4,026
Consumption ---do---	7,087	9,244	[1] 8,483	[1] 9,496	10,373
Price, approximate, per unit BeO imported, cobbed beryl at port of exportation---	$30	$34	$37	$35	$33
Bertrandite ore: Utah, low-grade, shipped from mines ---short tons--	--	--	W	W	W
World production of beryl ---do---	5,442	7,242	8,869	8,307	5,553

p Preliminary. NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Includes some bertrandite ore which was calculated as equivalent beryl containing 11 percent BeO.

Table 2.—Government yearend stocks of beryllium materials
(Short tons)

Material	National stockpile	Supplemental stockpile	All stocks
Beryl (11 percent BeO):			
Objective---	12,364	2,851	15,215
Excess---	3,910	1,592	5,502
Total---	16,274	4,443	20,717
Beryllium-copper master alloy:			
Objective---	--	4,750	4,750
Excess---	1,075	1,562	2,637
Total---	1,075	6,312	7,387
Beryllium metal:			
Objective---	--	150	150
Excess---	--	79	79
Total---	--	229	229

Source: Office of Emergency Preparedness. Statistical Supplement, Stockpile Report to the Congress. OEP–4, July–December 1971.

DOMESTIC PRODUCTION

Production of beryllium metal and beryllium oxide increased, but beryllium copper alloy production decreased in 1971. Some beryl ore was produced in South Dakota and Colorado.

Brush Wellman, Inc. (Brush) opened a new deposit of bertrandite ore east of the first deposit and north of Delta, Utah. This mine is the largest domestic source of beryllium ore, although production figures are company confidential data. Brush converts bertrandite ore to beryllium hydroxide in their plant at Delta, Utah. The beryllium hydroxide is shipped to their Elmore, Ohio plant for further conversion to metal, alloys, and compounds.

Kawecki Berylco Industries, Inc. (KBI) used mostly imported beryl as a raw material for producing metal. KBI also purchased the refining and manufacturing facilities of General Astrometals Co. in Yonkers, N.Y.

CONSUMPTION AND USES

The beryllium and ceramics industries consumed beryllium ore equivalent to 10,373 tons of beryl containing 11 percent BeO. Kawecki Berylco Industries, Inc., at Hazelton, Pa., and Brush Wellman, Inc., at Elmore, Ohio, converted beryl to beryllium metal, alloys, and compounds. KBI also produced alloys and compounds at its Reading, Pa., plant. Brush likewise converted the beryllium hydroxide produced from bertrandite at its plant at Delta, Utah, into metal, alloys, and compounds.

Beryl Ores, Arvada, Colo., processed beryl ore for use in the ceramics industry. Lapp Insulator Co., LeRoy, N.Y., used beryl for ceramic purposes.

The U.S. Atomic Energy Commission awarded 94 contracts, and increases to existing contracts, for beryllium parts and materials totalling $10.2 million in fiscal year 1971. There were 52 contracts for $3.5 million awarded during fiscal year 1970.

The Report of the Ad Hoc Committee on Beryllium of the National Materials Advisory Board (NMAB–281) [2] examined the role of the Department of Defense in using beryllium and advancing its technology. Table 1 in the report lists 63 current and potential beryllium applications under seven categories. Opposite each item is noted the relevant load-strain-density, thermal-physical, nuclear, and special properties for each use. Another publication which gave more detailed descriptions of specific applications was Proceedings of the Beryllium Conference (NMAB–272).[3]

STOCKS

Consumers' stocks of hand-sorted beryl at yearend totaled 6,299 tons, compared with 5,698 tons at yearend 1970. Dealers' stocks of beryl are not reported. Stocks of bertrandite ore are company confidential data.

PRICES AND SPECIFICATIONS

Domestic beryl prices were negotiated between producers and buyers and were not quoted in the trade press. The price of imported beryl generally was negotiated. The nominal published price was $37 to $40 per ton in January; it dropped to $35 to $37 per ton in June, where it remained throughout the rest of 1971.[4]

Prices for beryllium mill products remained steady throughout 1971. Metal powder of 98 percent purity, delivered, was $54 to $66 per pound. Rod with 5-inch diameter held at $102 per pound, with billet at $70 per pound.

Beryllium copper master alloy started the year at $50 per pound of contained beryl-

[2] National Materials Advisory Board. Report of the Ad Hoc Committee on Beryllium. NMAB–281, October 1971, 93 pp; available from National Technical Information Service, Springfield, Va., 22151.

[3] National Materials Advisory Board. Proceedings of the Beryllium Conference. V. 1, NMAB–272, July 1970, 655 pp.

[4] Metals Week. V. 42, Nos. 1–52, January–December 1971.

lium, with the copper at the current market price. In mid-February the price rose to $53 per pound of contained beryllium, the level at which it remained for the rest of 1971. Casting ingot containing 2 to 2.25 percent beryllium is quoted in 1-ton lots for 5-pound ingots. The quoted price began the year at $2 per pound, rose to $2.03 on February 1 and to $2.06 on April 12, where it remained for the duration of 1971. The price quoted for Alloy 25 in the form of strip, rod, bar, and wire was $2.93 per pound in January, $3.02 per pound February 1, and $3.05 per pound through December of 1971.

FOREIGN TRADE

Beryllium exports decreased less than 1 percent in 1971 from the level of the previous year. There was a 19-percent drop in imports of beryl, with a 5-percent drop in the unit price. There were no reported imports of beryllium compounds or metal as in previous years.

Table 3.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap [1]

Country	1970		1971	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Australia	--	--	87	(2)
Brazil	77	$4	--	--
Canada	11,340	50	495	$45
Denmark	140	3	--	--
France	9,050	295	5,560	171
Germany, West	960	121	2,453	31
India	--	--	2,499	2
Israel	17	(2)	600	67
Italy	44	1	28	5
Japan	8,671	226	6,658	126
Korea, Republic of South	8	1	--	--
Mexico	500	2	--	--
Netherlands	347	2	244	2
New Zealand	16	(2)	--	--
Norway	--	--	12,000	12
Spain	44	2	--	--
Switzerland	4	(2)	760	4
United Kingdom	10,131	314	9,730	586
Yugoslavia	4	(2)	--	--
Total	41,353	1,021	41,114	1,051

[1] Consisting of beryllium lumps, single crystals, and 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 countries

Customs district and country	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Philadelphia district:				
Argentina	275	$107	248	$84
Australia	61	26	59	22
Brazil	3,411	1,340	2,342	889
Burundi-Rwanda	50	18	[1] 120	36
Congo (Brazzaville)	--	--	23	7
Kenya	--	--	88	32
Malagasy Republic	34	11	16	5
Mozambique	171	67	163	55
Portugal	27	10	11	4
Romania	25	8	--	--
South Africa, Republic of	294	101	593	222
Uganda	373	132	224	67
Western Africa, n.e.c	23	10	--	--
Total	4,744	1,830	3,887	1,423
New York City district:				
Australia	--	--	21	7
Brazil	165	68	23	10
Congo (Brazzaville)	--	--	23	7
Spain	--	--	4	1
Uganda	33	13	--	--
Total	198	81	71	25
Baltimore district: Brazil	--	--	47	19
Boston district: France	(2)	1	--	--
Detroit district: Canada	--	--	17	6
Norfolk district: Australia	--	--	4	2
Grand total	4,942	1,912	4,026	1,475

[1] Rwanda became separate country effective Jan. 1, 1971.
[2] Less than ½ unit.

WORLD REVIEW

Argentina.—In December, the Minister of Industry and Mining presided over the opening of bids on four mineral projects. The one which could apply to beryllium was a 100,000-peso contract for a feasibility study of concentration plants for mineral derivatives from pegmatites.

France.—Trifimetaux-Berylco was jointly established by Trifimetaux GP (Pechiney Group) of France and Kawecki-Berylco Industries, Inc. of the United States for the production of copper and beryllium alloy castings. The new company has a capitalization of 5 million francs.

India.—Estimates of beryl production in India have been discontinued because world trade figures would indicate great difficulty in disposing of the estimated production.

Table 5.—Beryl: World production, by countries

(Short tons)

Country [1]	1969	1970	1971 p
Argentina	571	333	e 330
Australia	r 8	20	e 30
Brazil	[2] 3,964	[2] 3,674	e 2,450
India e	1,450	1,450	NA
Kenya	3	4	e 4
Malagasy Republic	83	57	e 55
Mozambique	134	36	e 33
Portugal	32	15	18
Rhodesia, Southern e	100	100	100
Rwanda	r 324	315	e 265
South Africa, Republic of	345	355	541
Uganda	r 315	405	243
U.S.S.R. e	1,380	1,400	1,400
United States (mine shipments)	W	W	W
Zaire (formerly Congo-Kinshasa)	160	143	84
Total	8,869	8,307	5,553

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, the Territory of South-West Africa also may have produced beryl, but mineral production of this area has not been officially reported since 1966 and no reliable information is available as a basis for estimating output since that time.
[2] Exports.

TECHNOLOGY

Improvements in the forming of beryllium parts are important, since fabrication is a major part of the cost of using beryllium. Lockheed Missiles & Space Co., Sunnyvale, Calif., designed a large milling cutter with 12 right-hand cut, left-hand helix replaceable carbide blades. The new 12-blade cutter drastically reduced machining time, taking a 0.250-inch depth of cut at 39 rpm with a feed rate of 6 inches per minute. It provides a finish to parts.

A Canadian patent reported the use of an aqueous solution of sodium carbonate and bicarbonate, with pH adjusted from 9.5 to 10.5, to leach beryllium as well as molybdenum, vanadium, or tungsten, from their respective ores.[5] Also noted were American patents for a procedure for chill-casting beryllium composites,[6] one for electrochemical cutting of beryllium,[7] a patent on a new alloy composition,[8] and another patent on ore leaching in the basic pH range.[9]

One of the factors limiting the use of beryllium is its brittleness. Research to reveal the reasons for cracking during fabrication and to detect incipient failure was discussed in two articles in Metallurgical Transactions.[10] Precipitation in the beryllium-iron system was the subject of an article discussing precipitation phenomena.[11]

A study of the deposition of beryllium as an ore was reported.[12]

The Bureau of Mines conducted research to develop alloys utilizing the low density, high heat capacity, mechanical strength, corrosion resistance, and stiffness of beryllium. Preliminary findings on alloys with additions of Ni-Al were reported.[13] A report on the electrolytic preparation of beryllium-copper alloys was published.[14]

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[5] Bauer, W. C., and C. K. Amano (assigned to FMC Corp.). Alkaline Leaching. Canadian Pat. 860,863, Jan. 12, 1971.

[6] Richmond, William J., Leonard B. Griffith, and Vernon C. Mallory (assigned to P. R. Mallory & Co., Inc.,). New Procedure for Chill Casting Beryllium Composite. U.S. Pat. 3,548,195, Dec. 22, 1970.

[7] Distler, William B. and Harold J. Wiesner (assigned to U.S. Atomic Energy Commission). Electrochemical Process for Cutting Beryllium. U.S. Pat. 3,556,963, Jan. 19, 1971.

[8] Stonehouse, Albert J. (assigned to Brush Wellman, Inc.). Beryllium-Antimony Composition. U.S. Pat. 3,574,608, Apr. 13, 1971.

[9] Hanson, C. K. and M. E. Wadsworth (assigned to the University of Utah). Alkaline Leaching of Siliceous Beryllium Ores. U.S. Pat. 3,615,260, Oct. 26, 1971.

[10] Armstrong, R. W. and N. R. Borch. Thermal Microstresses in Beryllium and other HCP Materials. Met. Trans., v. 2, No. 11, November 1971, pp. 3073–3077.

Glass, H. L. and S. Weissman. Application of the X-ray Synergy Method to Analysis of Room Temperature Compression of Beryllium Crystals. Met. Trans., v. 2, No. 10, October 1971, pp. 2865–2874.

[11] Levine, E. and G. Lutjering. Precipitation in the Beryllium-Iron System. J. Less-Common Metals, v. 23, No. 4, April 1971, pp. 343–357.

[12] Clark, A. H. Early Beryllium-Bearing Veins, South Crofty Mine, Cornwall. Inst. Min. Met. Trans., sec. B., v. 79, No. 765, August 1970, pp. 173–175.

[13] Armentrout, C. E., and C. O. Sims. Selected Properties of Beryllium-Rare Alloys Consolidated by Vacuum-Arc Melting. J. Vacuum Sci. and Technol., v. 8, No. 6, November–December 1971, pp. 23–28.

[14] Kirby, D. E., D. A. O'Keefe, and T. A. Sullivan. Electrolytic Preparation of Beryllium-Copper Alloys. BuMines Rept. of Inv. 7629, 1972, 14 pp.

Bismuth

By Charlie Wyche [1]

Consumption of bismuth in the United States declined sharply in 1971. Total consumption decreased about 561,000 pounds, 25 percent less than that of 1970. The most pronounced drop was in pharmaceuticals, reflecting substitution for bismuth in medicinal, catalytic, and cosmetic applications. The oversupply condition, resulting from the decline in consumption, brought several price reductions during the second half of the year. In 1971 domestic production of refined bismuth metal dropped compared with the previous year. As a result of the oversupply, Government sales to consumers totaled only 15,500 pounds during 1971, although the General Services Administration's (GSA) authorization to sell up to 150,000 pounds of bismuth each calendar quarter from the national stockpile remained in effect. Bismuth exports were over 71,000 pounds during the year, or about 8 percent of the total exported in 1970. Consumer stocks increased from 722,000 to 1,107,200 pounds, and total general imports, principally from Mexico, Japan, Peru, and Canada were down 23 percent compared with those of 1970.

Legislation and Government Programs.—GSA, as authorized under Public Law 90-153, enacted November 30, 1967, continued the disposal of surplus Government stocks of bismuth at the rate of 150,000 pounds each calendar quarter. Sales were conducted on an off-the-shelf basis at market prices at the time of offering. Purchasers had to agree that the bismuth was for domestic consumption and that exports would not exceed the smallest quantity exported in any of the three preceding quarters. Of the 15,500 pounds sold during 1971, 5,500 pounds were sold in the first quarter and 10,000 pounds during the second quarter; no sales were made in the third and fourth quarters. Total sales from Government stocks in 1970 amounted to 553,000 pounds. Prices to domestic consumers of bismuth metal and to domestic alloyers, compounders, and catalyst makers were $6 per pound, in ton lots; through July 11, the price was reduced to $4.75 per pound effective July 12, and to $3.50 in November.

Through the Office of Minerals Exploration (OME), U.S. Geological Survey, the Government continued to offer financial assistance in the form of a loan of up to $250,000 for 75 percent of bismuth exploration costs.

Federal income tax laws provide a 23-percent depletion allowance to domestic bismuth producers and a 15-percent allowance to U.S. companies producing from foreign sources.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient bismuth statistics

(Pounds)

	1967	1968	1969	1970	1971
United States:					
Consumption	2,513,652	2,347,768	2,531,959	2,209,641	1,648,718
Exports [1]	152,684	120,466	447,931	910,275	71,187
Imports, general	1,379,729	1,265,671	894,804	997,924	848,708
Price: New York, average ton lots	$4.00	$4.00	$4.63	$6.00	$5.26
Stocks Dec. 31: Consumer and dealer	659,600	621,500	597,901	[2] 721,714	[2] 1,107,215
World: Production	7,441,000	8,312,000	8,289,000	8,408,000	7,891,000

[1] Includes bismuth, bismuth alloys, and waste and scrap.
[2] Consumer stocks only.

DOMESTIC PRODUCTION

Domestic bismuth production is obtained largely as a refinery by-product from domestic and foreign lead, copper, and zinc ores. American Smelting & Refining Co. at its Omaha, Neb., plant, and the East Chicago, Ind., plant of U. S. Smelting, Refining, & Mining Co. produced most of the U.S. primary production. Although specific details were not available, more than 50 percent of the domestic production of bismuth was obtained from processing imported raw materials. Secondary smelter recovery of bismuth from scrap, alloys, chemicals, spent catalysts, and other secondary materials accounted for about 4 to 7 percent of U.S. annual production. A small quantity of metallic bismuth was produced from secondary sources at Franklin Park, Ill., by United Refining & Smelting Co.

Data relating to U.S. refinery production are withheld because individual company confidential data would be disclosed. Total refinery production, however, at the two primary and one secondary plant decreased about 15 percent below the 1970 level.

CONSUMPTION AND USES

Domestic consumption of bismuth continued the downward movement initiated in 1970, with the combined total of the three major categories well below the quantity used that year. The 1.6 million pounds used principally for pharmaceuticals, fusible alloys and metallurgical additives, represents a decline of 27 percent in comparison with the previous year.

Pharmaceutical requirements, mainly cosmetics and therapeutic agents, comprised the largest end-use market in 1971. The cosmetic use of bismuth, regarded once as a temporary fad, is now an established end use. Bismuth oxychloride is the chemical compound used to produce the pearlescent pigment that goes into cosmetic preparations. The pearlescent look in eye shadow, lipstick, powders, hair spray, and some nail polishes accounted for about 350,000 pounds of bismuth in 1971. Therapeutically, bismuth-based indigestion remedies and numerous other medicinal compounds were widely used. Annual usage has been estimated at about 175,000 pounds. Bismuth-molybdate catalyst used in a process for making acrylonitrile continued the decline started in 1966, when a non-bismuth catalyst was substituted.

Fusible alloys, consisting of bismuth and various quantities of lead, tin, cadmium, and indium remained the second largest use area and the principal metallurgical use for bismuth. The alloys were used in safety devices, temperature regulators, molds for plastic casting and forming, tools, and fixtures; in addition, uses included joining and holding applications. Recently, attempts were made by aircraft engine manufacturers to use nonbismuth alloys for turbine blade holding devices, but bismuth alloys proved to be the most economical.

In alloys other than fusible types, bismuth was used primarily as a metallurgical additive to improve machinability of aluminum, carbon steel, and malleable iron.

Table 2.—Bismuth metal consumed, in the United States, by uses

(Pounds)

Use	1970	1971
Fusible alloys [1]	643,691	514,203
Metallurgical additives	361,484	362,527
Other alloys	12,998	17,439
Pharmaceuticals [2]	1,183,035	724,592
Experimental uses	109	26,175
Other uses	8,324	3,782
Total	2,209,641	1,648,718

[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

Reporting dealer stocks of bismuth, representing less than 10 percent of combined consumer-dealer stocks, was discontinued at the close of 1969. Therefore, yearend stocks shown in table 1 for 1970 and 1971 are not directly comparable with figures given for previous years. Stocks of bismuth metal held by consumers were 721,700 pounds at the beginning of 1971, which increased to 790,000 pounds by midyear. At yearend metal stocks at domestic consumers totaled 1,107,200 pounds.

PRICES

The delivered price of refined bismuth metal held firmly at $6 per pound, in ton lots through the first half of 1971. The price, however, was reduced for the first time in many years, when the two principal U.S. companies dropped their price from $6 to $4.75 per pound, in ton lots, in July and to $3.50 in November. The new domestic price of $3.50 per pound continued in effect throughout the remainder of 1971.

The London Metal Exchange (LME) price for imported bismuth metal, c.i.f., was quoted in the range of $5.55-$5.70 per pound through February, but dropped to $5.45-$5.50 in early April. The price held through May but resumed the downward trend in June to the $3.55-$3.75 level. The European market continued to grow weaker during the summer and fall months and was quoted in the range of $2.98-$3.03 per pound at yearend.

FOREIGN TRADE

In 1971, exports of bismuth in all forms to 20 countries amounted to 71,000 pounds gross weight, declining drastically from the 910,000 pounds exported in 1970. The sharp decrease in bismuth exports valued at $200,000 was attributable to the relatively low LME price. Canada, the United Kingdom, and India received 64 percent of the exports, and other countries of Western Europe took 20 percent. Argentina, Brazil, and Mexico imported 11 percent of U.S. bismuth and other countries took the remaining 5 percent.

General imports of bismuth metal in 1971 amounted to 848,700 pounds, approximately 85 percent of the amount imported in 1970. The decline was especially evident in the receipts from Peru and Mexico. The 800-percent increase from Japan failed to offset the decrease from these two major suppliers. In addition to imports of bismuth metal, nearly 472,000 pounds gross weight of bismuth in bismuth-lead alloys containing more than 30 percent lead was imported from Mexico, in comparison with about 844,000 pounds in 1970. The 44-percent drop compared with 1970 reflects the absence of shipments from Peru. Imports of bismuth compounds totaling 6,400 pounds gross weight were from Japan, West Germany, France, United Kingdom, and Canada. The total bismuth content of imported alloys and compounds is not known.

Table 3.—U.S. exports of bismuth [1]

Year	Gross weight (pounds)	Value
1968	120,466	$292,245
1969	447,931	1,515,363
1970	910,275	2,332,423
1971	71,187	199,084

[1] Includes bismuth, bismuth alloys, and waste and scrap.

Table 4.—U.S. general imports of metallic bismuth, by countries

Country	1970		1971	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Belgium-Luxembourg	4,415	$35	40,579	$171
Canada	109,909	642	87,985	374
Italy	--	--	2,216	8
Japan	24,998	168	228,491	1,047
Korea, Republic of	--	--	28,675	153
Mexico	364,962	1,923	251,591	1,135
Netherlands	221	3	15,400	78
Peru	491,118	2,842	191,732	1,074
United Kingdom	2,301	23	2,039	10
Total	997,924	5,636	848,708	4,050

WORLD REVIEW

The oversupply situation and the slackening demand in the industrialized areas of the world resulted in a weak market and several price reductions. World production of bismuth metal in 1971, excluding data withheld for the United States, has been estimated at 7.9 million pounds, compared with 8.4 million pounds in 1970. Because of the byproduct relationship of bismuth to copper, lead, molybdenum, and zinc ores, future production is expected to continue increasing as the demand for the host metals increase. Japan was again the principal producer of metallic bismuth, largely from imported raw material. Bolivia was the largest producer of bismuth-in-ore and was followed by Peru, Mexico, and the United States. Peru was also a leading producer of refined bismuth metal. The United States produces a large quantity of metal from domestic and foreign ores and from secondary material. The United States consumes about one-fourth of the world production, followed by Japan, France, and other European countries.

Table 5.—Bismuth: World production by countries [1]

(Thousand pounds)

Country	1969	1970	1971 p
Argentina (in ore)	2	(2)	e 1
Australia (in concentrates)	r 441	433	e 500
Bolivia [3]	r 1,338	1,340	e 1,440
Canada [4]	579	590	267
China, People's Republic of (in ore) e	r 550	550	550
France (metal)	137	159	e 165
Germany, West (in ore) e	26	29	28
Italy (metal) e	22	22	22
Japan (metal)	1,531	1,495	e 1,445
Korea, Republic of (metal)	245	234	214
Mexico [4]	1,336	1,259	e 1,260
Mozambique (in ore)	r 5	3	e 3
Peru [4]	1,500	1,777	e 1,435
Romania (in ore) e	r 180	r 180	180
South Africa, Republic of	(2)	--	--
Spain (metal)	r 26	26	e 26
Sweden (in ore) e	33	33	33
Uganda (in ore)	e 2	e 2	--
U.S.S.R. (metal) e	110	110	120
United States	W	W	W
Yugoslavia (metal)	226	166	202
Total	r 8,289	8,408	7,891

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 Corporacíon Minero de Bolivia (COMIBOL) and exports by medium and small mines.

[4] Bismuth content of refined metal and bullion and recoverable content of concentrates exported.

Australia.—Mine production in 1971 was about 500,000 pounds, all of which was exported to Japan for refining, and is expected to expand within the next year. Active exploration and expansion work, mainly by Peko Wallsend Investments Ltd. is continuing, particularly at Tennant Creek, in the Northern Territory. In 1970, the company began an expansion project, which was to include an Outokumpu flash smelter and bismuth recovery plant at Tennant Creek. The new plant is expected to start operating in 1973 and will treat ores from the Juno and nearby Warrego mines. The plant will have a rated annual bismuth production capacity of 3 million pounds. Reserves of copper-gold-bismuth ore at the Juno mine were estimated at 275,000 tons assaying 0.65 percent bismuth and 2.2 ounces of gold per ton. The Warrego mine has reserves of 5 million tons averaging 0.30 percent bismuth.

Belgium.—Two giant base-metal complexes, Société Géneral Métallurgie de Hoboken, S.A., and Société des Mines et Fonderies de Zinc de la Vieille-Montagne S.A. produced refined bismuth metal. Most of the bismuth was refined from imported ores and a large portion exported to the consuming industries of neighboring countries.

Bolivia.—Bolivia is one of the few areas where ores, which run as high as 40 percent bismuth, are mined for bismuth alone. A decline in lead production would not affect the Bolivian bismuth industry. Bismuth ores and concentrates, which in the past have been exported to Peru and Europe for treatment, will soon be processed at a Bolivian smelter. The smelter will be built in Telemayo by Reunione Poudriere Belgique of Belgium. The operation, which is scheduled to begin in 1972, will produce, in the initial phase, a crude bismuth bullion to be exported for further refining.

Canada.—Bismuth is obtained in Canada as a byproduct in the processing of ores mined for other metals. The most important sources are molybdenum ores mined in the Malartic district of western Quebec, lead-zinc ores produced in southeastern British Columbia, and copper ores mined near Gaspé in eastern Quebec. Molybdenite Corp. of Canada Ltd., Preissac Molybdenite Mines Ltd., and Cadillac Moly-Mines Ltd. produced about 60 percent of the Canadian output from molybdenum ores. This bismuth was recovered as concentrates and treated as far as the crude-metal step and exported for commercial upgrading. Of the remainder of its bismuth production, about 35 percent, was produced from lead-zinc ores at Trail by Cominco Ltd. and 5 percent was recovered from copper smelting flue dust by Gaspé Copper Mines Ltd.

France.—Crude bismuth was recovered as a byproduct of lead-zinc production at both Société des Mines & Usines de Salsigne and Société Minière et Métallurgique de Peñarroya. The crude bullion (98 percent bismuth) was exported to the United Kingdom for refining.

Japan.—Although a leading producer of bismuth metal, a sizeable portion of the output from the eight metallurgical plants came from imported base-metal ores, concentrates, and smelter products. Most of the domestic production is a byproduct of copper and lead mining.

Mexico.—Almost all Mexican bismuth production was from lead refinery byproducts recovered by Met-Mex Peñoles, S.A., and Asarco Mexicana S.A. at Monterrey. Approximately one-half of the crude output was refined to metal, which was consumed in domestic chemicals, pharmaceuticals, and the alloy industries. Unrefined bismuth was exported as bullion to the United States and the United Kingdom.

Peru.—Bismuth associated with the Peruvian base-metal ores was recovered mainly by Cerro Corp. at the vast metallurgical complex at La Oroya. Additional Peruvian production was obtained from many other smaller producers. The concentrate products from these mines, together with some Bolivian copper-bismuth ores were smelted and refined in Peru. Virtually all Peruvian refined bismuth was exported to the Latin American Free Trade Association, Europe, and the United States.

Boron

By K. P. Wang [1]

Production and domestic consumption of boron minerals continued the rising trend that began in 1961 and reached a new high in 1971. However, recorded exports declined sharply as compared with the previous 2 years. For some time, all U.S. output had been in the form of sodium borates (such as "tincal" and kernite) and boric acid. In mid-1971 production of calcium borate (colemanite) was started on a commercial scale in California, the same State which provides the entire domestic production of boron minerals.

Legislation and Government Programs.—During 1971 there were no Government programs and no legislation proposed or enacted pertaining to boron. The Government had no stocks of boron, and no procurement programs for borates were in effect in 1971. All Government stocks had been sold in 1967.

The depletion allowance remained at 14 percent for both domestically and foreign-produced borates in accordance with the Tax Reform Act of 1969.

Table 1.—Salient boron minerals and compounds statistics in the United States
(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
Sold or used by producers:					
Quantity					
Gross weight	892	963	1,020	1,041	1,047
Boron oxide	473	519	551	562	568
Value	$69,819	$76,535	$81,261	$86,827	$89,856
Imports for consumption: [1]					
Quantity	27	19	r 24	r 27	7
Value	r $684	r $558	r $718	r $831	$233

r Revised.
[1] Colemanite only.

DOMESTIC PRODUCTION

Domestic production and sales of boron minerals increased very slightly in 1971 as compared with 1970. As in past years, most of the output came from Kern County, Calif., and to a lesser extent from San Bernardino County, Calif.

A large open pit mine at Boron in Kern County, belonging to the U.S. Borax & Chemical Corp., a subsidiary of Rio Tinto Zinc Corp. Ltd., remained the world's foremost source of boron. U.S. Borax produced an upgraded crude sodium borate at the mine site and refined borates at plants located at Wilmington, Calif., and Burlington, Iowa. Wilmington was also the company's port of export. A new processing line and two new thickeners installed at Boron raised processing capacity by one-fifth in 1971. U.S. Borax's plant capacity in the United States in 1971 topped 500,000 short tons of B_2O_3 per year. The firm maintains a storage center at Botlek in the Netherlands whence borax and borates are transported to other parts of Europe.

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 plants in Trona, Calif. American Potash's plant production is rated at 100,000 short tons of B_2O_3 per annum and that of Stauffer Chemical's plant at 25,000 to 30,000 tons per annum.

[1] Supervisory physical scientist, Division of Nonmetallic Minerals.

During 1971, the Tenneco Oil Co. started to produce colemanite commercially from its deposit in the Furnace Creek district of Inyo County, Calif. Prior to that time, small-scale extraction of colemanite was for testing purposes only. Tenneco built a full-scale plant of 150,000 short tons of raw colemanite per annum at a location 10 miles north of Death Valley Junction, Calif., and made the first shipment of calcined colemanite to Owens-Corning Fiberglass Corporation in Toledo around late July.[2]

Occidental Petroleum Corp. was scheduled to become the third borate-producing company near Searles Lake before yearend 1972 with a plant to be operated by Hooker Chemical Corp., a subsidiary. Borax, soda ash, and potassium sulfate are to be produced by a solar evaporation process. Occidental's new plant will have an annual capacity of 60,000 to 65,000 short tons of B_2O_3, intermediate in size when compared with the two existing plants near Searles Lake.[3]

CONSUMPTION AND USES[4]

About half of the U.S. output of boron minerals and compounds was consumed at home, and the other half was exported. Official U.S. trade statistics reveal only the exports of refined products and imply that consumption may be larger than credited. Actually, shipments of unfinished products abroad, usually to affiliated companies, were larger than those of fully refined products.

Glasses, enamels, soaps and detergents, and agricultural chemicals were the major categories of boron consumption. An estimated 40 percent of the boron consumed went into the production of heat-resistant glasses, insulation glass fibers, and textile glass fibers, with approximately 15 percent each in the first two categories and 10 percent in the third. 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 percent of the boron consumption.

Approximately 15 percent of the boron compounds consumed in the United States went into soaps and cleansers during 1971. Borax and boric acid were used in soaps, cleansers, and detergents because of their bactericidal characteristics, easy solubility in water, and excellent water-softening qualities. These same properties make the boron compounds mentioned above useful in the manufacture of toothpaste, mouthwash, and eyewash. Late in the year it was suggested that boron detergents may be harmful to vegetation and sewage treatment. In agriculture, borax was added to fertilizers to supply boron as an essential plant nutrient and also utilized in making herbicides. Boron compounds consumed in agriculture accounted for just under 10 percent of the boron demand.

Boron compounds, being excellent fluxing materials, were used in welding, soldering, and to some extent, in metal refining. A small percentage of the boron compounds was consumed in this manner during 1971. Boron minerals did not make much headway even on an experimental basis, because the fluorspar shortage was alleviated temporarily as a result of cutback in world steel and of oversupply in aluminum.

About one-fourth of the boron consumed in the United States went into many miscellaneous uses. Use of boron compounds in abrasives gained ground. Boron carbide was used in the manufacture of abrasion-resistant parts of spray nozzles, bearing liners, and furnace parts, and as an abrasive for ultrasonic grinding and drilling. Cubic boron nitride, with a hardness approaching that of diamond and with better heat resistance, was making headway as a new abrasive. Boron nitride was also used as a thermal insulator and as a mold lubricant in glass manufacture.

Increasing use was being made of boron trichloride as a catalyst in silicone production, as a synthesis intermediate, and as an extinguishing agent for magnesium fires. Boron trifluoride was used as a catalyst for many organic reactions. Borate esters were used to a growing extent as dehydrating agents, synthesis intermediates, special solvent, and catalysts. Boron compounds were used as plasticizers, adhesive additives for latex paint, and fire retardants in plastics and protective coatings. Water solutions of borax were used in cleansing and dyeing leather and textiles.

Other uses of boron included compounds

[2] Chemical Week. V. 109, No. 6, Aug. 11, 1971, p. 39.

[3] Industrial Minerals. Occidental's Searles Lake Borax. No. 45, June 1971, p. 35.

[4] Stanford Research Institute. Chemical Economics Handbook. Boron Minerals and Chemicals. May 1970, 88 pp.

added to alloy steels to increase hardenability. Some elemental boron was used as a deoxidizer in nonferrous metallurgical reactions, 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.

PRICES

Prices of virtually all borate products at yearend 1971 were the same as the prices posted for yearend 1970. Elemental boron prices were quoted at yearend 1971 by the American Metal Market as follows, per pound, in ton lots: 90 to 92 percent, $13; 97 to 99 percent, $18; and over 99 percent, $70. Prices of various kinds of borates are shown in table 2.

Table 2.—Borate prices at yearend, 1971

	Per short ton [1]
Borax, technical:	
Anhydrous, 99 percent:	
Bags	$113.00
Bulk	103.25
Granular, decahydrate, 99.5 percent:	
Bags	64.75
Bulk	56.25
Granular, pentahydrate, 99.5 percent:	
Bags	83.75
Bulk	75.25
Boric acid, technical: [2]	
Anhydrous, 99.9 percent, bags [3]	197.00
Crystals, 99.9 percent, bags	253.00
Granular, 99.9 percent, bags	138.00
Sodium borate powder, U.S.P., bags	117.25

[1] Carlots, f.o.b. plant works.
[2] Technical boric acid $33 per ton higher in drums.
[3] Anhydrous and granular $10 to $12 per ton lower in bulk.

Source: Oil Paint and Drug Reporter and industry sources.

FOREIGN TRADE

U.S. exports of boric acid in 1971 declined 31 percent in quantity and 21 percent in value compared with 1970 data. In contrast, exports of refined sodium borate decreased only 8 percent in quantity and, in fact, increased 1 percent in value.

The largest tonnages of both boric acid and refined sodium exports were consigned to Japan and the Netherlands. Detailed breakdown data by countries are given in table 3. In addition to the exports listed in table 3, more than 100,000 tons of unrefined sodium borate was exported. Specific data are company confidential and may not be published.

In 1971 the United States imported 7,369 short tons of calcium borate (colemanite) valued at $232,770, all from Turkey; in 1970 imports of colemanite from Turkey were 27,336 short tons. The United States also imported boron carbide and boron metal during 1971, specifically 18 short tons of boron carbide valued at $56,098 primarily from Canada and West Germany, and 293 pounds of boron metal valued at $26,084 mainly from West Germany.

Table 3.—U.S. exports of boric acid and sodium borates, in 1971 [1]

Destination	Boric acid (H_3BO_3 content)		Sodium borates (refined) [1]	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	2,646	$416	6,524	$656
Belgium-Luxembourg	--	--	392	22
Brazil	988	169	2,321	292
Canada	4,236	544	10,658	1,030
Chile	188	30	512	65
Colombia	532	83	851	96
Costa Rica	--	--	806	79
El Salvador	--	--	204	28
Finland	--	--	248	29
France	--	--	8,021	899
Germany, West	646	74	139	11
Hong Kong	182	27	5,550	647
Indonesia	--	--	156	15
Israel	43	5	723	76
Italy	42	10	661	74
Japan	13,367	1,939	47,393	5,118
Korea, Republic of	442	73	2,520	207
Mexico	1,754	277	7,069	783
Netherlands	8,195	1,297	54,179	6,968
New Guinea	306	48	167	21
New Zealand	321	49	3,261	506
Pakistan	137	22	90	9
Peru	72	13	614	64
Philippines	561	86	1,036	122
Singapore	--	--	275	32
South Africa, Republic of	86	19	606	98
Spain	--	--	489	56
Sweden	171	24	352	26
Switzerland	--	--	734	43
Taiwan	247	37	2,361	214
Thailand	90	16	532	57
United Kingdom	--	--	714	40
Venezuela	441	76	301	27
Vietnam, South	376	58	2,436	178
Yugoslavia	44	12	2,122	253
Other	296	53	1,070	113
Total	36,409	5,457	166,087	18,954

[1] Revisions for 1970: Yugoslavia should read 4,961 tons ($531) and total should read 180,589 tons ($18,745). Excludes unknown quantities of crude sodium borate and other borate compounds estimated to be over 100,000 tons, but exact data are not available.

WORLD REVIEW

Argentina.—During 1971, Argentina was the only South American country producing borates, Chile having discontinued operations a few years back. Argentina's 1971 output data for sodium borates have not yet been made available. In 1970, however, production was officially reported at 47,744 short tons, up 36 percent from 1969.

By far the largest producer is Boroquimica Limitada, another subsidiary of Rio Tinto Zinc Corp., with an open pit mine at Tincalayu and a refinery at Campo Quijano, both in Salta Province. An ore development program has taken place in recent years to expand production. Also, plans were being made to produce boric acid, in addition to sodium borates. More than half of the output is exported, almost entirely to neighboring countries within the Latin American Free Trade Association, principally to Brazil.

China, Peoples Republic of.—Sodium borate has been produced as one of the many products from extensive lake salt deposits in the Iksaydam area of Sinkiang Province. Although data are not available, annual output of sodium borate and/or boric acid may be many thousand tons. In 1970 Japan imported 940 metric tons of boric acid and 613 metric tons of sodium borate from mainland China.

Turkey.—Turkey's 1971 output of boron minerals (virtually all colemanite) showed little change from the approximately 428,000 short tons (grade 42 to 44 percent B_2O_3) produced in 1970. The sharp production growth that had taken place in recent years did not continue in 1971 because of the sluggish world demand for boron and difficulty in product quality control within Turkey. A proposed beneficiating plant at Emet to replace handcobbing was still on the drawing board. About half of Turkey's colemanite production in 1970–71 was accounted for by the

Turkish Government-owned company, Etibank, which works the Emit operations.

In the fall of 1971, the Turkish Government announced its intention to nationalize the boron industry which means taking over operations of the Türk Boraks Madençilik Co., subsidiary of Rio Tinto Zinc Corp. and by far the leading private producer with mines in the Killick district, the Rasih ve Ihsan Co. with mines in the Balikesir district, and the Kemad Co. affiliated with the American Potash & Chemical Corp. The Government also indicated a willingness to reimburse them to the value of their original investment.[5]

Late in 1971, however, opposition in parliament caused a group of ministers in the cabinet to resign. Thus, the policy of nationalization was apparently reversed. Subsequently, Prime Minister Erim also dropped a plan to limit the entry of foreign capital and, in fact, welcomed it.[6]

U.S.S.R.—Boron minerals are produced from deposits north of the Caspian Sea. Virtually all output, which may amount to 77,000 short tons of B_2O_3 content annually, has been consumed within the country.

TECHNOLOGY

Research by United States steel companies on the use of colemanite as a substitute for fluorspar in the basic oxygen furnace (BOF) steel process apparently continued on a limited scale. No breakthrough was reported on the lowering of costs, despite the fact that borates improve lime solubility and reduce heating time. Interest in this process was not as great as in the previous year because of the general recession in the world steel industries and consequently the softening of fluorspar demand.

A patent[7] was granted on a process of low-temperature froth flotation to beneficiate mixed salts of borax obtained from Searles Lake. An improved collector for the borax values, consisting of sulfonated fatty acids or salts derived therefrom, was the key to the process.

Early in the second half of 1971, the Lockheed-Georgia Co. was awarded a 4½-year contract by NASA to test lightweight boron in reinforcing aircraft structures. Specifically, the objective was to utilize boron composite materials in place of aluminum in the wings of the C130E Hercules aircraft and thereby reduce wing weight by about 600 pounds. Lockheed-Georgia Co. received $4.8 million for the first phase and promises testing for the aircraft with boron parts within 30 months.[8]

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[5] Industrial Minerals (London). Turkey Government Merges Boron Operations Into One. No. 49, October 1971, pp. 32–33.
[6] Industrial Minerals (London). Erim Remembers. No. 52, January 1972, p. 34.
[7] Chemtob, E. M., and W. R. White (assigned to Occidental Petroleum Corp.). Reagent Flotation of Borax From Salt Mixtures at low Temperature. U.S. Pat. 3,635,338, Jan. 8, 1972.
[8] Atlanta Journal. Aug. 19, 1971, p. 20–D.

Bromine

By Charles L. Klingman [1]

The effect of efforts to reduce atmospheric pollution was felt by the bromine industry in 1971 as evidenced by a significant reduction in consumption of ethylene dibromide, a gasoline additive. This loss was offset, however, by a gain in the production of other bromine compounds; the gross amount of bromine compounds sold was virtually the same as that of 1970, 384,300,000 pounds.

DOMESTIC PRODUCTION

Over the past 10 years the bromine industry has expanded at an average rate of 7.2 percent per year. Between 1970 and 1971, however, the rate of increase was only 1.8 percent. The total 1971 U.S. production for bromine was 355,946,000 pounds, an increase of 6,198,000 pounds over that of 1970.

This reduced rate of increase was almost entirely due to a lowered production of ethylene dibromide, a scavenger for antiknock lead additives in gasoline. Whereas ethylene dibromide production had been increasing in the past at a annual 6-percent rate, the change between 1970 and 1971 was a loss of 4.1 percent. Actual 1971 production of ethylene dibromide was 279,191,000 pounds, compared with 291,002,000 pounds in 1970. There was a corresponding decrease in the use of tetraethyl lead and tetramethyl lead in gasoline in spite of a 4.6-percent increase in total gasoline usage. These reductions in the use of gasoline additives may be attributed to the Clean Air Act of 1970, which requires a 90-percent reduction in harmful emissions from automotive exhausts by the year 1975.

The amount of elemental bromine sold to nonmanufacturers of bromine compounds was 33,295,000 pounds in 1971, a reduction of about 1 percent from that of 1970.

All bromine compounds, other than ethylene dibromide, however, showed a gain of about 13 percent, which resulted in a 1971 figure for the total weight of bromine compounds almost exactly the same as that of 1970. Producers of bromine were fortunate that new bromine outlets were originated in 1971 to offset the loss in the ethylene dibromide and elemental bromine business.

[1] Physical scientist, Division of Nonmetallic Minerals.

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)

	1970		1971	
	Quantity	Value	Quantity	Value
Sold	33,602	$6,221	33,295	$6,074
Used	316,146	54,339	322,651	55,676
Total	349,748	60,560	355,946	61,750

Table 2.—Bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

Compound	1970			1971		
	Quantity		Value	Quantity		Value
	Gross weight	Bromine content		Gross weight	Bromine content	
Ethylene dibromide	291,002	247,555	$47,187	279,191	237,508	$44,126
Other compounds, includes ammonium, sodium, potassium, ethyl, methyl, and other bromides [1]	93,265	66,626	41,747	105,132	75,804	45,926
Total	384,267	314,181	88,934	384,323	313,312	90,052

[1] Combined to avoid disclosing individual company confidential data.

Table 1 contains the salient statistics for bromine production divided into the categories "sold" and "used." The bromine classified as "sold" includes that which is bought by customers outside the manufacturing industry such as swimming pool operators, chemical supply houses, and the like, who do not generally convert the bromine into compounds. The bromine classified as "used" is that which is retained within the bromine manufacturing industry for conversion to compounds. Except for processing losses and inventory variations, the bromine labeled "used" in table 1 is the same bromine that appears in table 2 as the bromine contained in compounds.

Table 2 deals exclusively with the manufactured compounds of bromine that are produced for the market.

At the beginning of the year there were 11 bromine-producing plants in three States operated by seven companies. Two of these plants extracted elemental bromine only for sale and did not produce compounds. Two bromine-compound manufacturing plants, not included on the producers list, made compounds only from purchased bromine. Arkansas continued to be the top ranking State in bromine production with a 7-percent increase over that of 1970, and Michigan had a loss of about 9 percent.

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	American Potash & 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.
	Do	Manistee	East Lake [1]	Do.
	Morton Chemical Co	do	Manistee	Do.

[1] Closed operations June 1971.

CONSUMPTION AND USES

The Clean Air Act of 1970 has affected the bromine usage pattern in 1971. The production of bromine going into the manufacture of ethylene dibromide was reduced from 71 to 67 percent of the total production. It is also probable that there will be further reductions in the production of ethylene dibromide in future years.

Other bromine uses in the order of production volume were as follows: sanitation preparations, which include disinfecting agents, fumigants, bleaching agents, and swimming pool sanitizers; fire-extinguishing and fire-retardant compounds, which showed increases in 1971; and a miscellaneous category, which includes photographic films and paper, dyes, inks, pharmaceuticals, hydraulic fluids, and laboratory reagents.

PRICES

Prices quoted at yearend for bromine and bromine compounds in Chemical Marketing Reporter were as follows:

	Cents per pound
Bromine, purified:	
Cases, carlots, truckloads delivered east of Rocky Mountains	49
Zone I:[1]	
Returnable drums, carlots, truckloads, delivered	30
Bulk tank car, tanktrucks (45,000-pound minimum) delivered	17
Ammonium bromide, national formulary (N.F.), granular, drums, carlots, truckload, freight equalized	48
Bromochloromethane, drums, carlots, freight equalized	51.5
Tanks, same basis	50
Ethyl bromide, technical, 98 percent, drums, carlots, freight allowed, East	68
Ethylene dibromide, drums, carlots, freight equalized	25
Tanks, freight equalized	20
Methyl bromide, distilled, tanks, 140,000 pounds minimum, freight allowed	34
Potassium bromate, granular, powdered, 200-pound drums, carlots, freight allowed	64
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 tanktruck 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.

Significant price changes between 1970 and 1971 in equivalent classifications are listed below:

	Cents per pound
Elemental bromine in cases	+13
Elemental bromine in returnable drums	+3
Elemental bromine in tank cars	−0.25–+1.5
Potassium bromate	+5
Potassium bromide	+0.5

FOREIGN TRADE

Exports of bromine and bromine compounds from the United States are not separately recorded at this time. The United States imported a total of 13,506 pounds of potassium bromide, primarily from Belgium–Luxembourg, and France. The total value of these imports was less than $7,000. The United States produces and consumes about 75 percent of the world supply of bromine and bromine compounds.

WORLD REVIEW

Israel.—The Dead Sea Bromine Co. (a subsidiary of the Dead Sea Works, Ltd.) produced a total of 13,400 short tons of bromine in the 1970–71 fiscal year, a 9-percent increase over that of 1969–70. Their exports amounted to 9,700 short tons valued at US$2.9 million. The Dead Sea Works, Ltd., made a profit for the first time in 5 years and paid a royalty to the Israeli Government.[2] U.S. investors recently acquired 35 percent of the shares of the Dead Sea Bromine Co. Bromine production from the Dead Sea is predicted to reach 14,900 short tons in the 1971–72 fiscal year.[3]

TECHNOLOGY

Cambridge, Mass. was chosen as the site for the study of atmospheric pollution in a densely populated area. The study revealed an average total bromine concentration of 68 micrograms per cubic meter. Over two-thirds of this was in the form of particulate bromine and the remainder gaseous. The bromine in the air displayed a good correlation with the lead contamination in the air, but at a generally lower ratio of bromine to lead than the original ratio of these two elements in gasoline antiknock compounds.[4]

A method of selective laboratory bromination of carbohydrates and derivatives of nucleic acid has been devised. End products of this reaction, pyrimidine nucleosides, are well-known antiviral and antitumor agents.[5]

[2] Chemical Age. Dead Sea Works First Royalties Paid. V. 103, Nov. 5, 1971, p. 4.
[3] U.S. Embassy, Tel Aviv, Israel. State Department Airgram A–389, Oct. 29, 1971.
[4] Environmental Science Technology. Gaseous Bromine and Particulate Lead, Vanadium, and Bromine in a Polluted Atmosphere. V. 6, No. 1, January 1972, pp. 68–71.
[5] Chemical Engineering News. Bromination Gives Specific Nucleosides. Vol. 49, No. 15, Apr. 12, 1971, p. 32.

Cadmium

By Burton E. Ashley [1]

The cadmium market remained depressed in 1971 and a price cut came into effect at midyear. In spite of a 16-percent decline in metal output, stocks continued to build as a result of a 40-percent increase in imports, an 82-percent decrease in exports, and increased shipments. Yearend 1971 stocks totaled 5,313,000 pounds, an increase of 11 percent during the year.

Cadmium is recovered as a byproduct in the processing of zinc ore, and the closing of 15 zinc mines and four plants producing slab zinc in the United States decreased the domestic capability to produce (mine and smelter) cadmium. A zinc roasting plant which produced byproduct cadmium source materials was also closed during the year. Despite the opening of the Blackcloud zinc mine in Colorado and the expansion of the Balmat mine in New York, a net loss of domestic production of cadmium resulted. Greater dependence on imports of cadmium metal will be necessary, at least over the short term.

Results for the first quarter of 1971 showed gains in metal production and shipments over the final quarter of 1970; metal imports declined as did exports. However, during the second and third quarters of 1971, shipments and metal production declined or leveled off, while stocks increased. The fourth quarter showed substantial revival in metal production and shipments with declining imports.

Effective July 26, 1971, the price was reduced from $2.25 to $1.50 per pound in 1-ton lots, and from $2.30 to $1.55 per pound in lots less than 1 ton.

Legislation and Government Programs.— During 1971, only 1,000 pounds of cadmium was sold from the national stockpile; sales were authorized under Public Law 91-314 of July 10, 1970. The excess remaining in the stockpile for disposal amounted to 4,147,806 pounds valued at $9,333,000. At yearend a total of 10,147,904 pounds of cadmium valued at $15,222,000 remained in the stockpile.

Effective August 16, 1971, stockpile sales of ingots and slabs, f.o.b. storage location, were annuounced at $1.38 per pound in lots of 1 ton or more, and at $1.43 in lots of less than 1 ton. Sticks, sold on the same basis, were valued at $1.50 and $1.53 per pound.

Early in the year, the Department of the Treasury investigated charges that cadmium from Japan was being sold at less than fair value in U.S. markets within the meaning of the Antidumping Act of 1921. At yearend, notice was given that there were reasonable grounds for such charges, and customs officers were directed to withhold appraisement of cadmium from Japan. Further investigation of possible price differential and injury to the U.S. industry continued.

The stockpile objective, set by the Office of Emergency Preparedness, remained at 6 million pounds.

The Office of Minerals Exploration, U.S. Geological Survey, provides to eligible participants, up to 50 percent of allowable costs of exploration for cadmium. Cadmium producers are granted a depletion allowance of 22 percent on domestic production and 14 percent on foreign production.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient cadmium statistics

(Thousand pounds)

	1967	1968	1969	1970	1971
United States:					
Production [1]	8,699	10,651	12,646	9,465	7,930
Shipments by producers [2]	9,606	11,244	12,978	6,848	7,774
Value thousands	$24,665	$28,409	$40,636	$24,163	$12,258
Exports	691	530	1,085	373	66
Imports for consumption, metal	1,587	1,927	1,078	2,492	3,499
Consumption	11,578	13,328	15,062	9,063	10,832
Price: Average [3] per pound	$2.64	$2.65	$3.27	$3.57	$1.92
World: Production	29,069	33,105	38,749	36,641	34,153

[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

Production of cadmium metal in the first quarter of 1971 gained 5 percent over the final quarter of 1970. Output declined in the second and third quarters, but in the fourth quarter showed a considerable recovery to 2.2 million pounds. The year ended with a total production of 7,930,382 pounds, a 16 percent decline from the 9,464,936 pounds produced in 1970. Value of producer shipments similarly declined and ended the year at $12.3 million, a loss of 49 percent from the value of shipments in 1970.

Flue dust imported from Mexico contained 1.1 million pounds of cadmium for domestic recovery and refining. Imported zinc ore and small amounts of waste and scrap also provided a source of cadmium for U.S. producers.

Cadmium content of sulfide compounds produced (including cadmium sulfoselenide and lithopone) increased very slightly during the year to 2.2 million pounds.

Cadmium oxide was produced by American Smelting and Refining Company, Blackwell Zinc Co., and Harshaw Chemical Co.

Table 1 lists comparative salient statistics for cadmium for 1967–71; table 2 refers to cadmium sulfide output for the same period.

Table 2.—Cadmium sulfide [1] produced in the United States

(Thousand pounds)

Year	Sulfide [2] (cadmium content)
1967	1,536
1968	2,457
1969	2,439
1970	2,137
1971	2,235

[1] Cadmium oxide withheld to avoid disclosing individual company confidential data.
[2] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Apparent consumption of cadmium amounted to approximately 10.8 million pounds, a 20 percent increase over the (revised) level of 9,063 million pounds in 1970. Government sales in 1971 amounted to only 1,000 pounds. Derivation of apparent consumption is shown in table 3.

About 50 percent of the cadmium consumed in the United States was used in the plating industry. Cadmium affords an attractive finish and under certain conditions is resistant to corrosion. For these reasons it is used to coat parts for airplanes, automobiles, and boats. Small household ap-

Table 3.—Apparent consumption of cadmium

(Thousand pounds)

	1970	1971
Stocks—beginning	r 2,254	4,781
Production	9,465	7,930
Imports, metal	2,492	3,499
Government sales	6	1
Total (supply)	14,217	16,211
Exports	373	66
Stocks—end	r 4,781	5,313
Apparent consumption	r 9,063	10,832

r Revised.

pliances are cadmium coated, as are hardware parts such as nuts, bolts, accessories, and fasteners.

Cadmium compounds were used as colorants and stabilizing compounds in the manufacture of plastics; as colorants, compounds were also used in printing inks and paints.

Cadmium was also used in the manufacture of sealed and vented batteries. Such batteries have a variety of uses and were used in aircraft, hand tools, and communi-

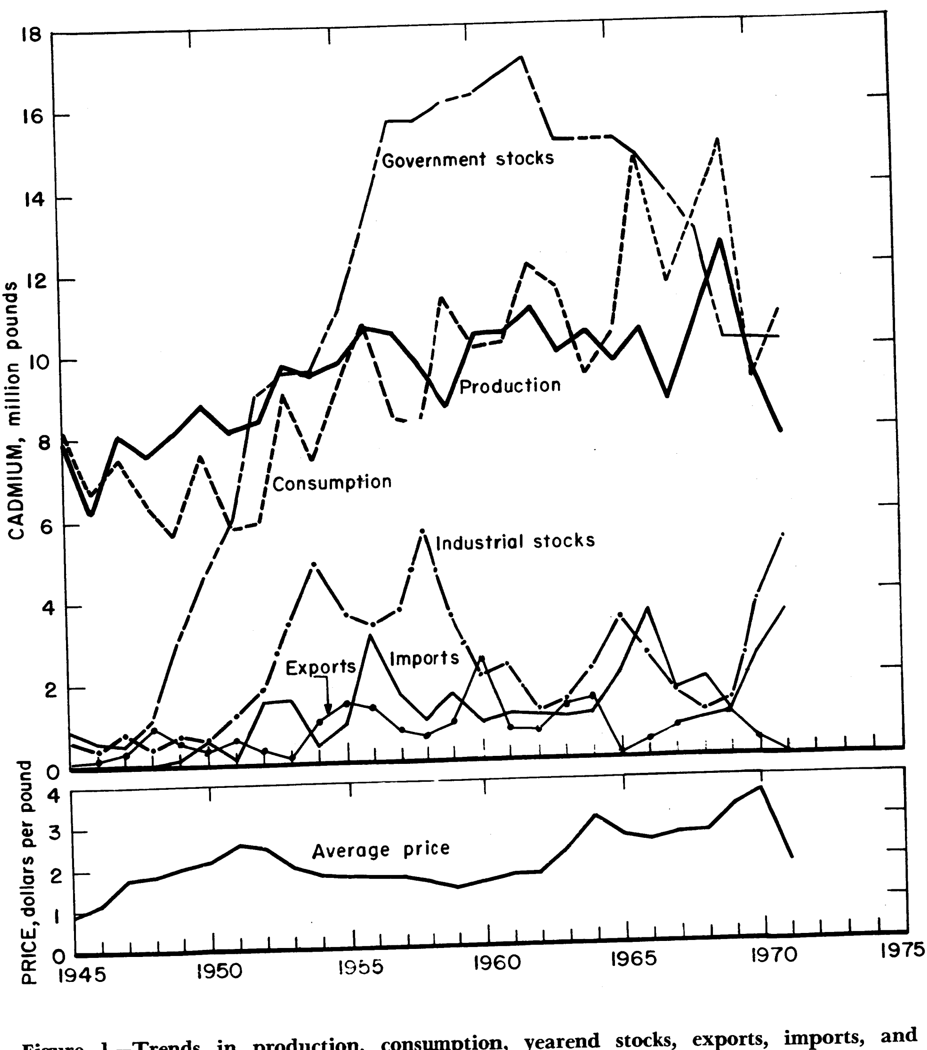

Figure 1.—Trends in production, consumption, yearend stocks, exports, imports, and average price of cadmium metal in the United States.

cation equipment. Other uses included phosphors for television picture tubes and night-sighting devices. In addition, cadmium was used in alloys for hardening copper, fusible alloys, solders, and electrical contacts in switches and relays.

STOCKS

Yearend 1971 industry stocks of cadmium metal and cadmium held in compounds totalled 5,313,101 pounds, an increase of 11 percent over like stocks held at yearend 1970. Industry stocks of cadmium in compounds rose by 3 percent. Table 4 shows the details of industry stocks as of December 31, 1970, and 1971.

Table 4.—Industry stocks, December 31

(Thousand pounds)

	1970		1971	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	3,325	W	3,502	W
Compound manufacturers	157	r 912	492	935
Distributors	r 355	r 32	344	40
Total	r 3,837	r 944	4,338	975

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Compound manufacturers."

PRICES

The 1970 yearend domestic price of cadmium in 1-ton lots held at $2.25 a pound until July 26, 1971, when it was reduced to $1.50 a pound. The average price for the year was $1.92.

Table 5 shows the 1971 domestic price range to consumers.

Table 5.—Cadmium prices 1971

(Per pound)

Date	Producer to consumer	
	1-ton lots	Less than 1-ton lots
Jan. 1	$2.25	$2.30
July 26 to Dec. 31	1.50	1.55

FOREIGN TRADE

Exports of cadmium metal declined by 82 percent to a total of 65,879 pounds, the lowest level for 18 years. Chief destinations of U.S. exports were as follows, in percent: United Kingdom, 30; India, 26; and Canada, 18.

Metal imports at 3,499,089 pounds were 40 percent over the 1970 level. Imports came from 16 countries, of which the following supplied the major share, listed by percent of the total quantity; Japan, 27; Australia, 15; Belgium-Luxembourg, 13; Canada, 11; and Peru, 9. The cadmium content of flue dusts imported from Mexico was 1.1 million pounds, at essentially the same level as in 1970. Value of metal imports declined 20 percent and value of cadmium in flue dust dropped 54 percent.

The import duty on cadmium metal was discontinued on January 1, 1971, in accordance with decisions negotiated under the General Agreement on Tariff and Trade. Imported cadmium-containing flue dust is duty free. Cadmium metal imports from Communist bloc countries, Yugoslavia excepted, were subject to a statutory duty of 15 cents per pound.

Table 6 shows U.S. exports of cadmium for 1969–71. U.S. imports of cadmium are shown in table 7.

Table 6.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value
1969	1,085	$3,254
1970	373	997
1971	66	172

Table 7.—U.S. imports for consumption [1] of cadmium metal and cadmium flue dust, by countries

(Thousand pounds and thousand dollars)

Country	1970		1971	
	Quantity	Value	Quantity	Value
Cadmium metal:				
Australia	319	$854	514	$950
Belgium-Luxembourg	165	522	457	780
Bulgaria	17	49	--	--
Canada	212	825	375	639
Ecuador	2	8	--	--
Finland	--	--	33	55
France	32	119	17	29
Germany, West	36	100	207	328
India	3	10	--	--
Italy	59	166	90	161
Japan	932	2,705	938	1,797
Mexico	259	996	220	312
Netherlands	46	158	81	134
Peru	303	948	332	680
South Africa, Republic of	56	201	67	134
Spain	11	21	22	27
Switzerland	--	--	7	11
U.S.S.R.	22	61	--	--
United Kingdom	13	41	134	220
Yugoslavia	5	16	5	7
Total	2,492	7,800	3,499	6,264
Flue dust (cadmium content): Mexico	1,111	2,438	1,112	1,118
Grand total	3,603	10,238	4,611	7,382

[1] In 1970 general imports were 2,503,081 pounds ($7,827,166); in 1971, general imports were 3,470,323 pounds ($6,208,146). The difference was reflected in Japan.

WORLD REVIEW

World smelter production of cadmium in 1971 amounted to 34.1 million pounds, a 7-percent decrease from the revised total for 1970. The United States accounted for 23 percent of world output, followed by Japan, 17 percent; U.S.S.R., 16 percent; West Germany, 7 percent, and Belgium 5 percent. The remaining 32 percent was produced by 23 other countries.

Apparent consumption of cadmium in the United States was equivalent to about 32 percent of world production; this was above domestic consumption in 1970. Table 8 shows preliminary figures of world cadmium production in 1971.

Table 8.—Cadmium: World smelter production by countries [1]

(Thousand pounds)

Country	1969	1970	1971 p
North America:			
Canada (refined)	2,124	1,845	1,504
United States [2]	12,646	9,465	7,930
Latin America:			
Mexico (refined)	462	591	e 620
Peru	371	410	e 440
Europe:			
Austria	55	49	53
Belgium	r 2,092	2,410	e 1,870
Bulgaria e	440	440	440
Finland	--	196	265
France	1,153	1,166	e 1,170
Germany, East e	26	r 33	35
Germany, West	1,746	2,282	e 2,220
Italy	930	937	785
Netherlands e	310	r 265	265
Norway	198	216	203
Poland e	925	990	1,100
Romania e	130	180	180
Spain	r 117	245	265
U.S.S.R. e	5,100	5,200	5,300
United Kingdom	541	701	578
Yugoslavia	375	e 330	e 350
Africa:			
South-West Africa [3]	422	511	e 520
Zaire (formerly Congo Kinshasa)	661	699	e 530
Zambia	14	26	26
Asia:			
China, People's Republic of e	220	220	220
India	r 97	75	e 90
Japan	r 6,095	5,601	e 5,700
Korea, North e	240	240	240
Oceania: Australia	1,259	1,318	1,254
Total	r 38,749	36,641	34,153

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 or not; 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, and 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.

TECHNOLOGY

General Electric Co. described[2] a technique for plating plastics with cadmium, indium, zinc, or lead. The method was said to reduce to 5 steps the process which hitherto has required 15 to 20 steps. A larger variety of plastics can be coated by this method than was possible by previously used means. Applications of plated plastic parts were suggested in the automobile industry for use in grills and trim, and for marine applications, decorative parts for appliances, and plumbing fixtures. It was stated that great savings in weight and cost would be possible by using plated plastic parts.

Bell Laboratories[3] was reportedly developing a cadmium-helium laser some 15 inches in length. Helium-cadmium lasers are used in biological and photochemical studies and are usually several feet in length. It was thought that the new cadmium-helium laser would compete with helium-neon laser of comparable power.

An improved method of maximizing[4] dispersion of cadmium in silver-cadmium alloy was announced by the Silver Products Department of Engelhard Minerals and Chemicals Corp.; called Lectroloy, the contact material has improved ductility which allows the better forming of contacts with more uniform electrical properties.

The cathodic reduction of n-type cadmium fluoride single crystals was investigated.[5] Thermal conductivities of four

[2] American Metal Market. V. 78, No. 183, Sept. 22, 1971, pp. 1, 3.

[3] American Metal Market. V. 79, No. 4, Jan. 6, 1972, p. 13.

[4] American Metal Market. V. 79, No. 5, Jan. 7, 1972, p. 9.

[5] Nicholson, M. M. Cathodic Behavior of N-type Cadmium Fluoride. J. Eletrochem. Soc., v. 118, No. 7, July 1971, pp. 1047–1050.

types of sealed, 20 A-hr nickel-cadmium cells were measured perpendicular to (x-direction) and parallel with (y-direction) the plane of the electrodes.[6] A modified Bridgman method for growing cadmium telluride was described.[7]

The adsorption of cadmium ions in an experimental cadmium-air battery cell was studied.[8]

Phase diagrams were presented for the gadolinium-cadmium system [9] and the ytterbium-cadmium system.[10]

Environmental Developments.—Interest continued in regard to cadmium as an environmental pollutant. Only a few of the many papers published can be noted here.

In 1971 the U.S. Geological Survey [11] published the results of a reconnaissance examination of surface water samples collected in the 50 states, Puerto Rico, and the District of Columbia. Cadmium in quantities of 1 to 10 micrograms per liter [12] was detected in 42 percent of the samples. In about 4 percent of the samples cadmium was detected in amounts in excess of 10 micrograms per liter, which is the upper limit set by the U.S. Public Health Service for cadmium in drinking water. The highest concentration found was 130 micrograms of cadmium per liter of water.

An article written by Julian McCaull [13] contained a popular discussion of the cadmium problem in relation to the various aspects affecting the biosphere. The bibliography and notes add to the interest of the article.

The Federal Food and Drug Administration issued a warning in San Francisco regarding enameled patterns on metal tableware which contained excessive amounts of cadmium. Leaching of the cadmium and subsequent ingestion was usually effected by an acid, such as vinegar in salad dressing, coming into contact with the cadmium-containing enamel.

It was claimed that cadmium in gasoline was a pollutant; tests on gasoline and additives were reported as negative.

A potential health hazard was pointed out when cadmium was [14] found in the tissue of rock scallops collected off the coast of southern California.

Cadmium metal in relation to the environment was also discussed and avenues of research were pointed out.[15]

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[6] Brooman, E. W. and J. McCallum. Thermal Conductivity Measurements of Nickel-Cadmium Aerospace Cells. Part 1: Cell Conductivities. J. Eletrochem. Soc., v. 118, No. 9, September 1971, p. 1518–1523.

[7] Kyle, Nanse R. Growth of Semi-Insulating Cadmium Telluride. J. Electrochem. Soc., v. 118, No. 11, November 1971, pp. 1790–1797.

[8] Gilman, S. and L. D. Sangermano. Adsorption of Cadmium Ions from KOH Solution at a Platinum Electrode. J. Eletrochem. Soc., v. 118, No. 12, December 1971, pp. 1953–1957.

[9] Bruzzone, G., M. L. Fornasini, and F. Merlo. The Gadolinium-Cadmium System. J. Less-Common Metals, v. 25, No. 3, November 1971, pp. 295–301.

[10] Palenzona, A. The Ytterbium-Cadmium System. J. Less-Common Metals, v. 25, No. 4, December 1971, pp. 367–372.

[11] Durum, W. H., J. D. Hem, and S. G. Heidel. Reconnaissance of Selected Minor Elements in Surface Waters of the United States, October 1970. U.S. Geol. Survey Circ. 643, 1971, 49 pp.

[12] One microgram per liter is equal to one part per billion.

[13] McCaull, Julian. Building a Shorter Life. Environment, v. 13, No. 7, September 1971, 38 pp.

[14] Canner and Packer. Cadmium found in rock scallops. V. 141, No. 1, January 1972, p. 41.

[15] Environmental Science and Technology. Metal Focus Shifts to Cadmium. V. 5, No. 9, September 1971, pp. 754, 755.

Calcium and Calcium Compounds

By Avery H. Reed [1]

Calcium metal was manufactured by one company in Connecticut. Calcium chloride and calcium-magnesium chloride were recovered from brine by two companies in California and three companies in Michigan. Synthetic calcium-magnesium chloride was manufactured by one company in New York, one in Ohio, and two in Washington. Output of these materials was about the same as in recent years.

DOMESTIC PRODUCTION

Pfizer, Inc., produced a modest quantity of calcium metal at Canaan, Conn. The metal was made by heating quicklime with aluminum in vacuum retorts, and was sold for use as a reducing agent for other metals.

Two companies in California and three companies in Michigan recovered calcium-magnesium chloride from brine: The Dow Chemical Co. at Ludington and Midland, Mich.; Michigan Chemical Corp. at St. Louis, Mich.; Leslie Salt Co. at Amboy, Calif.; Wilkinson Chemical Corp. at Mayville, Mich.; and National Chloride Co. of America at Bristol Lake, Calif.

Allied Chemical Corp., Onondega, N.Y.; PPG Industries, Barberton, Ohio; and Hooker Chemical Corp. and Reichold Chemicals, Inc., Tacoma, Wash., manufactured synthetic calcium-magnesium chloride as a byproduct of soda ash.

Salt Lake Minerals and Chemical Corp. constructed a plant near Great Salt Lake, in Weber County, Utah. The plant will recover calcium-magnesium chloride as a byproduct.

CONSUMPTION AND USES

Calcium metal was sold for use as a reducing agent to obtain other metals from their oxides, chlorides, or fluorides; in inorganic chemical reactions; and for purifying petroleum fractions. Other important uses were in the manufacture of calcium hydride; in the manufacture of pure grades of calcium pantothenate; as a purifying agent in steel, and as an alloying element in aluminum, beryllium, copper, nickel, and lead.

Calcium-magnesium chloride was used mainly as a deicer for roads, streets, bridges, and pavements. It is usually mixed with rock salt in proportions that vary with temperature, and range from 1 to 4 at 32° F, 1 to 3 at 25° F, 1 to 1 at 15° F, to straight calcium chloride below 10° F. Other important uses were as a deliquescent in dust control for roads and as an accelerator for concrete.

[1] Physical scientist, Division of Nonmetallic Minerals.

PRICES AND SPECIFICATIONS

Price schedules for calcium metal were about the same as in previous years, ranging from $1 to $5 per pound.

Calcium chloride is usually sold either as solid flake or pellet averaging about 75 percent $CaCl_2$, or as a concentrated liquid averaging about 40 percent $CaCl_2$. Price quotations for calcium chloride are shown in table 1.

Table 1.—Price quotations for calcium chloride in 1971

(Per short ton)

Grade	Jan. 4	Dec. 27
Flake or pellet, 94-97 percent [1]	$55.00	$55.00
Flake, 77-80 percent [1]	44.00	44.00
Powdered, 77 percent minimum [1]	52.50	52.50
Liquor, 40 percent [2]	16.50	16.50
Granulated, U.S.P.[3]	580.00	780.00

[1] Paper bags, carload lots, plant, freight equalized.
[2] Tank cars, freight equalized.
[3] 225-pound drums, freight equalized.

Source: Oil, Paint and Drug Reporter. V. 197, No. 1, Jan. 5, 1971; v. 198, No. 26, Dec. 28, 1971.

FOREIGN TRADE

Total imports of calcium and calcium compounds were 137,091 tons valued at $7,635,166, a decrease of 25 percent.

Twenty-four tons of calcium metal were imported from Ontario, Canada. Imports of calcium chloride were 13,019 tons, an increase of 57 percent; most of the material was imported from Canada and Belgium.

Other imports of calcium compounds included 39,541 tons of calcium nitrate from Norway, Sweden, Belgium, West Germany, the Netherlands, and Canada; 23,121 tons of dicalcium phosphate from Belgium and Canada; 19,973 tons of calcium carbide from Canada; 18,097 tons of whiting from France, the United Kingdom, Belgium, Switzerland, and West Germany; 7,369 tons of calcium borate from Turkey; 5,453 tons of calcium cyanamide from Canada, Belgium, Norway, and West Germany; 5,427 tons of calcium cyanide from Canada and Norway; 1,699 tons of precipitated calcium carbonate from the United Kingdom; 682 tons of calcium hypochlorite from Japan; 244 tons of chlorinated lime from the United Kingdom; 2 tons of calcium acetate from West Germany; and 2,440 tons of miscellaneous calcium compounds from various countries. Table 2 shows imports of calcium and calcium chloride by year, 1967–71; table 3 shows imports of calcium chloride in 1971, by countries.

Table 2.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value	Short tons	Value
1967	423,631	$370,407	4,385	$157,570
1968	137,251	120,416	14,069	522,680
1969	[1] 662,200	[1] 619,000	9,226	349,998
1970	164,769	141,125	8,280	359,096
1971	48,391	29,751	13,019	543,656

[1] Adjusted by the Bureau of Mines.

Table 3.—U.S. imports for consumption of calcium chloride, by countries

Country	Short tons	Value
Canada	11,153	$455,674
Belgium	1,486	72,578
Japan	200	9,978
United Kingdom	180	5,122
Germany, West	(1)	304
Total	13,019	543,656

[1] Less than ½ unit.

WORLD REVIEW

Calcium metal was produced in Canada, France, and the United States. Dominion Magnesium Limited manufactured calcium at Haley, Ontario. Planet-Wattohm S.A. produced calcium in France. World statistics are not available but are reported to average about 500 tons per year.

Carbon Black

By Richard B. Smith [1]

Carbon black shipments resumed their long-term growth pattern in 1971 by increasing 6.1 percent, following a decline in 1970 caused by strikes in the automobile and rubber industries.

Production rose to a new peak. Exports reached their lowest level in 28 years, but a 7.7-percent gain in domestic sales was sufficient to keep producer's stocks at about the 1970 level. The rubber industry continued to be the leading user of carbon black. Almost 94 percent of carbon black shipments were used in rubber products with 65 percent of the volume used by tire manufacturers. In 1971, U.S. passenger tire production increased 14 percent to 187.7 million tires, according to preliminary figures of the Rubber Manufacturers Association, Inc.

The carbon black industry operated at 76-percent capacity in 1971. Over the past 5 years, capacity has risen from 8,023,300 pounds to 10,902,330 pounds per day, an increase of 35.9 percent. The capacity of carbon black plants has increased at an annual growth rate of almost 4.5 percent per year over the past decade compared with a growth in production rate of 4.3 percent per year.

Although overall production of carbon black in 1971 topped that of the preceding year by nearly 86 million pounds, channel black output dropped 67 million pounds, thus further depressing the downward trend that began in the late 1940's.

As shown in table 5, the average value of carbon black at the plant in 1971 was 7.69 cents per pound, an increase of 0.11 cent from the level of a year earlier.

The volume of natural gas used for manufacturing carbon black declined 25.8 percent below that of the 1970 level, whereas total production of carbon black increased 2.9 percent. This follows the trend that began in 1950 of decreasing percentages of channel black made from natural gas, and larger percentages of furnace black made from liquid hydrocarbons.

Yields of carbon black produced from liquid hydrocarbons increased in 1971, yields from natural gas decreased. Each gallon of liquid hydrocarbon consumed yielded an average of 4.92 pounds of carbon black, up from 4.87 pounds in 1970. The yield from natural gas in 1971 was 6.09 pounds of carbon black per 1,000 cubic feet of gas consumed, compared with 6.20 pounds in 1970. In 1950, about 2.57 pounds of carbon black were produced per thousand cubic foot of gas consumed. By 1970 this ratio had increased by 137 percent. Yields by the furnace process increased less dramatically, from 3 pounds per gallon in 1950 to nearly 5 pounds in 1971.

[1] Petroleum engineer, Division of Fossil Fuels.

Table 1.—Salient statistics of carbon black produced from natural gas and liquid hydrocarbons in the United States

(Thousand pounds)

	1967	1968	1969	1970	1971
Production:					
Channel process	149,420	142,948	132,471	113,548	46,354
Furnace process	2,334,420	2,668,858	2,830,790	2,817,605	2,970,781
Total	2,483,840	2,811,806	2,963,261	2,931,153	3,017,135
Shipments:					
Domestic sales	2,216,145	2,588,402	2,777,949	2,649,521	2,853,527
Exports	236,035	263,122	196,203	192,636	163,246
Total	2,452,180	2,851,524	2,974,152	2,842,157	3,016,773
Losses	559	359	5,259	929	421
Producer stocks Dec. 31	264,247	224,170	208,020	296,087	296,028
Value:					
Production thousand dollars	$178,158	$205,849	$215,120	$222,271	$232,049
Average per pound cents	7.17	7.32	7.26	7.58	7.69

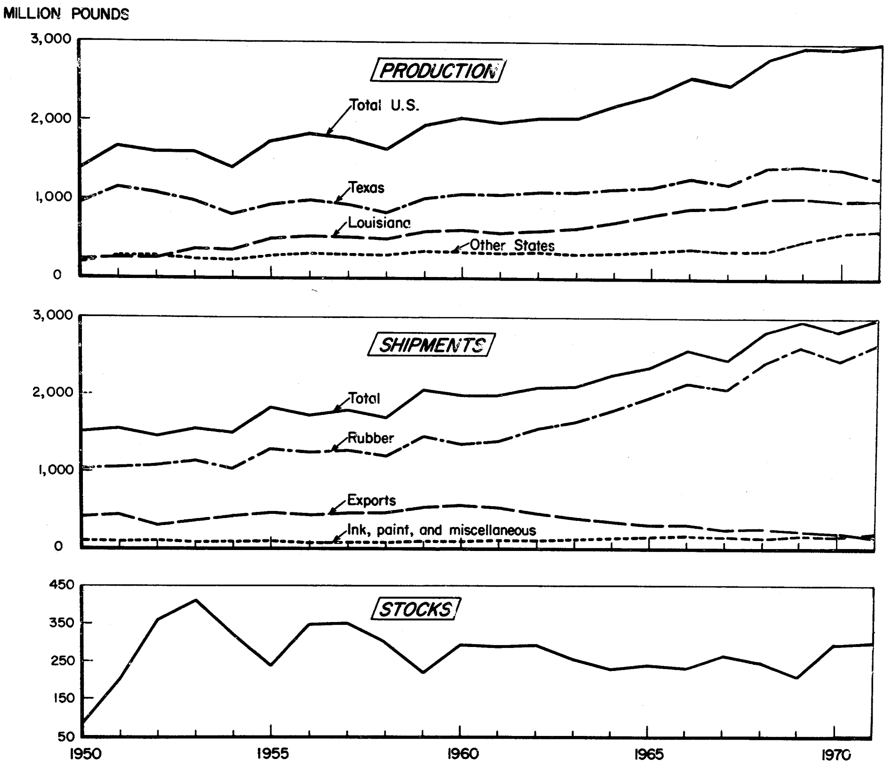

Figure 1.—Production by States, shipments by use, and exports, and stocks of carbon blacks.

PRODUCTION AND CAPACITY

Production by States.—Reflecting a greater demand for carbon black after the rubber and automobile plant strikes of 1970, production of carbon black totaled 3,017 million pounds in 1971, an increase of 86 million pounds, or 2.9 percent, above the somewhat depressed level of 1970. Louisiana supplied about 36 percent of the total, a slight increase from its 1970 percentage. Texas' share of the total dropped to 44 percent from 48 percent in 1970. The eight States that produced the remaining 20 percent of carbon black were Alabama, Arkansas, California, Kansas, New Mexico, Ohio, Oklahoma, and West Virginia. In the period 1966 to 1971 output from these States increased from 14.6 percent to 20.2 percent of total production.

Production by Grades and Types.—Although carbon black was produced by both channel and furnace processes, the latter accounted for 98.5 percent of 1971 production. There are seven major grades of carbon black plus thermal black produced by the furnace process. Two of these grades, SRF (Semireinforcing-furnace) and HMF (High-modulus-furnace), are gas furnace blacks. The remaining five grades are oil furnace blacks. Substantial changes occurred the past 10 years in the output of gas furnace grades SRF, which dropped 10.5 percent from 1961 to 1971, and HMF, which declined by 76.0 percent.

The largest percentage growth was demonstrated by General-purpose-furnace (GPF) grade, which increased from 142 million pounds in 1961 to 549 million pounds of production in 1971, a 287-percent increase.

Number and Capacity of Plants.—The total number of producing carbon black plants remained at 37, unchanged from 1970. In terms of capacity, however, there has been an increase from 2,159,919 to 2,374,219 pounds per day or nearly 10 percent in capacity of carbon black plants located outside of Louisiana and Texas.

The new furnace black plant in Marshall County, W. Va., was placed in operation during 1971 by the Columbian Division of Cities Service Co. According to the company's Annual Report, the facility has an annual capacity of 60 million pounds of fine-particle-size carbon black and 90 million pounds of coarse-grade black for rubber industry use. The carcass black unit is reported to be the first of its type in the northeastern United States. At yearend expansion was under way at Cities Service Co.'s North Bend, La., plant to increase furnace black output for the ink, paint, and plastics market.

Ashland Chemical Co.'s Herkness plant in Lea County, N. Mex., was inoperative during 1971. This 80-thousand-pound-per-day plant was shut-down in 1970 and sold to be dismantled.

The Sid Richardson Carbon & Gasoline Co. plant in Odessa, Tex., one of three channel black plants operative in 1970, ceased production at midyear 1971 and was being dismantled. Plants using the channel process comprised only 3.2 percent of the U.S. capacity in 1971 and produced only 1.5 percent of the total domestic output.

Materials Used and Yields.—In 1971, a total of 547.7 million gallons of liquid hydrocarbon was consumed in the manufacture of 2,694.7 million pounds of carbon black. This quantity was 24 million gallons more than was consumed in 1970. Yields from liquid hydrocarbon in 1971 averaged 4.92 pounds per gallon, compared with 4.87 pounds in 1970. The yield from natural gas dropped slightly to 6.09 pounds from the 1970 level of 6.20 pounds per thousand cubic feet. Natural gas consumption decreased 25.8 percent to 63.7 billion cubic feet, and production from natural gas dropped 59.0 million pounds, a reduction of 15.5 percent from 1970 production.

CONSUMPTION AND USES

In 1971, domestic sales of carbon black increased by 204 million pounds, or 7.7 percent, over 1970 sales. Exports dropped 15.3 percent to the lowest level in 28 years. Domestic sales to the rubber industry, which accounted for 93.9 percent of all carbon black sales, were higher by 192 million pounds, or 7.7 percent. Sales gains were made in the carbon black used in ink manufacture, rising 3.3 percent to 75.2 million pounds. The oil-furnace-type carbon black, known as "Short-Ink," was used in the manufacture of ink for printing newspapers. Carbon black produced by the channel process, known as "Long-Ink," was used in lithographic or halftone printing ink. As shown in table 7, substantial changes occurred in sales to paint manufacturers, up 28.3 percent to 18.7 million pounds, and paper manufacturers, down 16.8 percent from the 1970 level.

STOCKS

Inventories of carbon black remained at the 1970 level as a result of an increase of 12.3 million pounds in furnace black stocks and a decrease of the same quantity in channel black stocks. Stocks of thermal black increased by 25.9 million pounds. HAF and FEF grades increased 4.7 and 2.8 million pounds, respectively. Decreases in stocks were reported for GPF grade, down 11.0 million, and ISAF grade, down 7.6 million pounds.

FOREIGN TRADE

In 1971 carbon black exports totaled 163.2 million pounds, the lowest level since 1944. During the intervening 27 years, exports grew in quantity and value until a high was reached in 1960. That year 543 million pounds, valued at $49.6 million, was exported by the United States. Since 1960 exports have declined in quantity by 70 percent and in value by 59 percent.

Exports of carbon black in 1971 consisted of 86 percent furnace black, up from 75 percent in 1970.

European countries are by far the best customers for U.S. exports of carbon black. They accounted for 54 percent of the quantity and 55 percent of the value of exports in 1971. Ninety percent of U.S. exports to Europe were received by France, West Germany, Italy, Netherlands, and the United Kingdom. Canada received 88 percent of all U.S. exports to Western Hemisphere countries.

In 1971 most of the carbon black imported into the United States was specialty grades. About 5.7 million pounds of acetylene black was imported from Canada and 344,000 pounds came from East Germany. About 833 thousand pounds of bone black was supplied to the United States by West Germany, Brazil, and the United Arab Republic. No lampblack was imported in 1971.

WORLD REVIEW

Carbon black experienced record sales worldwide in 1971 with most of the growth achieved in European markets. Higher carbon black manufacturing costs were experienced throughout the world and were felt most severely in Europe where there were substantial increases in wage rates and raw material costs.

The United States, Japan, West Germany, and the United Kingdom, continued to lead the world in output of carbon black in 1971. The United States, which produces 48.9 percent of the world output, was responsible for almost half the gain in world production from 1970 to 1971. West Germany's growth in production was second among producing countries of the world with a 10-percent gain over its 1970 rate. The only country reporting a drop in output in 1971 was Taiwan. The Republic of Korea increased production by 124 percent in 1971 over a 1970 base of 7.4 million pounds.

TECHNOLOGY

Carbon black, a petrochemical, is an extremely fine soot, primarily carbon (90 to 99 percent), which contains some oxygen and hydrogen. Oil furnace black may contain also small amounts of sulfur. The properties of carbon black are determined largely by the process by which it is manufactured. Furnace black, which accounts for 96 out of every 100 pounds produced, is made by three different processes—oil furnace, gas furnace, and thermal. Brief descriptions of these processes, the channel process, and the manufacture of lampblack and acetylene black follow.

Oil Furnace.—In the oil furnace process, liquid hydrocarbons are used. 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 percent to 65 percent depending on the grade of black produced. Oil furnace grades are GPF, FEF, HAF, ISAF, and SAF. (The full name of each grade is given in the footnotes to table 3.)

The most desirable feedstock oil for furnace black plans has 0° to 4° API gravity and is low in sulfur and 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. The rising cost of natural gas has 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. At the same time, it should be recognized that oil furnace processing has become very flexible. Oil furnace blacks supplement channel blacks in most high-performance applications, notably passenger car tire treads. Over the past 2 decades, carbon black technology has centered on the oil furnace black process.

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 percent 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. The grades SRF, HMF, and FF are generally produced from gas. (The full name of each grade is given in the footnotes to table 3.)

Thermal.—Unlike channel and furnace blacks, thermal blacks are produced by cracking a hydrocarbon; that is, by separating the carbon from the hydrogen and not by the combustion of a hydrocarbon. Thermal furnaces are built in a checkerboard brickwork pattern. Two refractory-lined furnaces, or generators, are used. One generator is heating, using hydrogen as a fuel, while the other generator is being charged with natural gas, which decomposes to produce thermal black and hydrogen. The hydrogen is collected and 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 percent.

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. The 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 percent; for finer particle-size, high-color blacks, the yield shrinks to 1 percent. 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 lower in jetness and coloring power. They are of value as tinting pigments in certain paints and lacquers. In most applications they have been replaced by carbon blacks.

Acetylene Black.—Acetylene blacks, produced by the thermal decomposition of acetylene, possess a high degree of structural, or chaining, tendency. Their particle size is about 40 millimicrons. They provide high-elastic modulus and high conductivity in rubber stocks.

A potentially important process for converting rice hulls and other organic wastes into carbon black was tested during 1971 at Stanford Research Institute, Palo Alto, Calif. At yearend, prospective purchasers of the products were testing and evaluating samples of the output from a pilot unit at Stanford Research Institute. Continental Energy Corp. of Los Angeles announced plans to build a plant at Sacramento, Calif., when pilot tests are completed.

The Sid Richardson Carbon & Gasoline Co. began construction late in 1971 of a research center in Ft. Worth, Tex. The 12,000-square-foot installation of laboratories, library, and administrative offices is designed to provide research facilities for the development of new carbon blacks for the rubber and other related industries. Completion is scheduled for midyear 1972.

Table 2.—Carbon black produced from natural gas and liquid hydrocarbons in the United States, by State

(Thousand pounds)

State	1967	1968	1969	1970	1971	Change from 1970 (percent)
Louisiana	923,286	1,031,349	1,045,902	982,416	1,078,732	+9.8
Texas	1,214,349	1,426,307	1,442,033	1,395,851	1,326,153	−5.0
Other States	346,205	354,150	475,326	552,886	612,250	+10.7
Total	2,483,840	2,811,806	2,963,261	2,931,153	3,017,135	+2.9

Table 3.—Production and shipments of carbon black in the United States in 1971, by months and grades

(Thousand pounds)

Month	SRF [1]	HMF [2]	GPF [3]	FEF [4]	HAF [5]	SAF [6]	ISAF [7]	Thermal	Total (furnace)	Channel	Total
PRODUCTION [8]											
January	18,684	646	45,349	27,088	68,726	1,146	46,530	23,850	232,019	5,309	237,328
February	18,116	1,420	35,464	24,646	60,482	2,644	41,150	20,398	204,320	5,067	209,387
March	23,224	812	47,854	28,632	70,173	1,497	47,432	25,610	245,234	5,499	250,733
April	22,374	621	44,794	27,913	75,671	2,391	44,519	30,481	248,764	5,458	254,222
May	22,034	761	39,353	29,028	81,311	2,136	43,018	33,226	250,867	5,650	256,517
June	19,853	561	52,186	24,600	69,548	2,574	48,381	30,463	248,166	4,423	252,589
July	21,875	830	45,884	27,994	76,451	2,334	38,872	33,192	247,432	3,164	250,596
August	21,549	819	43,870	27,017	80,520	3,545	42,883	32,313	252,516	2,625	255,141
September	20,886	1,807	45,063	26,394	75,637	1,888	44,389	27,894	243,958	2,144	246,102
October	22,383	2,116	44,931	29,296	89,334	3,682	44,267	29,362	265,371	2,424	267,795
November	25,252	1,258	49,192	30,567	88,518	3,051	46,887	30,656	275,381	2,167	277,548
December	20,226	2,132	55,179	25,815	80,838	2,140	45,775	24,648	256,753	2,424	259,177
Total	256,456	13,783	549,119	328,990	917,209	29,028	534,103	342,093	2,970,781	46,354	3,017,135
SHIPMENTS (including exports) [9]											
January	22,866	899	56,699	29,599	81,474	2,184	54,053	26,482	274,256	4,807	279,063
February	18,491	1,008	28,983	21,426	53,179	2,048	38,249	21,468	184,852	4,908	189,760
March	25,212	781	47,476	27,845	75,491	1,348	45,461	27,575	251,189	5,971	257,160
April	22,099	667	47,288	29,973	74,457	1,907	45,529	27,555	249,475	5,525	255,000
May	20,909	625	45,176	26,109	70,800	2,028	46,653	29,199	241,499	5,251	246,750
June	21,079	897	48,436	27,406	77,240	3,032	45,317	29,018	252,425	8,015	260,440
July	19,954	949	48,386	24,201	75,211	2,377	38,663	26,568	236,309	4,674	240,983
August	21,622	701	43,969	27,153	78,851	3,134	49,755	33,382	258,567	6,058	264,625
September	23,473	1,405	48,825	30,931	81,381	1,557	45,405	22,899	255,876	4,169	260,045
October	22,707	1,793	49,458	26,974	79,913	3,158	44,118	23,480	251,601	2,243	253,844
November	22,438	1,696	50,003	29,502	83,719	3,544	45,452	22,105	258,459	2,820	261,279
December	19,930	1,252	45,465	25,023	80,801	1,960	43,091	26,494	244,016	4,229	248,245
Total	260,780	12,673	560,164	326,142	912,517	28,277	541,746	316,225	2,958,524	58,670	3,017,194

[1] Semireinforcing furnace.
[2] High-modulus furnace.
[3] General-purpose furnace.
[4] Fast-extrusion furnace.
[5] High-abrasion furnace.
[6] Superabrasion furnace.
[7] Intermediate-abrasion furnace.
[8] Compiled from reports of a survey firm and producing companies. Figures adjusted to agree with annual reports of individual producers.
[9] Includes losses.

Table 4.—Number and capacity of carbon black plants operated in the United States

State	County or Parish	Number of plants 1970 Channel	Number of plants 1970 Furnace	Number of plants 1971 Channel	Number of plants 1971 Furnace	Total daily capacity (pounds) 1970	Total daily capacity (pounds) 1971
Texas	Aransas	--	1	--	1		
	Carson	1	--	1	--		
	Ector	1	--	1	--		
	Gaines	1	--	1	--		
	Gray	--	1	--	1		
	Harris	--	1	--	1		
	Howard	--	2	--	2	4,630,137	4,697,737
	Hutchinson	--	2	--	2		
	Montgomery	--	1	--	1		
	Moore	--	1	--	1		
	Orange	--	1	--	1		
	Terry	--	1	--	1		
	Wheeler	--	1	--	1		
Total Texas		3	12	3	12	4,630,137	4,697,737
Louisiana	Avoyelles	--	1	--	1		
	Calcasieu	--	1	--	1		
	Evangeline	--	1	--	1	3,492,574	3,830,374
	Quachita	--	2	--	2		
	St. Mary	--	3	--	3		
	West Baton Rouge	--	1	--	1		
Total Louisiana		--	9	--	9	3,492,574	3,830,374
Alabama	Russell	--	1	--	1		
Arkansas	Union	--	1	--	1		
California	Contra Costa	--	1	--	1		
	Kern	--	2	--	2		
	Mojave (District)	--	1	--	1		
Kansas	Grant	--	1	--	1	2,159,919	2,374,219
New Mexico	Lea	1	1	--	1		
Ohio	Lucas	--	1	--	1		
	Washington	--	1	--	1		
Oklahoma	Kay	--	1	--	1		
West Virginia	Pleasants	--	1	--	1		
	Marshall	--	--	--	1		
Total other States		1	12	--	13	2,159,919	2,374,219
Total United States		4	33	3	34	10,282,630	10,902,330

Table 5.—Carbon black and the feedstocks used in its production, by States

	Louisiana	Texas	Other States [1]	Total
1970				
Carbon black production:				
Total—thousand pounds	982,416	1,395,851	552,886	2,931,153
Value—thousand dollars	$70,566	$112,461	$39,244	$222,271
Average value—cents per pound	7.18	8.06	7.10	7.58
Natural gas used: [2]				
Total—million cubic feet	24,404	50,351	11,129	85,884
Value—thousand dollars	$4,015	$8,115	$1,995	$14,125
Average value—cents per thousand cubic feet	16.45	16.12	17.93	16.45
Carbon black produced [3]—thousand pounds	268,179	55,987	57,252	381,418
Liquid hydrocarbons used:				
Total—thousand gallons	150,601	276,677	96,636	523,914
Value—thousand dollars	$10,360	$20,538	$7,606	$38,504
Average value—cents per gallon	6.88	7.42	7.87	7.35
Carbon black produced—thousand pounds	714,237	1,339,864	495,634	2,549,735
1971				
Carbon black production:				
Total—thousand pounds	1,078,732	1,326,153	612,250	3,017,135
Value—thousand dollars	$78,169	$108,679	$45,201	$232,049
Average value—cents per pound	7.25	8.19	7.38	7.69
Natural gas used: [2]				
Total—million cubic feet	25,984	31,987	5,728	63,699
Value—thousand dollars	$4,552	$5,551	$1,051	$11,154
Average value—cents per thousand cubic feet	17.52	17.35	18.35	17.51
Carbon black produced [3]—thousand pounds	257,759	42,855	21,817	322,431
Liquid hydrocarbons used:				
Total—thousand gallons	170,864	263,976	112,864	547,704
Value—thousand dollars	$12,989	$21,139	$9,469	$43,597
Average value—cents per gallon	7.60	8.01	8.39	7.96
Carbon black produced—thousand pounds	820,973	1,283,298	590,433	2,694,704

[1] Arkansas, California, Kansas, New Mexico, Ohio, Oklahoma, and West Virginia. Includes Alabama in 1971.
[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

	1967	1968	1969	1970	1971
Natural gas used [1]—million cubic feet	108,961	104,973	98,251	85,884	63,699
Average yield of carbon black per thousand cubic feet [2]—pounds	5.54	5.79	6.28	6.20	6.09
Average value of natural gas used per thousand cubic feet—cents	14.02	13.71	14.88	16.45	17.51
Liquid hydrocarbons used—thousand gallons	421,286	484,404	524,370	523,914	547,704
Average yield of carbon black per gallon—pounds	4.79	4.86	4.78	4.87	4.92
Average value of liquid hydrocarbons used per gallon—cents	7.07	7.11	7.23	7.35	7.96
Number of producers reporting	9	9	9	9	9
Number of plants	35	35	38	37	37

[1] Includes natural gas used to enrich liquid hydrocarbons.
[2] Average yield based on natural gas used as feedstock, excluding natural gas used to enrich liquid hydrocarbons.

Table 7.—Sales of carbon black for domestic consumption in the United States, by uses

(Thousand pounds)

Use	1967	1968	1969	1970	1971	Change from 1970 (percent)
Ink	63,963	67,721	73,077	72,824	75,201	+3.26
Paint	12,553	13,435	17,711	14,570	18,693	+28.30
Paper	5,658	4,710	5,668	4,527	3,767	−16.79
Plastics	20,907	26,863	(1)	(1)	(1)	--
Rubber	2,072,543	2,445,550	2,616,166	2,486,146	2,678,151	+7.72
Miscellaneous [2]	40,521	30,123	65,327	71,454	77,715	+8.76
Total	2,216,145	2,588,402	2,777,949	2,649,521	2,853,527	+7.70

[1] Included in "Miscellaneous."
[2] Chemical, food, and plastics (1969, 1970, 1971) combined with "Miscellaneous" to avoid disclosing individual company confidential data.

Table 8.—Producers' stocks of channel-and furnace-type blacks in the United States, December 31

(Thousand pounds)

Year	Furnace SRF	HMF	GPF	FEF	HAF	SAF	ISAF	Thermal	Total	Channel	Total
1967	43,747	4,916	13,669	20,029	58,688	6,284	37,951	26,943	212,227	52,020	264,247
1968	29,695	2,900	14,756	20,047	55,590	3,592	41,621	23,074	191,275	32,895	224,170
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

Table 9.—U.S. exports of carbon black, by country

Country	1969 Quantity	1969 Value	1970 Quantity	1970 Value	1971 Quantity	1971 Value
North America:						
Canada	26,454	$2,394	21,917	$2,195	26,736	$2,472
Guatemala	1,132	98	1,186	113	396	42
Mexico	4,089	415	2,742	302	2,080	247
Other	1,037	98	1,766	178	1,295	121
Total	32,712	3,005	27,611	2,788	30,507	2,882
South America:						
Argentina	1,914	273	1,793	304	3,412	433
Brazil	2,865	301	5,343	565	6,423	689
Chile	455	50	357	58	433	69
Colombia	475	78	515	104	529	97
Peru	338	35	231	25	192	27
Venezuela	2,376	228	695	88	941	100
Other	393	57	202	24	183	24
Total	8,816	1,022	9,136	1,168	12,113	1,439
Europe:						
Belgium-Luxembourg	3,448	326	4,559	409	2,143	233
Denmark	1,105	154	1,355	273	823	130
Finland	314	39	412	69	163	27
France	33,236	3,625	35,603	3,751	16,514	1,900
Germany, West	15,041	1,647	15,338	1,766	6,997	878
Italy	10,934	1,384	12,055	1,657	5,894	830
Netherlands	2,470	320	13,484	2,047	43,622	5,550
Norway	934	72	1,052	84	874	82
Portugal	1,668	148	509	66	253	39
Spain	3,684	445	4,457	587	2,295	274
Sweden	2,380	217	3,392	338	1,006	89
Switzerland	1,511	150	1,271	145	986	93
U.S.S.R	7,345	863	--	--	--	--
United Kingdom	17,117	2,782	16,638	3,032	6,416	989
Yugoslavia	72	12	147	38	99	26
Other	568	73	331	76	249	46
Total	101,827	12,257	110,603	14,338	88,334	11,186
Africa:						
Ghana	818	72	1,122	100	1,089	100
Kenya	--	--	--	--	631	56
South Africa, Republic of	4,660	463	6,696	646	5,939	600
Tanzania	--	--	--	--	168	16
Other	498	57	427	94	125	15
Total	5,976	592	8,245	840	7,952	787
Asia:						
India	5,554	587	1,468	207	912	146
Indonesia	759	65	432	38	185	15
Iran	139	12	1,457	132	573	50
Israel	555	55	383	42	324	38
Japan	8,109	2,117	9,905	2,596	8,828	2,335
Korea, Republic of	13,779	1,375	3,481	354	480	95
Pakistan	1,794	173	3,159	292	209	18
Philippines	3,614	333	689	69	637	72
South Vietnam	800	79	1,368	144	725	88
Taiwan	526	107	583	109	796	196
Thailand	958	82	1,406	124	1,050	92
Turkey	428	47	1,798	160	687	66
Other	1,151	126	1,256	131	760	98
Total	38,166	5,158	27,385	4,398	16,166	3,309
Oceania:						
Australia	5,384	559	6,951	728	6,074	635
New Zealand	3,322	322	2,705	245	2,100	187
Total	8,706	881	9,656	973	8,174	822
Grand total	196,203	22,915	192,636	24,505	163,246	20,425

Table 10.—U.S. exports of carbon black in 1971, by month

(Thousand pounds and thousand dollars)

Month	Channel		Furnace		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
January	4,514	$850	6,708	$603	11,222	$1,453
February	1,805	459	9,808	821	11,613	1,280
March	1,431	399	13,988	1,539	15,419	1,938
April	1,933	541	12,020	1,031	13,953	1,572
May	1,077	400	13,596	1,591	14,673	1,991
June	2,309	681	15,244	1,391	17,553	2,072
July	2,783	914	17,702	1,963	20,485	2,877
August	1,903	694	13,566	1,238	15,469	1,932
September	3,220	951	21,396	2,272	24,516	3,223
October	327	170	2,581	220	2,908	390
November	269	88	7,328	603	7,597	691
December	1,191	311	6,547	695	7,738	1,006
Total	22,762	6,458	140,484	13,967	163,246	20,425

Table 11.—Carbon black: World production, by country

(Thousand pounds)

Country [1]	1969	1970	1971 [p]
Argentina	52,911	[r] [e] 66,000	[e] 66,000
Brazil [2]	[r] 120,152	109,129	[e] 110,000
France	302,474	327,827	[e] 330,000
Germany, West	474,220	523,491	577,987
India	[e] 55,000	[r] [e] 66,000	83,776
Italy	231,038	272,401	[e] 275,000
Japan	574,531	650,511	[e] 660,000
Korea, Republic of	1,001	7,374	16,535
Netherlands	179,456	189,597	203,927
Romania	124,411	159,778	[e] 165,000
South Africa, Republic of [e]	71,000	57,800	[e] 60,000
Spain	[r] 83,776	[r] [e] 88,000	[e] 88,000
Taiwan	[e] 550	584	322
United Kingdom	[r] 437,024	464,128	[e] 470,000
United States	2,963,261	2,931,153	3,017,135
Venezuela	16,001	16,200	[e] 16,500
Yugoslavia	34,240	29,694	[e] 30,000
Total	[r] 5,721,046	5,959,667	6,170,182

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Australia, Belgium, Canada, People's Republic of China, Colombia, Mexico, Norway, Poland, Sweden, and the U.S.S.R. produce carbon black, but available information is inadequate to make reliable estimates of output levels.

[2] Partial figure. (Output of one of the two known producers, data for second producer is not available.)

Cement

By Brinton C. Brown [1]

Portland cement shipped from plants in the United States and Puerto Rico reached an alltime high of 420.2 million barrels in 1971, surpassing the previous 1969 record by 10.4 million barrels. Mill value rose to $1.48 billion, 13 percent above the 1969 value, and reflected increased fuel and manufacturing costs and modest price increases in 1971. A record 16.4 million barrels of cement and clinker were imported for consumption in the United States and Puerto Rico, 19 percent above 1970 imports. Cement sales were spurred by an unprecedented high level of housing construction.

The cement industry commenced a new era in which capacity was declining, consumption was rising, costs were increasing, and prices were showing an upward trend. However, producers pleaded that profits were not large enough to provide capital for reinvestment and new investment for new facilities. Companies scheduling price increases effective after the President's price freeze on August 16, 1971, were caught in a squeeze. Price increases granted under the President's Phase II price control guidelines were nominal; probably about enough to offset increased labor, fuel, power, and transportation costs.

Demand for coal continued to exceed production, and as a result the price increased. Shortage of low-sulfur coal necessary to meet emission standards, together with higher costs, forced more cement plants using coal to change to natural gas and fuel oil. A shortage of natural gas in Louisiana and Mississippi curtailed clinker production in these States. As the price of fuel increased, the cost of electric power also increased. Many new labor contracts were signed in 1971, which increased labor costs 5.5 to 20 percent.

During the year, virtually every plant in the country was modernizing and improving the efficiency of dust-collecting facilities, not only to meet the new stringent pollution control standards and regulations, but to take advantage of the rapid amortization provisions of the Tax Reform Act of 1969. Many cement manufacturers were alarmed with the new emission standards issued by the Environmental Protection Agency (EPA) for new and modified cement plants that call for a stricter performance level than is required by other fossil-fuel-consuming industries. The companies also questioned the attainability of the emission standards within the scope of existing technology and equipment.

In 1971 one new 4-million-barrel cement plant started operation in Detroit, Mich., and a major modernization was completed at Thomaston, Maine, replacing a 44-year-old plant. Although 14 plant-expansion programs were in the planning stage or under construction during the year, only one was completed. This plant replaced six 60-year-old kilns at Hagerstown, Md. New clinker-production capacity installed in 1971 was offset by companies permanently retiring small, old, marginal kilns in the United States so the net capacity increase was only 3.8 million barrels.

Employees at Ideal Cement Co., Division of Ideal Basic Industries, Inc., Portland, Colo., plant established an enviable safety record by working 3,000 consecutive days (more than 2 million man-hours) without a lost-time or disabling injury. During the past 20 years only six lost-time accidents have occurred in the plant. On December 17, 1971, Louisville Cement Co.'s Logansport plant completed 6 years (2,191 days) without a lost-time accident. Calaveras Cement Co.'s plant at San Andreas, Calif., recorded 1.1 million man-hours without a lost-time injury. Huron Cement Co.'s Alpena, Mich., plant was recognized by the National Safety Council for having 1 mil-

[1] Mining engineer, Division of Nonmetallic Minerals.

lion man-hours without lost-time injuries. The National Safety Council cited Universal Atlas Cement Division of United States Steel Corp's plant at Penn Hills, Pa., for a 1-year accident-free record for operating 579,542 man-hours without a disabling injury. Universal Atlas achieved first place in safety performance among Portland Cement Association (PCA) members in the United States and Canada with five or more plants. Lone Star Industries' plant at Davenport, Calif., received the PCA safety trophy 2 years in succession for 503,707 man-hours worked accident free.

Columbia Cement Co., Division of PPG Industries, Inc., donated a 40-acre lake to the Maysville Water District in Zanesville, Ohio. The 15-foot-deep lake formed in a mined-out quarry will hold a 6-month water supply for the residents of the community.

Historical Note.—One hundred years ago on September 26, 1871, U.S. Patent No. 119,413 was granted to David O. Saylor of Allentown, Pa., for an improvement in the manufacture of cement. He claimed that ordinary cement (natural) on the market is burned with the least possible degree of heat and the stage of calcination is arrested before it fuses. This cement weighed 70 to 90 pounds a bushel. In his process of making hydraulic cement from argillo-magnesian and argillo-calcareous limestone, the material is burned to a state of incipient vitrifaction. He claimed production of a very superior and heavy hydraulic cement weighing 110 to 120 pounds a bushel and in every respect equal to the portland cement made in England and imported into this country.

On the centennial of this significant patent, the portland cement industry in the United States has grown to 167 active clinker-producing plants plus five grinding plants in 41 States. With technological advances in recent years many of these plants are automated; some have computer controls. In addition to manufacturing five standard types of portland cement, a wide variety of specialty cements are produced. Among these are the expansive cements that are relatively new on the market. Still in the experimental stage are the controlled fast-setting cements that are rapid-hardening with very high-early-strength development. Just as Saylor was constantly seeking ways to make cement of better quality, research today in cement manufacturing is directed towards filling the needs of the concrete products and construction industries. A statistical summary of cement production, shipments, and mill values in the United States during the period 1818–1971 is given in table 18.

Legislation and Government Programs.—Standards of performance for new stationary sources that contribute to air pollution, including new or modified portland cement plants, were promulgated on December 23, 1971, by the EPA as required by Section III of the Clean Air Act (PL 91–604). Limits of particulate matter from the kiln are 0.30 pound per ton of feed and from the clinker cooler, 0.10

Table 1.—Salient cement statistics

	1967	1968	1969	1970	1971
United States:					
Production [1 2] thousand 376-pound barrels	377,885	403,349	407,944	395,347	416,626
Shipments from mills [1 2 3] thousand 376-pound barrels	381,824	405,863	418,284	396,844	427,639
Value [1 2 3 4] thousands	$1,210,736	$1,294,533	$1,354,033	$1,336,255	$1,528,056
Average value [1 2] per barrel	$3.17	$3.19	$3.23	$3.37	$3.57
Stocks Dec. 31 at mills:[1 5] thousand 376-pound barrels	41,529	41,977	37,920	r 40,288	33,943
Exports do	980	942	589	847	663
Imports for consumption do	5,913	7,289	9,687	13,812	16,422
Consumption, apparent [6 7] do	386,757	412,210	427,382	r 404,098	433,449
World: Production do	2,812,729	3,021,620	3,185,240	3,353,592	3,460,674

r Revised.
1 Excludes Puerto Rico.
2 Includes portland, masonry, and slag cement (1967–69). Excludes slag cement (1970–71).
3 Includes imported cement shipped by domestic producers only.
4 Value received, f.o.b. mill, excluding cost of containers.
5 Includes portland, masonry (1970–71), slag cements (1967–69).
6 Quantity shipped plus imports minus exports.
7 Adjusted to eliminate duplication of import (clinker and cement) shipped by domestic cement manufacturers, (1970–71).

pound per ton of feed to the kiln. Ringelmann standards were deleted. No visible emissions are permitted from sources other than the kilns and clinker cooler that exceed 10 percent opacity. Existing plants must comply with one set of State and Federal standards, but new and modified plants must abide by a stricter set of rules issued by the EPA. These stricter standards, as recently promulgated, call for the cement industry to achieve markedly higher levels of performance than were required by power generating plants and other fossil-fuel-consuming industries. Occupational safety and health standards became effective August 27, 1971, under the Williams-Steiger Occupational Safety and Health Act of 1970 (84 stat. 1593). New standards and regulations together with new amendments to the Federal Metal and Nonmetallic Mine Safety Act of 1966 are applicable to both mining and manufacturing facilities and operations.

Nevada Cement Co. and its parent firm, Centex Corp. of Dallas, Tex., filed a notice of appeal to the Nevada Supreme Court following a district judge's award of $1.8 million to 85 residents in Fernley, Nev. The company was accused of polluting the air with 27,000 pounds of dust per day for 19 months. In addition to paying the 85 plaintiffs $5,000 each for general damages the company was directed to pay $1.4 million punitive damages to be divided equally among the 85 persons. Alpha Portland Cement Co., Lone Star Industries, and Universal Atlas were among 13 firms facing suit by Alabama's attorney general for air pollution. Because the State's antipollution laws were considered inadequate, the attorney general was taking action under the centuries old legal concept of "public nuisance" dating back to English Common Law. Atlantic Cement Co. has already paid $383,000 in air pollution damages to homeowners complaining about dust covering their homes, lawns, and automobiles. Payments for pending suits could reach $1 million. In December, Signal Mountain Division of General Portland Cement Co. was ordered by the Air Pollution Control Board to post a $10,000 bond against future violations of the objectionable odors provision of the county's air pollution ordinance. The Florida Division of General Portland Cement Co. chose a legal fight to avoid a closure order from the County Pollution Control Department claiming it cannot shut down the Tampa plant without irreparable economic and social damage to the community.

A suit filed jointly by the Wayne County Air Pollution Control Division and the City of Detroit against the Peerless Cement Co. in Michigan was settled quickly by the company's agreement to a court order involving a series of steps designed to control air and noise pollution.

The decision was made by the PCA and the Bureau of Mines to discard the obsolete 376-pound barrel as a unit of measure. Starting January 1, 1972 cement production and shipment statistics will be reported in short tons. Although cement will be marketed in hundredweight, no industrywide decision was made to change the 94-pound (1-cubic-foot) bag. However, Wynadotte Cement Corp. announced changing to an 80-pound bag, which will divide evenly into the short ton.

DOMESTIC PRODUCTION

PORTLAND CEMENT

Manufacturers in the United States and Puerto Rico produced 400.2 million barrels of clinker, imported 3.7 million barrels of clinker, and used clinker from stocks to grind a record high 409.6 million barrels of portland cement. To supplement production of 409.6 million barrels, domestic producers imported 6 million barrels of cement and reduced stocks to offset demands by consumers in some areas.

The combined domestic and imported cement shipped by domestic producers totaled a record 420.2 million barrels. In addition to the 420.2 million barrels of portland cement shipments by producers in the United States and Puerto Rico, another 6.7 million barrels of cement were imported by customers and importers not in the portland cement manufacturing industry.

Production Capacity.—Although three new kilns were brought into production in 1971 with a combined annual capacity of 9.0 million barrels, 16 old kilns were permanently removed from production at five plants, leaving a net annual capacity increase of only 3.8 million barrels. By yearend, 466 kilns were operating at 170 plants in 41 States and Puerto Rico with an estimated 24-hour daily clinker production capacity of 1,366,000 barrels. An average of 31 days downtime was reported for kiln maintenance and replacing refractory bricks, so, based on 334 days of operation, the apparent annual clinker production capacity of the industry was 456 million barrels.

In addition to 170 clinker-producing plants, including eight white cement facilities, five plants had grinding mills operating only on imported, purchased, or interplant transfers of clinker. A sixth plant operating on an existing stockpile of clinker ceased grinding in March 1971 when the stockpile was depleted. Information was not collected on grinding capacity, but the total in the United States and Puerto Rico was estimated to be about 500 million barrels. About 3.7 million barrels of the imported clinker were ground into cement at domestic plants, and included in portland cement production and shipment figures.

The following tabulation shows the daily clinker production capacities of cement plants in the United States and Puerto Rico grouped according to relative size:

Daily clinker capacity as of December 31, 1971

Barrels (376-pound) per 24-hour period	Number of plants [1]	Kilns [2]	Total capacity	Percent of total capacity
Less than 3,000	6	10	14,206	1.0
3,000 to 6,000	49	98	215,183	15.8
6,000 to 9,000	65	170	473,017	34.6
9,000 to 12,000	28	95	288,847	21.1
12,000 to 15,000	11	37	152,841	11.2
15,000 and over	11	56	222,193	16.3
Total	170	466	1,366,287	100.0

[1] Includes white-cement-producing facilities.
[2] Total number in operation at plants.

Production Facilities.—In May, American Cement Corp., Peerless Division, started operating its new $45 million cement plant in Detroit, Mich. The one kiln plant has an annual capacity of 4 million barrels. In 1968 the City of Detroit issued $30 million of Industrial Development Revenue Bonds for the purpose of constructing the new cement plant, which was contemporaneously leased to the company. The bonds are to be retired by the trustee from rental payments made by American Cement Corp. Dragon Cement Co., Division of Martin Marietta Corp. began operation of its new plant at Thomaston, Maine, in July and shut down the old kilns permanently in October. The new 14.25-foot by 17-foot-diameter by 520-foot-long kiln has an annual capacity of 2.5 million barrels and was equipped with a glass bag dust collector. The net capacity increase by the replacement of the old plant was 300,000 barrels.

Only one plant expansion was completed in 1971. Marquette Cement Manufacturing Co. started operating its new facilities at Hagerstown, Md., in February. One new 15-foot by 17-foot-diameter by 520-foot-long kiln replaced six 60-year-old kilns, and the annual clinker production capacity was increased by 450,000 barrels, to 2.5 million barrels.

Ideal Cement Co. operated the finish grinding mills only at the Redwood City, Calif., plant until the clinker stockpile was depleted. Production equipment was being dismantled, but the storage facilities will be used as a distribution terminal. In August, Lone Star Industries shut down six old kilns at its Davenport, Calif., plant and continued to operate on the remaining kilns. Because of State air pollution control laws, Lone Star planned to phase out kiln production at its Norfolk, Va., plant by April 1972 and convert to a cement grinding facility operating on imported clinker. In December, Medusa Cement Co., Division of Medusa Corp., acquired the 2.5-million-barrel cement plant at Clinchfield, Ga., from Penn-Dixie Corp., along with the distribution terminals at Jacksonville and Orlando, Fla. The company plans to replace the three small kilns with one new dry-process kiln that will increase the annual clinker capacity from 2.3 to 4.0 million barrels by January 1974.

St. Lawrence Cement Co. purchased Lehigh Portland Cement Co.'s silos in Buffalo, N.Y., and acquired the cement production facilities of BASF Wyandotte Corp. in the Detroit area. Grinding operations were conducted by Wyandotte Cement Corp., a subsidiary of St. Lawrence Cement Co., and clinker was furnished from the company's Mississauga plant in Ontario, Canada.

Penn-Dixie Cement Corp. installed a new finish mill and completed its air pollution abatement program at the Des Moines, Iowa, plant. Monolith Portland Cement Co. started operating its new 8,000-barrel a day finish-grinding mill at Monolith, Calif. Monarch Cement Co. completed construction of new storage and shipping facilities at its Humboldt, Kan., plant. General Portland Cement Co. completed installation of facilities at the Tampa, Fla., plant to utilize a new raw-material aragonite, which is dredged from Caribbean deposits and barged to the plant. The company was also modernizing its plant at Pauling, Ohio. The Flintkote Co. combined two subsidiaries—Diamond Portland Cement Co., Middlebranch, Ohio and Kosmos Portland Cement Co., Kosmosdale, Ky. under the name Diamond-Kosmos Cement Division. American Cement Corp. sold its interest in Hellenic Cement Co., S.A., in Greece and increased its investment in Portland de Mallorca in Spain from 50 to 67 percent. By yearend Cheney Lime and Cement Co. had discontinued manufacturing slag cement at Allgood, Ala. The company could not purchase granular slag because the steel company ceased processing slag. The source of slag for Southern Cement Co. at Birmingham also terminated.

Puerto Rican Cement Co., Inc., reactivated its white cement production facility, which had been temporarily converted for gray cement late in 1970. The company planned an expansion program that will increase bagged cement output in 1972 by 2 million sacks; about a 13-percent increase over the 1971 output of 15.4 million sacks. San Juan Cement Co., Puerto Rico's newest producer, which began operations in mid-1970, planned to install a third kiln in 1972 that will increase the annual capacity from 2.5 to 4.0 million barrels.

Five plant expansions were under construction and scheduled for completion in 1972. Hawaiian Cement Co. was installing a 12-foot-diameter by 240-foot-long kiln at its plant near Ewa Beach to increase the annual capacity by 1.5 million barrels to 2.5 million barrels. Operation was scheduled for July 1972. California Portland Cement Co. expected completion of the expansion and modernization of its Rillito, Ariz., plant by September 1972. Annual capacity will be increased from 3.0 to 4.2 million barrels. New equipment includes a grinding mill and a 10,000-barrel-a-day suspension preheater 200 feet high, and a conveyor belt 4.2 miles long with a capacity of 900 tons per hour to transport crushed limestone from the quarry to the plant. Gifford-Hill Portland Cement Co. was starting construction for a third kiln at its plant in Midlothian, Tex., to increase the annual capacity from 3.0 to 4.5 million barrels. Operation was scheduled for late 1972. Marquette Cement Manufacturing Co. was replacing eight old kilns at the Oglesby, Ill., plant with one 15-foot by 17-foot-diameter by 520-foot-long kiln with an annual capacity increase of 150,000 barrels. The 4.0 million barrel plant was scheduled for operation by yearend 1972. Texas Industries, Inc., was increasing the annual capacity of its plant at Midlothian, Tex., from 4.8 to 6.4 million barrels by the addition of a fourth 12-foot-diameter by 450-foot-long kiln. Operation was expected early in 1972.

Four other modernization and expansion programs were announced or under construction and scheduled for completion in 1973. American Cement Corp. was expanding annual production capacity at Clarkdale, Ariz., by 30 percent, to 3.4 million barrels. Glens Falls Cement Co., Div. of the Flintkote Co. was increasing the annual capacity of the Glens Falls, N.Y., plant from 1.7 to 3.0 million barrels and was converting from wet to dry process. Operation was scheduled for the spring of 1973. Ideal Cement Co. started work to replace four old kilns at Trident, Mont., with a 12-foot-diameter by 450-foot-long kiln and convert from dry to wet process. The capacity will be increased about 12 percent to 1.7 million barrels when completed in April 1973. Louisville Cement Co. was installing a new 13-foot by 15 foot-diameter by 500-foot-long kiln at Speed, Ind., that will increase the annual capacity by 1.0 million barrels to 5.9 million barrels and replace three smaller kilns. Operation was scheduled for early 1973.

Ideal Cement Co. announced plans to double the annual capacity of the Portland, Colo., plant to 5.0 million barrels by mid-1974. Maule Industries planned to install additional finish mills in 1972 as the first step in the expansion of its plant near Miami, Fla. One new kiln will be erected to increase the annual capacity from 2.4 to 5.6 million barrels in 1974. Centex was planning a new 2.0 million barrel plant at LaSalle, Ill., tentatively scheduled for completion in 1974. Gifford-Hill announced plans to build a new 1.5-million-barrel plant at Eutawville, S.C., similar to its Midlothian, Tex., plant. Santee Portland Cement Co. planned to increase kiln capacity at its plant in Holly Hill, S.C. General Portland planned modification of the kilns at the Dade County, Fla. plant that will increase the output of the plant by 20 percent. Monolith Portland Cement Co. planned to replace the five old kilns at Monolith, Calif., with two new 7,000-barrel per day kilns, one in 1974 and the other in 1976.

Ash Grove Cement Co. planned to replace five, 42-year-old wet-process kilns with one dry-process kiln at its Louisville, Nebr., plant. In addition, new crushing and storage facilities will be built and two 13-foot by 47-foot, 4,400-horsepower finish mills will be installed. Monarch Cement Co. planned to install a 12-foot-diameter by 165-foot rotary kiln with a Humboldt preheater and glass bag house at its plant in Humboldt, Kan. Completion was scheduled for late 1973.

OKC Corp. planned to start construction in 1972 to increase the annual capacity of its plant at New Orleans, La., from 1.7 to 3.6 million barrels at an estimated cost of $15 million. Concurrently, the company would increase the capacity of the Pryor, Okla., plant from 2.0 to 2.4 million barrels. Giant Portland Cement Co. planned installation of new equipment, including a new kiln, at its plant in Harleyville, S.C., that would increase the capacity by 20 percent.

Although the following lists are not complete, they give an indication of the millions of dollars expended or committed by the cement industry to air pollution abatement equipment and systems.

New air pollution control equipment was installed by Martin Marietta at the Martinsburgh, W. Va., plant; and by Penn-Dixie at Des Moines, Iowa. Other dust collecting equipment was being installed by cement companies at the following plants: California Portland Cement Co. at Rillito, Ariz., and Mojave, Calif.; Huron Cement Co. at Alpena, Mich.; Lehigh Portland Cement Co. at Alsen, N.Y., Mason City, Iowa, and Union Bridge, Md.; Lone Star Industries at Davenport, Iowa, Bonner Springs, Kans., and New Orleans, La.; Louisville Cement Co. at Logansport, Ind.; Martin Marietta at Lyons, Colo.; Penn-Dixie at Richard City, Tenn.; and Universal Atlas at Universal, Pa., Hudson, N.Y., Fairborn, Ohio, Waco, Tex., Leeds, Ala., Hannibal, Mo., and Independence, Kans.

Electrostatic precipitators were installed or were being installed by the following companies: Alpha Portland Cement Co. at Birmingham, Ala., and Jamesville, N.Y.; Arkansas Cement Corp. at Foreman, Ark.; Columbia Cement Co. at Zanesville, Ohio; Dundee Cement Co. at Dundee, Mich.; General Portland Cement Co. at plants in Tampa, Fla., Dallas, Forth Worth, and Houston, Tex., and Chattanooga, Tenn.; Flintkote Co. at Middle Branch, Ohio; Ideal Cement Co. at plants in Okay, Ark., Portland, Colo., Knoxville, Tenn., and Devils Slide, Utah; Lone Star Industries at Houston, Tex.; Louisville Cement Co. at Bessemer, Pa.; Marquette Cement Mfg. Co. at Rockmart, Ga.; Monolith Portland Cement Co. at Laramie, Wyo.; Northwestern States Portland Cement Co. at Mason City, Iowa; and Universal Atlas at Duluth, Minn.

Glass bag house dust collectors were becoming increasingly important in use for hot gases. Kaiser Cement & Gypsum Corp. was installing glass bag collectors at Permanente, Calif., to boost particulate collection efficiency to 99.9 percent. Medusa Cement Co. installed a glass bag unit at Dixon, Ill., to supplement the electrostatic precipitator. Whitehall Cement Manufacturing Co. was replacing the electrostatic precipitator at Cementon, Pa., with a glass bag system. Other companies that installed or were installing glass bag dust collectors were as follows: American Cement Corp. at Crestmore, Calif.; Giant Portland Cement Co. at Harleyville, S.C.; Lone Star Industries at Maryneal, Tex.; Louisville Cement Co. at Speed, Ind.; and Martin Marietta at Thomaston, Maine.

MASONRY CEMENT

Shipments of masonry cement reached an alltime record of 24,228,000 barrels (280-pound), an increase of 14 percent over 1970 and 4 percent over the previous record shipments in 1965.

By yearend 117 plants were producing masonry cement in the United States. Four plants manufactured masonry cement exclusively: Riverton Corp., Riverton, Va.; M. J. Grove Lime Co., Frederick, Md.; Cheney Lime and Cement Co., Allgood, Ala.; and Southern Cement Co., Birmingham, Ala. Masonry Cement production was not reported in California and Puerto Rico because most masons preferred to purchase portland cement and add clay or lime for plasticity on the job. Imports of masonry cement increased 36 percent in 1971 to 368,000 barrels.

ALUMINOUS CEMENT

Lone Star Industries in a joint venture with Cements Lafarge, S.A., of France, was importing calcium aluminate cement and marketing it under the name "Fondu." Universal Atlas Cement Division of U.S. Steel Corp. completed the first full year of operation of its new calcium aluminate refractory cement plant at Gary, Ind., and closed the old facility.

TRANSPORTATION

About 20 percent of the cost of cement to the buyer represents delivery expense from the mill. A recent trend of multiplant cement manufacturers to consolidate production in larger more efficient plants to reduce manufacturing costs, also lengthened the distance for distribution to customers. Cement distribution by use of satellite transfer terminals and pneumatic unloading equipment was proposed as a method to reduce costs. These have been in operation for the Atomic Energy Commission in Nevada and, in an adaptation, on barges shuttling between islands in the Bahamas. Utilizing readily available components of pneumatic unloading trailers, rail cars, and portable storage units, throughputs range from 250 to 2,600 barrels per hour. Estimated cost from $5,000 to $100,000 is a small fraction of the cost of a permanent terminal facility. Satellite distribution terminals are particularly applicable to meet short-term demands, to service special customers, and for investigation of new markets.

Missouri Portland Cement Co. acquired four new river barges in 1971, which increased its fleet to 34 bulk cement barges.

While the new plant was under construction at Thomaston, Maine, Martin Marietta Corp. enlarged the capacity of its rail distribution terminal at Wilmington, Mass., to 25,000 barrels. The company leased 27 pressure-flow rail cars, each with a capacity of 540 barrels.

Calaveras Cement Co. Div. of the Flintkote Co. started operating a new 14,000-barrel distribution terminal at Union City, Calif., and Kaiser Cement & Gypsum Corp. was constructing a 12,000-barrel distribution plant at Spokane, Wash.; completion was scheduled for January 1972. The facility will be supplied by rail from the corporation's Montana City, Mont., plant. Rinker Materials, Inc., purchased a 160,000-barrel cement distribution facility at Port Everglades, Fla., from Atlantic Cement Co., Inc.

Titan Cement Co. purchased two ships to facilitate transport of its output, inaugurated a new distribution facility at Alexandroupolis, Greece and was constructing another at Heraklion, Crete. Canada Cement Lafarge also planned to build a storage and shipping facility on Birch Island, Ontario with government assistance to benefit the White Fish Indians; completion was scheduled for mid-1972. Jalaprathan Cement also operated a distribution terminal at Phra Pradaeng and a small fleet of cement-carrying vessels including the M.V. Xujati, Thailand's first bulk cement carrier.

CONSUMPTION AND USES

Shipments of cement, by State of destination, are considered to be an index of consumption. Consumption of portland cement increased nearly 8 percent above 1970 consumption and 3 percent above the previous record year in 1969. Although 38 States and shipping districts had an increase in shipments, 13 had lower consumption and three remained about the same. The largest increase was in Texas with nearly 4 million barrels; followed by Illinois and Michigan with more than 3 million each; Puerto Rico, 2.1 million; and northern California, 1.9 million. Other States with shipment increases exceeding 1 million barrels were Florida, Arizona, Missouri, Louisiana, Georgia, and Colorado. States and shipping districts with increases ranging between 650,000 and 1 million barrels were West Virginia, Arkansas, Alabama, Tennessee, eastern Pennsylvania, Indiana, and eastern New York. The greatest decrease in consumption was in southern California with 2.0 million barrels, followed by the New York metropolitan area with 1 million; western New York, 481,000; and Hawaii, 448,000.

Ready-mix concrete producers were the primary customers of portland cement, accounting for 63.1 percent of the total shipments. Concrete product manufacturers used 13.4 percent of the cement shipments to make concrete blocks, concrete pipes, and precast, prestressed concrete and other concrete products. Direct shipments to highway contractors amounted to 9.4 percent of the total cement consumed. Building materials dealers received 8.5 percent of the shipments; other contractors received 3.0 percent; Federal, State, or other government bodies purchased 0.4 percent; 2.2 percent went for miscellaneous uses.

Construction reached a record high in 1971, up 7 percent over that of the preceding year. Dominated by housing, private construction increased 11 percent, which was in sharp contrast to the 2 percent decrease in public construction. The slack in the economy during 1971 created an ease in credit markets and an abundant supply of mortgage money. New housing starts in 1971 increased 42 percent, an alltime high. Housing starts were 48 percent greater than the average for the preceding 5 years. Expenditures for religious and educational building construction continued to decrease, but hospital and institutional building reached new highs. Although expenditures for public construction reached an alltime high, price increases erased the gains, and real output was down 2 percent. Outlays for public construction accounted for 27 percent of total construction activity in 1971. Highway and street construction, which accounted for about one-third of all public construction increased a nominal 2 percent. Public buildings and road construction together still accounted for about three-fourths of all public construction in 1971, about the same proportion as in recent years.

PRICES

The average mill value[2] of a barrel of portland cement (all types) was $3.52 in 1971, an increase of 20 cents per barrel. The mill value ranged from a low of $3.19 in New York to a high of $5.12 in Hawaii. Prices rose 7 to 10 percent for bulk gray cement in some market areas where price increases were effective before the President's price freeze on August 16. Individual company price increases announced before the freeze to become effective after August 16 were not permitted. However, the Price Commission recognized the need for some flexibility in granting price relief to companies who were in a depressed competitive position during the base years (1968–70) and allowed cement companies to make application for price increases on an individual basis rather than industry-wide. Price increases granted to cement companies in 1971 by the Price Commission under the President's Phase II price control guidelines have been nominal (about 25 cents per barrel).

Figures published by the Engineering News-Record show the December bulk mill

[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 terminal, if any; less total cost of operating terminal, if any; less cost of paper bags and pallets.

prices range from a low of $3.75 per barrel in Independence, Kans., to a high of $5.78 per barrel in Waianae, Hawaii, with $4.85 reported at Demopolis, Ala., and Lake Oswego, Oreg. Most prices were subject to cash discounts. Bagged cement prices were $0.65 to $1.50 per barrel higher than bulk prices. Base prices for portland cement in carload lots f.o.b. were reported monthly in the Engineering News-Record for 20 cities across the United States. The December 1971 average for bulk cement was $4.50 per barrel, compared with $4.29 in December 1970. In the 20-city survey, bulk prices ranged from a low of $4.00 in St. Louis, Mo., to a high of $5.29 in Denver, Colo. Masonry cement averaged $5.07 per barrel in December 1971, compared with $4.68 in 1970, and ranged in price from $4.44 per barrel in Baltimore, Md., to $6.33 in Kansas City.

In June 1971, the Consumer Service Administration (CSA) ended the Puerto Rican government's 23-year price freeze by granting an interim 25-cents per bag increase for bagged cement. Effective December 9, the price of bulk cement was controlled for the first time, and producers' prices for both bagged and bulk cement were established at a maximum of $1.30 per 1-cubic-foot bag (94 pounds). The maximum price to the consumer was set at $1.45. Under the new flexible pricing system, the companies were allowed future increases of 5 cents per bag annually. Increases exceeding 5 cents require the approval of the CSA.

Despite record sales, price increases up to 50 cents per barrel, and cash discounts reduced from 20 to 10 cents a barrel, many companies continued to claim financial difficulties, stating that increased costs of labor, fuel, power, transportation, and purchased materials offset price gains. While Phase II price controls were restricting price increases and temporarily impeding free economic balance of the cost-price relationship in the United States, many foreign countries were rapidly increasing cement prices to compensate for sharp rises in essential production costs. Fuel prices, particularly fuel oil, increased 25 to 100 percent; wages increased 10 to 12 percent in 1971. Greece and Portugal were among the few countries to maintain their old price level.

Cement price patterns were very complex. For example, items included in the gross sales price were freight to the customer and freight to the terminal, if any. In addition, the gross sales price was subject to cash discounts. These three items were reported to exceed $1.25 per barrel in some companies.

FOREIGN TRADE

Exports of cement from the United States in 1971 decreased 22 percent in quantity and 33 percent in value. Although 72 countries received 662,796 barrels of cement from the United States, Canada, Panama, the Leeward and Windward Islands, and the French West Indies took 75 percent of the total exports.

Portland cement and clinker imported from 13 countries for consumption in the United States and Puerto Rico reached another alltime high of 16,422,288 barrels, surpassing the previous record set in 1970 by 19 percent. Imports were more than double that of any year during the period 1878–1968. The importing and marketing of foreign cement in some regions was an important factor and, in effect, was equivalent to a large cement plant in the market area. Customers in New York and Florida received 63 percent of the imports. Canada supplied more than 50 percent of the imported cement and clinker, followed by the Bahamas with 25 percent; Norway, 14 percent; and Mexico, 5 percent.

The rate of duty on white, nonstaining portland cement decreased from 2.0 to 1.5 cents per 100 pounds on January 1, 1971, and the rate of duty for other hydraulic cement and clinker decreased from 0.9 to 0.4 cent per 100 pounds at the same time. The annual rate modifications were a result of concessions granted by the United States in the Kennedy round of trade negotiations concluded on June 30, 1967, under the General Agreement on Tariffs and Trade.

A 10-percent ad valorem surcharge was imposed by the President on August 16, 1971, for dutiable imports not to exceed the statutory limit and was removed on November 15, 1971. The statutory limit was 8 cents per 100 pounds for white, nonstaining portland cement and 6 cents per 100 pounds for other hydraulic cement and clinker.

WORLD REVIEW

Approximately 1,450 cement plants were in operation in the world; total capacity was about 3.8 billion barrels. Numerous new cement plants were under construction or in various stages of planning and financing in many countries. An increasing number of old plants were being modernized or replaced, not only to increase efficiency, but to meet air pollution control demands brought about by a growing concern of people in many nations for the quality of the environment.

The world cement situation was a dichotomy of chronic shortage in many countries: Algeria, Congo, Dominican Republic, India, and Indonesia, to name a few, and a surplus in other countries such as the Philippines and Thailand. American Cement Corp., International Telephone and Telegraph Corp. (ITT), Kaiser Cement & Gypsum Corp., Lone Star Industries, and U.S. Steel Corp. invested or were planning to invest in foreign plants.

In 1971, European countries belonging to CEMBUREAU, the European Cement Association, put into operation 34 new kilns, representing a combined annual capacity increase of 13 million tons. Another 23 kilns were scheduled for operation in 1972 to produce an additional 7 to 8 million tons of clinker.

Angola.—A new cement plant costing $47 million was scheduled for construction at Nova Lisboa. Companhia dos Cimentos de Angola had an annual capacity of 99,000 tons per year, and the other producer, Companhia de Cimento Secil do Ultramar (Secil) expected to attain a capacity of 600,000 tons per year in 1971 at its Luanda plant.

Argentina.—Six companies operated 39 kilns at 16 plants with a total annual capacity of 8,088,000 tons in 1971. Calera Avellaneda S.A. obtained a $5.5 million loan from the International Finance Corp. to increase the output of its Olavarria plant from 374,000 to 770,000 tons a year. Cia. Sud Americana de Cemento Portland plans a new $28 million plant with an annual capacity of 484,000 tons.

Brazil.—Cement was produced at 32 plants operated by 31 companies in 17 States. Sindicato National da Industria do Cimento estimated that the annual capacity by the end of 1971 was 12.5 million tons. Cemento Aratu S.A., subsidiary of Lone Star Industries, was increasing the Salvador, Bahia, plant capacity by 660 tons per day by the end of 1971. A Swiss concern was financing a cement plant at Pedro Leopoldo, Minas Gerais, with an annual capacity of 700,000 tons. The Leiria group of Portugal will install a $40 million cement plant at Lagoa Santa, Minas Gerais; annual capacity will be 1 million tons. Cia. Cimento Itau do Paraná, S.A., was constructing a 1,000-ton per day plant in Rio Branco do Sul, Paraná. Construction of a 2,000-ton per day plant was started in 1971 at Apiai, São Paulo. Cia. Brasileira de Ligantes Hidraulicos was building a 2,400-ton per day plant at Macaé, Rio de Janeiro. A new plant was under construction near Jacupiranga about 300 kilometers southwest of São Paulo. The dry-process plant with a daily capacity of 1,000 tons was scheduled for completion in 1972. Cia de Cimento Sul Paulisto expected completion of a new cement plant at Iporanga, Vale do Ribeira, São Paulo by 1973. Annual capacity will be 700,000 tons. Other plants reported under construction in 1971 were at Corumba de Goiás, Goiás; Lajes, Rio Grande do Norte; Codo, Maranhão; Tanhacú; Bahia; Monte Alegre, Pará; and Mossoró, Rio Grande do Norte. Annual cement production capacity was expected to increase to 21.6 million tons by 1975.

Canada.—In December 1971 Genstar Ltd. acquired the Ocean Cement & Supplies Ltd. cement plant at Bamberton, British Columbia. The company also owns the Inland Cement Industries Ltd. plant at Edmonton, Alberta. Canada Cement Lafarge Ltd. planned to double the annual capacity of its plant at Exshaw, Alberta, to 1.0 million tons. Operation of the new 500,000-ton per year kiln is scheduled for late 1974. A similar project was in the design stage for the St. Constant, Quebec, plant. St. Lawrence Cement Co. ordered an

8,700-horsepower gearless drive ball mill, 18 feet in diameter by 73 feet long, for its plant in Clarkson, Ontario. The company planned to double the annual grinding capacity of its Mississauga plant to 1.8 million tons and start operating three kilns that were retired 3 years ago.

Central African Republic.—A clinker grinding mill with a capacity of 55,000 tons per year was proposed as the first phase of a cement factory.

Chile.—Fabrica de Cemento El Melon S.A. was modernizing one of its kilns. The Government was studying plans to build a cement plant in Antofagasta province. Plans were made for a cement plant in the Puerto Natales region north of Punta Arenas in the Province of Magallanes.

China, People's Republic of.—Small cement plants were built throughout the country to reduce dependence on the major industrial centers. About 40 percent of the country's 1971 production came from small plants.

Colombia.—Cementos Diamante, S.A., was increasing the daily output capacity of its Ibagué plant from 700 to 1,100 tons.

Cuba.—A second kiln was being installed at the Nuevital plant in Camaguey Province. Final mill capacity will be 660,000 tons a year. In addition to two cement plants under construction, one by U.S.S.R. and one by Czechoslovakia, two plants were proposed. Each plant would have about 440,000 tons per year capacity.

Dominican Republic.—Despite a shortage of cement, reflected in virtual rationing of cement, the Government would not grant permission to build two new privately owned cement plants, one by a Dominican-Spanish group at Barahona, and one by Gulf-Western Industries at Guayacanes. The Government-owned (and the country's only) cement plant increased production 23 percent in 1971.

France.—Ciments Français purchased the cement interests of Establissements Poliet Et Chausson, adding 3.58 million tons to its annual capacity. Ciments Lafarge announced plans for a cement plant at Dunkirk with an annual capacity of 165,000 tons; completion was scheduled for 1974. Société Creusot Loire completed modernization of its Porte de France plant, changing from wet to dry process. Specifications required a daily clinker output of between 660 and 990 tons; a heat consumption not greater than 830 K cal. per kg. of clinker; and a power consumption not to exceed 55 kilowatt hours (Kwhr) per ton of clinker.

Greece.—The country's cement industry has expansion programs expected to increase the total annual production capacity to 8.8 million tons. In the fall of 1971, Titan Cement Co. inaugurated the third kiln at its plant in North Efkarpia in Thessaloniki, raising the annual capacity by 495,000 tons, to 1.1 million tons. In March 1971 Titan Cement Co. acquired American Cement Corp's interest in Hellenic Cement Co. Titan was planning to add a second kiln at the plant in Drepanon, Petrás, for operation in mid-1973. The company also planned modernization of its Eleusis plant. In May 1971, Chalkis Cement Co. obtained Government approval for expansion of its plant at Avlís to increase the annual capacity from 726,000 tons to 1.2 million tons.

India.—The country's total installed cement capacity was 17.9 million tons in January 1971. New plants and plant expansions were under construction to increase the annual capacity to 23.3 million tons by 1973. The Cement Corp. of India planned to build plants at Bokajan, Assam, and Paonta, Himachal Pradesh. Construction of a plant near Dehra Dun, Uttar Pradesh, was being considered.

Indonesia.—Kaiser Cement & Gypsum Corp. acquired a 51-percent equity in P.T. Semen Tjibinong (Tjibinong Cement Co.). Design engineering for a 550,000-ton capacity cement plant at Tjibinong, 30 miles south of Djakarta, was started in 1971. Construction was scheduled for early 1973. A proposed plant expansion at Padang Cement's plant at Indarung in western Sumatra was expected to increase the annual capacity from 150,000 to 220,000 tons. A joint venture between P. N. Padang Cement and P. T. Tasindo planned to build a cement grinding mill at Belawan in northern Sumatra. Clinker will be supplied from the Padang plant. In September 1971 construction was started on another grinding plant at Belawan as a joint venture by P. T. Sumatra Cement Ltd., a Singapore firm, and P. T. Sumber Wangi, a domestic company. Completion was scheduled for September 1972. Concurrently, a clinker-producing plant was under construction at Bohorok in the Langkat district, about 90 kilometers from Belawan. When the plant is completed in 1974, annual capacity will be 400,000 tons. Clinker will be imported for the Belawan mill until the Bohorok plant is completed. The Central Java Provincial Administration, in a joint venture with an Australian firm, planned to build a cement plant at Pamotan near Rembang; capacity of the plant will be 7,500 tons per day. Gresik Cement Co. was installing an 11-foot by 375-foot rotary kiln at its plant in Surabaya in eastern Java. When completed in May 1972 the annual capacity of the plant was to be increased from 375,000 to 500,000 tons.

Iraq.—The Samawah Cement plant expansion under construction at As-Samawah will increase the annual production capacity by 550,000 tons, to 900,000, when completed in April 1973. Plans were made for a new cement plant at Fallanja.

Italy.—In late 1971 Union Cementerie Marchino Emiliane e di Augusta S.p.A. (Unicem) started operating its new plant near Turin. The completely automated plant has an annual capacity of 1.3 million tons and is one of the most modern plants in the world. Cementerie del Tirreno increased the annual capacity of its Taranto plant to 1.4 million tons. Plans were made to build a new plant at Maddaloni and expand the facilities at Spoleto.

Jamaica.—Caribbean Cement Co. Ltd. planned to install a fourth kiln at its plant in Rockfort, Kingston. When completed in 1975, the annual capacity will be increased to 650,000 tons.

Japan.—Japan continued to rank third among world cement producers, after the U.S.S.R. and the United States. Major Japanese cement producers were expanding or adding production facilities to meet an anticipated demand of 110 million tons per year by 1975. Osaka Cement Co. abandoned its plans to build a cement plant on reclaimed land at Usuki City. Despite a pollution prevention agreement with the Oita Prefecture and Usuki City, the Oita District Court nevertheless yielded to public reaction and stopped the project.

Khmer, Republic (formerly Cambodia).—Repair work was in progress at the cement plant near Chakrey Ting, in Kampot Province on the Gulf of Siam.

Korea, Republic of (South).—Chung Buk Cement Manufacturing Co., Ltd., was doubling the annual capacity of its plant at Jechon in Chung Bok Province to 1.1 million tons; completion was expected in December 1971. Ssang Yong Cement Industrial Co. Ltd. was increasing its Tonghae plant's annual capacity by 1.1 million tons to 2.9 million tons and the Yongwol plant's annual capacity by 1.3 million tons to 2.1 million with completion scheduled for 1973. A new firm, Ko Ryo Cement Manufacturing Co. Ltd. was constructing a plant at Chang-Seung; initial annual capacity was to be 880,000 tons. Completion target date was December 1971. Hyun Dai Cement Co. was increasing the annual capacity of its Tanyang plant from 440,000 to 1.1 million tons; completion was scheduled for June 1972. When the present expansion programs are completed, the country's annual capacity will increase from 7.5 million to 12.1 million tons.

Libya.—A consortium of German firms, Krupp, Siemens, & Sueas, have a contract to increase the daily capacity of National Cement Co's cement plant at Homs from 390 tons to 1,100 tons. A West German firm has a contract for expanding the cement plant at Benghazi.

Malaysia.—Plans were announced for construction of a new cement plant at Bukit Ketri, Perlis State, with an annual capacity of 385,000 tons.

Mexico.—Construction was started to double the daily capacities of the Cementos Mexicanos, S.A., plant in Monterrey, Nuevo Leon, from 2,000 to 4,000 tons and the plant in Torreon, Coahuila, from 550 to 1,100 tons. Cementos de Sinaloa, S.A., was expanding the daily capacity of its Hornillos plant from 440 to 1,300 tons. Mexicans acquired 51-percent control of Cementos Tolteca, S.A., the largest cement company in Mexico. The remaining 49 percent is owned by Associated International Cement Ltd. of Great Britain.

Morocco.—French-owned Lafarge-Maroc Cement Co. interests in Morocco were Moroccanized under an October 1971 agreement; the French parent company retained 41-percent interest. Plans were made to increase the annual capacity of the cement plant at Casablanca to 1.1 million tons.

Mozambique.—Companhia de Cimentos de Moçambique S.A.R.I. started installing a dry-process kiln at its Matola plant near Lourenço Marques to increase the daily capacity by 2,200 tons.

Nigeria.—The country's chronic cement shortage was aggravated by a labor "slow down" at the West African Portland Cement Co. plant at Ewekoro near Abeokuta in Western State, about 30 miles north of Lagos. A third kiln was being installed at the Ewekoro plant and when completed in 1972 the annual capacity of the plant was to be increased from 660,000 to 920,000 tons. Production was started in September 1971 with one kiln at the Nigerian Cement Co., Ltd., Nkalagu plant that was closed during the civil war. Full production was anticipated with two kilns by yearend. Five of the six original kilns were considered repairable. The Calabar Cement plant was expected to operate at the rated capacity of 110,000 tons per year when power is supplied from the Afam power station in late 1971. The Ukpilla cement plant in the Midwest was being completed by Udygog Nigerian Ltd. Nigerian Cement Co., Ltd., started operating the third kiln at its Enugu plant, which increased the annual capacity to 350,000 tons.

Pakistan.—Bids were solicited for construction of cement plant at the Jaipur Hat limestone deposit in East Pakistan. The daily capacity will be 2,200 tons of cement and an additional 1,100 tons of clinker (to be milled in the south). East Pakistan has no surface deposits of limestone, and a deposit found 6 years ago at Jaipur Hat has 1,500 feet of overburden and requires underground mining.

Philippines.—Seventeen cement plants were in operation by the end of 1971 with an annual capacity of 37.4 million barrels. Although production increased about 10 percent above the 1970 level, capacity utilization was still only 45 percent. In February 1971 Iligan Cement Co. started operating its new plant with an annual capacity of 2.25 million barrels at Iligan, Lanao. Apo Cement Co., the Philippines oldest cement plant at Naga City, Cebu, resumed operations in November with an annual capacity of 600,000 barrels. In September Floro Cement Corp. started operating its new cement plant with an annual capacity of 2.7 million barrels at Lugait, Misamis Oriental. Two plants were reported under construction: Midland (Quezon) at Tanay, Rizal, with 3 million barrels annual capacity and Continental at Norzagaray, Bulacan with a 2.6-million-barrel annual capacity.

Exports of cement exceeded $5 million in 1971 and therefore became subject to the 4-percent export tax set in the Stabilization Tax Act of 1970. About 14 percent of the Philippine cement production was exported. The Philippines exported 55,000 tons of cement to Saigon and 22,000 tons to QuinHon between April and June.

Poland.—The Yuzhgidro Cement Institute had plans for two cement plants, which would increase the country's annual capacity by 6 million tons. Both the plant in Opole and the Warta-2 plant near Lodz Voivoship will be equipped with Soviet-made machinery.

Portugal.—Cia. Industrial do Cimento do Sul was starting construction of a cement plant in southern Portugal with an annual capacity of 330,000 tons. The company also contracted to build a cement plant at Loulé near Faro with a daily capacity of 1,200 tons. Both plants were scheduled for completion in 1973.

Qatar.—Qatar National Cement Co. planned to double the daily capacity of its Umm Bab plant to 660 tons.

Romania.—The cement plant under construction at Cimpulung-Muscel in the Argesul Valley near Bucharest was scheduled for completion in 1972 with an annual capacity of 2.2 million tons. Another cement plant was under construction at Hoghiz northwest of Brasov with an annual capacity of 2.6 million tons.

Somali.—Construction of a cement plant by North Koreans was planned to start in 1972. The site will be either Berbera or Mogadishu.

South Africa, Republic of.—By the end of 1971 the country's annual cement-producing capacity was increased by 2.2 million tons. In May 1971, Pretoria Portland Cement Co. Ltd. started operating its new kiln at Germiston, which has an annual capacity of 660,000 tons. This raised the total plant capacity to 1,453,000 tons. In September 1971, White's South African Portland Cement Co. Ltd. inaugurated its new kiln near Lichtenburg, Western Transvaal, with an annual capacity of 660,000 tons. By yearend Anglo-Alpha Cement Ltd. completed installation of a second kiln at its Dudfield plant with an annual capacity of 880,000 tons, which increased the plant capacity to 1,375,000 tons. South Africa's three largest cement producers, Anglo-Alpha, Pretoria, and White's South African, have acquired an interest in Federale Kunsmis, whose subsidiary, Palcaso (Pty.) Ltd., operates the Palment (Pty.) cement plant at Phalaborwa, which uses waste phosphogypsum to manufacture cement. The capacity of the plant is 1,100 tons per day.

Spain.—Expansion programs were under construction to increase the country's annual cement production capacity from 22 to 23.7 million tons by the end of 1971. American Cement Corp. increased its ownership in Portland de Mallorca, S.A., to 67 percent.

Sweden.—Gullhogens Bruk increased the annual capacity of its plant at Skovde to 1.7 million tons with the addition of a 16.5-foot-diameter by 262-foot-long computer-controlled kiln. Heat consumption of this No. 6 kiln is less than 760 K cal. per kg. of clinker.

Syria.—Three new cement plants were approved for construction that will increase the country's annual cement production capacity by 1.1 million tons, or about double the present capacity.

Taiwan.—Taiwan Cement Corp. completed expansion of its Chutung plant in May 1971 by installing a new kiln with a daily capacity of more than 1,600 tons. In September 1971 Taiwan Cement Corp. started operating the new kiln at its Kaohsiung plant, which has a daily capacity of 1,600 tons. Yung Kang Industrial Development Co., Ltd., and East Asia Cement Corp. completed plant expansion in 1971, raising the country's annual capacity to 7.2 million tons. When the Cheng Tai Cement Co., Ltd., completes its plant expansion and other companies proposed plants are completed, Taiwan's total cement capacity will exceed 8.8 million tons.

Thailand.—In May 1971 Jalaprathan Cement Co. Ltd., in which Kaiser Cement & Gypsum Corp. has a 35-percent interest, started operating its Cha-Am plant south of Bangkok near Petchaburi, which has an annual capacity of 580,000 tons. The company's plant at Takli has an annual capacity of 522,000 tons. In December 1971 Siam Cement Co. Ltd., the country's largest cement producer, shipped cement from its new plant at Kaeng Khoi, 129 kilometers north of Bangkok. The fully computerized plant has an annual capacity of 826,000 tons, which brings the company's total capacity to nearly 3.3 million tons per year. Siam Cement Co. Ltd. started producing white cement at its Bangsue plant (on the outskirts of Bangkok); daily capacity is 75 tons. The only other producer of white cement was Universal White Cement Co. Ltd., which started production in 1970 at its plant in Saraburi and has an annual capacity of 33,000 tons. Completion of the Siam City Cement Co's. plant in Saraburi, about 129 kilometers north of Bangkok, was scheduled for February 1972. The dry-process plant will have an annual capacity of 468,000 tons.

Togo.—In July 1971 Societe des Ciments de l'Afrique de l'Ouest (CIMAO) began operating a grinding plant that has an annual capacity of 110,000 tons near Lome; the plant uses imported clinker. CIMAO was formed by the Governments of Togo and the Ivory Coast in partnership with Lambert Freres of France.

Uganda.—The Uganda Cement Industries plant at Hima near Kasese in Western Uganda will install three more kilns. Initial annual capacity was 100,000 tons. When the plants are completed in mid-1973, the output of the Hima plant will be 900 tons per day.

U.S.S.R.—Continuing to lead the world in portland cement production, the Soviet Union again established record shipments of 100.3 million tons in 1971. New cement production capacity made operational in 1971 totaled 3.1 million tons.

United Kingdom.—Associated Portland Cement Manufacturing Ltd., parent company of the Blue Circle Group, started production with the fifth large kiln (650 feet long) in July 1971 at its new plant at Northfleet, Kent. The sixth and final kiln was started up near yearend, bringing the total annual capacity of the plant up to 4 million tons.

Uruguay.—Administración Nacional de Combustibles Alcohol y Portland (ANCAP) was constructing a cement plant at Paysandu that was to have an initial annual capacity of 130,000 tons when completed in June 1972. Plans were made to expand the capacity of the plant to 300,000 tons.

Yugoslavia.—Plans were made by Brodoimpeks, a firm in Belgrade, to construct a cement plant that has an annual capacity of 440,000 tons. Plants with a combined annual capacity of 2.5 million tons were in different stages of construction or planning during 1971 at Kakanj and Lukavac in

Bosnia, Podsused near Zagreb, Ostruznica, and Popovac in Serbia. Construction of a 440,000 ton per year cement plant began near Kosjevic in Serbia.

Zaire.—The German firm, Klochner-Industrie-Anlagen, started constructing a cement plant in Kongo-Central that will have an annual capacity of 1.6 million tons when completed in 1976. At Lubudi, Ciments et Materiaux de Construction du Katanga (CIMENKAT) installed a coal processing facility to remove 27 percent moisture from the coal, thereby increasing the annual capacity of the plant by 33,000 tons to 130,000 tons. Work was in progress to change from wet to dry process to increase the capacity to 160,000 tons per year.

Zambia.—The Chilanga Cement Co. planned construction of a second kiln at its Ndola plant.

TECHNOLOGY

The cement industry spent millions of dollars in 1971 to modernize and improve dust collecting facilities. Virtually every plant was engaged at some stage in a program for increasing the capacity and efficiency of pollution abatement systems to comply with existing and new pollution control standards and regulations. The cost of air pollution abatement systems at new cement plants ranged from 10 to 20 percent of the capital investment. This ranged from $0.50 to $1.50 per barrel of capacity; the average was about $1.00. Electrostatic precipitators continued to be the major dust collector installed for kilns; however, glass bag dust collectors were becoming more important. Not only have glass bag houses supplemented the electrostatic precipitators to attain 99.9 percent efficiency, but in some instances have replaced the precipitators.

The Moscow Mining Institute in the U.S.S.R. reported a new electrostatic precipitation technique claiming twice the efficiency of the conventional electrostatic precipitation. By colliding oppositely charged streams of polluted air, very fine dust particles can be coagulated so that they will precipitate more readily. Air to be treated is divided in two, one stream passes through a positively charged chamber and the other stream flows through a negatively charged chamber. The two streams are brought into head-on collision; attraction of the dust particles form larger particles.

Because of sharp increases in fuel costs and an acute shortage of low sulfur coal, many companies were weighing the advantages of the dry process and the use of preheaters.

The option between building a dry- or a wet-process plant was becoming more important. New modern dry-process kilns with suspension preheaters used 550,000 Btu per barrel of clinker compared with new large wet-process kilns requiring 900,000 Btu per barrel. Old wet-process kilns with inadequate chain systems used 1.3 million Btu per barrel or more. By installing an adequate chain system, one plant was able to reduce fuel requirements 300,000 Btu per barrel.

Preheating raw mix kiln feed for dry process by counter flow of the hot waste gas through the feed material in a suspension preheater substantially reduces fuel consumption in making clinker. Three Krupp counterflow preheaters were installed on long, dry-process rotary kilns in Texas in 1971 that should materially increase clinker output and decrease fuel consumption. Gullhogens Bruk's new expansion at Skovde, Sweden, including a high-economy dry-process kiln with a cyclone preheater, exceeded the guaranteed production of 2,300 tons per day, and the heat consumption of 760 K cal. per kg. clinker was lower than the guaranteed figure. Clinker heat recovered was 200 to 250 K cal. per kg. of clinker.

Twelve years ago a one-kiln plant with a 1.5 million barrel annual capacity cost $7 per barrel of capacity to build. The new 4.0 million barrel plant at Detroit cost $10 a barrel to build.

There is a trend towards larger grinding mills with greater horsepower consumption, because of the lower capital cost, lower building space requirements, better grinding efficiency, less steel consumption; and a single mill is more readily adaptable to computer process control. Peerless Cement Co. installed a 15-foot-diameter by 49-foot-long ball mill with a 7,000-horsepower gear drive at its new plant in Detroit, Mich. The world's largest ball mill and the first gearless drive ball mill outside of Europe will be installed at St. Lawrence Cement Co.'s plant in Clarkson, Ontario. Nominal mill size is 17 feet in diameter by 56 feet, but the overall dimensions of the unit including the drive is 18 feet in diameter by 73 feet long. Around one end of the mill is a 32-foot-diameter stator, making the mill itself the rotor in the 8,700-horsepower motor. Mill delivery was scheduled for late 1972.

Dycherhoff Zementwerke A.G. in West Germany reported an 80-percent reduction in ball wear rate in pounds per ton of cement ground by replacing standard steel balls with high-chromium cast balls. A cement plant in the United States reported a grinding media cost reduction of 82 percent by changing to the high-chromium alloy.

In September, at the International Cement Convention in Dusseldorf, West Germany, papers were presented indicating that the trend in quarrying is towards large-diameter borehole blasting, large wheel-mounted loaders with bucket capacities up to 15 cubic yards, and portable crushers. One paper claimed a considerable reduction in investment and power consumption using dry-process, tandem grinding in a combination of an impact hammermill, a tube mill, and an airflow classifier as opposed to wet-process, closed-circuit grinding with screens and hydroclones. Although long dry-process kilns were mentioned favorably, about half of all the European clinker was produced in shorter kilns with suspension-type preheaters. The performance of a preheater kiln with a planetary cooler with a capacity of 4,000 tons per day was extolled, particularly the high thermal efficiency with only 80 to 100 K cal. per kg. clinker heat loss. In the United States the first modern planetary cooler was under construction at the Hawaiian Cement Corp's plant near Ewa Beach, Oahu. No burner building was necessary, and no dust collection is required. A 14,000-barrel-per-day preheater kiln with planetary cooler at Gullhogens Bruk in Skovde, Sweden, has heat recuperation of 130,000 to 160,000 Btu per barrel of clinker.

Seventeen process-control computers designed to control kiln and clinker cooler functions were reported in operation in U.S. cement plants. In addition, 15 of the computers were also programed to control the raw mix operations, and eight to control mill loads. Not all of the computer controls were 100 percent successful. Another process-control computer was scheduled for operation in 1972 at the California Portland Cement Co. plant in Rillito, Ariz.

Several plants installed or planned to install an oxygen supplement unit on the kiln burners. The Oxy-fuel burner, patented by Airco, has the potential to reduce sulfur dioxide in stack gases. The Oxy-fuel flame speeds insufflation by helping convert sulfur and lime dust to calcium sulfate in the clinker, thereby reducing the quantity of dust to be recycled.

Calaveras Cement Div. of the Flintkote Co. started operating its 17.6-mile limestone slurry pipeline in June 1971. Two 11-foot-diameter by 33-foot-long grinding mills near the new Cataract Quarry grind the limestone to 90 percent minus 200 mesh. A double-acting, reciprocating piston pump with a 700-horsepower motor, pumps the slurry containing 70 percent solids at the rate of 772 gallons per minute or 240 tons per hour, through a 7-inch pipeline to the plant at San Andreas, Calif. Clay and other raw materials are mixed with the limestone slurry at the plant.

Regulated fast setting cement, still in the experimental stage, was produced in limited quantities. The rapid-hardening hydraulic cement that develops very high early strengths offers promising applications in the manufacture of concrete blocks, pipe, prestressed precast forms; resurfacing and paving patching; underwater patching; and for slip form structures. During the year two patents were issued for controlled fast-setting cement. On December 21, 1971, U.S. Patent No. 3,628,973 was granted to N. R. Greening, L. E. Copeland, and G. J. Verbeck (assigned to the Portland Cement Association) for a modified portland cement having high-early set strength containing 1 to 30 percent by weight of 11 $CaO \cdot 7Al_2O_3 \cdot CaX$. U.S. Patent No. 3,615,787 was issued to H. Teramoto and T. Kasakawa (assigned to Nihon Cement Co., Ltd., Tokyo, Japan) for a method of producing super-high-early-strength portland cements. In the manufacture of this cement, optimum proportions of fluorspar and chromite are added to the conventional raw mix, whereby the clinker analyses 65 to 85 percent by weight of tricalcium silicate, 7 to 13 percent tricalcium aluminate, 0.3 to 1.5 percent chromium oxide, and 0.2 to 1 percent fluorine. The clinker is ground to a specific surface area of 4,500 to 6,000 square centimeters per gram.

Numerous patents have been granted for processing gypsum to produce hydraulic cement and sulfuric acid dating back as early as 1886. In 1968 four Germans obtained a British patent to manufacture portland cement and sulfuric acid from waste phosphogypsum, a byproduct in manufacturing phosphoric acid, fertilizers, and some detergents. Fried Krupp of Essen, West Germany built a 1,000-ton per day cement plant at Phalaborwa, Transvaal, South Africa for Palcaso (Pty.) Ltd., subsidiary of Federale Kunsmis, using phosphogypsum and clay as raw materials. In the process phosphogypsum is broken down to form sulfuric acid and cement by adding clay. Phosphates in the cement are held within limits.

Table 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by district [2]

District	Plants [3] active during year		Production [4] (thousand 376-pound barrels)		Shipments from mills 1970			Shipments from mills 1971			Stocks at mills Dec. 31 (thousand 376-pound barrels)	
	1970	1971	1970	1971	Thousand 376-pound barrels	Value: Total (thousands)	Value: Average per barrel	Thousand 376-pound barrels	Value: Total (thousands)	Value: Average per barrel	1970 r	1971
New York and Maine	11	10	27,518	27,416	28,402	$80,184	$2.82	28,111	$89,699	$3.19	1,980	1,663
Pennsylvania, eastern	17	15	31,357	31,002	30,909	89,782	2.90	30,809	105,352	3.42	1,998	1,827
Pennsylvania, western	5	5	10,295	11,667	9,999	31,319	3.13	10,944	35,108	3.21	1,753	1,645
Maryland and West Virginia	4	4	11,517	12,230	11,838	35,693	3.02	12,287	41,692	3.39	944	942
Ohio	9	8	11,898	14,966	11,752	39,997	3.40	15,411	54,338	3.53	1,946	1,487
Michigan	9	9	29,655	31,995	29,813	101,019	3.39	32,489	104,665	3.22	3,944	3,297
Indiana, Kentucky, Wisconsin	8	8	16,361	17,297	15,644	53,364	3.41	17,564	62,301	3.55	2,310	1,289
Illinois	4	3	7,400	8,046	7,946	25,252	3.18	7,578	25,975	3.43	996	673
Tennessee	6	6	8,534	8,619	8,878	29,832	3.36	9,110	33,733	3.70	834	698
Virginia, North Carolina, South Carolina	5	5	12,291	12,482	11,950	39,823	3.33	12,999	45,985	3.54	1,103	640
Georgia	3	3	5,639	6,486	r 5,567	17,604	3.16	6,458	22,470	3.48	332	396
Florida	4	4	10,217	11,626	r 9,888	33,962	3.43	11,581	48,970	4.23	907	571
Alabama	8	7	12,795	12,223	16,053	51,114	3.18	12,149	42,281	3.48	704	625
Louisiana and Mississippi	5	5	6,856	7,906	6,988	25,702	3.68	8,289	30,579	3.69	773	690
Minnesota, South Dakota, Nebraska	4	4	7,282	7,848	7,079	24,328	3.44	7,923	28,908	3.65	1,264	1,156
Iowa	5	5	13,421	12,358	12,744	45,432	3.56	12,726	47,925	3.77	1,873	1,519
Missouri	7	7	20,733	22,040	21,224	64,261	3.03	24,017	77,568	3.23	2,011	1,530
Kansas	6	5	8,973	9,570	9,197	28,177	3.06	9,208	29,961	3.25	1,120	1,124
Oklahoma and Arkansas	5	5	11,079	12,630	11,048	36,659	3.32	12,572	44,164	3.51	961	1,095
Texas	18	18	34,584	37,968	33,967	122,960	3.62	38,287	140,206	3.66	2,827	2,486
Wyoming, Montana, Idaho	4	4	4,494	5,009	4,518	16,127	3.57	4,986	18,450	3.70	709	743
Colorado, Arizona, Utah, New Mexico	8	8	13,820	15,715	13,553	52,972	3.91	17,014	69,160	4.06	1,188	1,086
Washington	4	4	6,670	7,041	6,495	24,832	3.82	6,113	23,735	3.88	987	899
Oregon and Nevada	3	3	3,935	4,469	3,944	15,231	3.86	4,511	18,048	4.00	254	220
California, northern	6	6	16,972	15,388	16,368	56,694	3.46	16,535	60,874	3.68	2,124	1,574
California, southern	8	8	33,100	33,040	33,131	116,432	3.51	31,958	109,047	3.41	1,847	2,081
Hawaii	2	2	2,271	1,983	2,105	9,968	4.74	1,993	10,196	5.12	278	268
Puerto Rico	3	3	9,523	10,594	9,460	29,515	3.12	10,642	38,413	3.61	187	140
U.S. total	181	174	389,190	5 409,617	5 390,461	5 1,298,233	3.32	414,264	1,459,801	3.52	38,154	32,364
Foreign countries [6]	NA	NA	NA	NA	NA	NA	NA	5,975	20,894	3.50	292	169
Grand total	181	174	389,190	409,617	390,461	1,298,233	3.32	5 420,238	5 1,480,696	3.52	38,446	32,533

r Revised. NA Not available; data included in U.S. total.
[1] Includes Puerto Rico.
[2] Includes grinding plants and white cement manufacturing facilities.
[3] Eight plants phased out during year (1970); 1 new plant went on stream in 1971.
[4] Includes cement produced from imported clinker.
[5] Data may not add to totals shown because of independent rounding.
[6] Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.

Table 3.—Portland cement shipped by plants in the United States, by type [1]

(Thousand 376-pound barrels and thousand dollars)

Type	1970 Quantity	1970 Value	1970 Average per barrel	1971 Quantity	1971 Value	1971 Average per barrel
General use and moderate heat (types I and II)	363,553	$1,191,215	$3.28	392,038	$1,362,997	$3.48
High-early-strength (type III)	14,171	50,086	3.53	14,316	54,214	3.79
Sulfate-resisting (type V)	3,155	11,652	3.69	2,899	10,890	3.76
Oil-well	3,310	12,627	3.81	3,370	13,220	3.92
White	2,243	16,832	7.50	2,203	17,194	7.80
Portland-slag and portland pozzolan	410	1,418	3.46	555	2,068	3.73
Expansive	W	W	W	1,122	5,354	4.77
Miscellaneous [2]	3,619	14,404	3.98	3,736	14,760	3.95
Total [3]	390,461	1,298,233	3.32	420,238	1,480,696	3.52

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous".
[1] Includes Puerto Rico.
[2] Includes type IV, waterproof cements, and expansive cements (1970).
[3] Data may not add to totals shown because of independent rounding.

Table 4.—Destinations of shipments of all types of finished portland cement from mills in the United States, by State [1] [2]

(Thousand 376-pound barrels)

Destination	Finished portland	
	1970	1971
Alabama	5,314	6,158
Alaska [3]	W	338
Arizona	5,638	7,255
Arkansas	3,270	4,165
California, northern	15,176	17,056
California, southern	30,316	28,316
Colorado	5,535	6,590
Connecticut [3]	4,435	4,436
Delaware [3]	860	950
District of Columbia [3]	967	897
Florida	19,165	20,932
Georgia	10,125	11,552
Hawaii	2,447	1,999
Idaho	2,704	2,332
Illinois	17,595	20,816
Indiana	8,530	9,184
Iowa	8,488	8,593
Kansas	5,127	5,229
Kentucky	5,181	5,762
Louisiana	10,118	11,591
Maine	1,094	1,210
Maryland	7,709	7,469
Massachusetts [3]	7,198	7,167
Michigan	14,664	17,813
Minnesota	8,391	8,691
Mississippi	4,328	4,198
Missouri	9,291	10,777
Montana	1,699	1,627
Nebraska	4,437	4,463
Nevada	1,600	2,198
New Hampshire [3]	887	964
New Jersey [3]	10,995	11,619
New Mexico	2,282	2,705
New York, Eastern	3,832	4,611
New York, Western	5,020	4,539
Metropolitan New York [3]	9,016	8,110
North Carolina	8,099	8,555
North Dakota [3]	1,536	1,488
Ohio	17,176	17,942
Oklahoma	6,573	6,470
Oregon	3,423	3,746
Pennsylvania, Eastern	11,144	11,736
Pennsylvania, Western	6,115	6,323
Rhode Island [3]	1,001	1,080
South Carolina	4,163	4,680
South Dakota	1,289	1,710
Tennessee	7,320	8,247
Texas	28,792	32,758
Utah	2,228	2,632
Vermont [3]	575	568
Virginia	9,424	10,037
Washington	6,041	6,470
West Virginia	2,496	3,400
Wisconsin	8,138	8,381
Wyoming	989	888
Total United States	379,956	409,423
Other countries [4]	10,505	10,813
Total shipped from cement plants	390,461	[5] 420,238

W Withheld to avoid disclosing individual company data, included with "Other countries."
[1] Includes imported cement shipped by domestic producers only.
[2] Excludes cement used in the manufacture of prepared masonry cement.
[3] Has no cement producing plants.
[4] Direct shipments by producers to foreign countries, Alaska (1970), and to Puerto Rico, including distribution from Puerto Rican mills.
[5] Data may not add to total shown because of independent rounding.

Table 5.—Clinker capacity and production in the United States,[1] by district, as of December 31, 1971

District	Active plants[2] Process used Wet	Active plants[2] Process used Dry	Active plants[2] Total	Number of kilns	Daily capacity (thousand 376-pound barrels)	Average number of days for maintenance	Apparent[3] annual capacity (thousand 376-pound barrels)	Production[4] (thousand 376-pound barrels)	Percent utilized
New York and Maine	7	3	10	20	91	34	30,085	27,300	90.7
Pennsylvania, eastern	4	9	13	43	98	30	32,850	31,172	94.9
Pennsylvania, western	3	2	5	13	42	21	14,432	11,880	82.3
Maryland and West Virginia	2	2	4	9	39	31	13,011	12,466	95.8
Ohio	5	3	8	22	50	30	16,738	14,164	84.6
Michigan	7	1	8	29	99	31	33,024	27,700	83.9
Indiana, Kentucky, Wisconsin	3	5	8	19	55	44	17,663	16,774	95.0
Illinois	--	3	3	15	29	22	9,958	7,575	76.1
Tennessee	6	--	6	12	31	44	9,963	9,102	91.4
Virginia, North Carolina, South Carolina	4	1	5	15	40	40	12,995	12,583	96.8
Georgia	1	2	3	7	19	28	6,408	6,472	101.0
Florida	4	--	4	12	40	30	13,383	11,981	89.5
Alabama	5	2	7	18	39	35	12,881	12,405	96.3
Louisiana and Mississippi	5	--	5	13	30	27	10,139	7,806	77.0
Minnesota, South Dakota, Nebraska	3	1	4	13	25	14	8,767	7,475	85.3
Iowa	3	2	5	19	43	33	14,285	12,360	86.5
Missouri	5	2	7	12	75	44	24,045	21,590	89.8
Kansas	3	2	5	15	34	18	11,793	9,722	82.4
Oklahoma and Arkansas	3	2	5	11	43	26	14,573	12,848	88.2
Texas	14	4	18	46	131	27	44,314	37,785	85.3
Wyoming, Montana, Idaho	3	1	4	8	15	32	5,000	4,759	95.2
Colorado, Arizona, Utah, New Mexico	3	5	8	18	51	21	17,542	14,822	84.5
Washington	3	1	4	7	20	47	6,355	5,833	91.8
Oregon and Nevada	2	1	3	7	18	49	5,680	4,256	74.9
California, northern	3	2	5	19	51	29	17,120	15,072	88.0
California, southern	2	6	8	30	113	28	38,036	32,408	85.2
Hawaii	1	1	2	2	8	38	2,615	1,858	71.1
Puerto Rico	3	--	3	12	36	13	12,681	9,998	78.8
Total	107	63	170	466	1,366	31	456,336	400,166	87.7

[1] Includes Puerto Rico.
[2] Includes white cement manufacturing facilities.
[3] Calculated on individual company data: (365 days, minus average days for maintenance, times the reported 24-hour capacity).
[4] Includes production reported for one new plant going on stream and plants which added or shut down kilns during the year.

Table 6.—Raw materials used in producing portland cement in the United States [1]

(Thousand short tons)

Raw materials	1969	1970	1971
Cement rock	23,315	22,824	23,074
Limestone (including oystershell)	84,202	83,230	85,857
Marl	716	1,669	1,741
Clay and shale [2]	12,190	11,833	11,808
Blast furnace slag	959	853	713
Gypsum	3,569	3,491	3,750
Sand and sandstone (including silica and quartz)	1,979	2,193	2,226
Iron materials [3]	783	777	693
Miscellaneous [4]	369	341	479
Total	128,082	127,211	130,341

[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin.
[3] Includes iron ore, pyrite cinders and ore, and mill scale.
[4] Includes fluorspar, pumicite, calcium chloride, soda ash, borax, staurolite, fly ash, bauxite, diatomite, air-entraining compounds, and grinding aids.

Table 7.—Clinker produced and fuel consumed by the portland-cement industry in the United States by process [1]

Year and process	Clinker produced			Fuel consumed		
	Plants active during year	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1970:						
Wet	112	237,542	60.4	4,347	7,486	143,262,418
Dry	67	156,022	39.6	3,619	2,542	68,550,508
Total	179	393,564	100.0	7,966	10,028	211,812,926
1971:						
Wet	107	239,442	59.8	4,072	8,155	145,888,563
Dry	63	160,724	40.2	3,110	2,599	74,084,672
Total	170	400,166	100.0	7,182	10,754	219,973,235

[1] Includes Puerto Rico.

Table 8.—Clinker produced in the United States, by kind of fuel [1]

Year and fuel	Clinker produced			Fuel consumed		
	Number of plants	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1970:						
Coal	42	[2] 73,893	18.8	3,560	--	--
Oil	11	[2] 25,102	6.4	--	5,509	--
Natural gas	48	[2] 105,413	26.8	--	--	118,817,083
Coal and oil	17	49,979	12.7	1,762	1,356	--
Coal and natural gas	28	52,267	13.3	1,392	--	30,628,839
Oil and natural gas	19	44,354	11.2	--	1,909	40,526,094
Coal, oil, and natural gas	14	42,557	10.8	1,252	1,254	21,840,910
Total	179	[3] 393,564	100.0	7,966	10,028	211,812,926
1971:						
Coal	40	[2] 83,899	21.0	4,026	--	--
Oil	16	[2] 45,475	11.4	--	8,626	--
Natural gas	45	[2] 99,354	24.8	--	--	111,297,106
Coal and oil	9	25,727	6.4	1,049	95	--
Coal and natural gas	25	48,933	12.2	967	--	36,605,834
Oil and natural gas	23	55,104	13.8	--	1,463	54,393,714
Coal, oil, and natural gas	12	41,673	10.4	1,140	570	17,676,581
Total	170	[3] 400,166	100.0	7,182	10,754	219,973,235

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of clinker produced as follows: 1970—coal, 96.4 pounds; oil, 0.21946 barrels; and natural gas, 1,127 cubic feet: 1971—coal, 96.0 pounds; oil, 0.18969 barrels; and natural gas, 1,120 cubic feet.
[3] Data may not add to total shown because of independent rounding.

Table 9.—Electric energy used at portland cement plants in the United States,[1] by process

Year and process	Electric energy used: Generated at portland cement plants: Active plants	Generated at portland cement plants: Million kilowatt-hours	Purchased: Active plants	Purchased: Million kilowatt-hours	Total: Million kilowatt-hours	Total: Percent	Finished cement produced (thousand 376-pound barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
1970:								
Wet	9	307	109	5,353	5,660	57.5	235,278	24.1
Dry	14	812	r 67	3,364	4,176	42.5	153,912	27.1
Total	23	1,119	r 176	8,717	9,836	100.0	389,190	25.3
Percent of total electric energy used	--	11.4	--	88.6	100.0	--	--	--
1971:								
Wet	6	174	106	5,536	5,710	56.9	245,151	23.3
Dry	10	677	64	3,643	4,320	43.1	164,465	26.3
Total [2]	16	851	170	9,179	10,030	100.0	409,617	24.5
Percent of total electric energy used	--	8.5	--	91.5	100.0	--	--	--

[1] Includes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.

Table 10.—Shipments of portland cement from mills in the United States, in bulk and in containers, by type of carrier [1]

(Thousand 376-pound barrels)

Type of carrier	Shipments from plants to terminal: In bulk	Shipments from plants to terminal: In containers	Shipments to ultimate consumer: From terminal to consumer: In bulk	From terminal to consumer: In containers	From plant to consumer: In bulk	From plant to consumer: In containers	Total shipments
Railroad	45,142	1,393	3,689	121	58,464	3,555	65,829
Truck	5,065	378	95,855	4,490	219,082	28,040	347,467
Barge and boat	44,834	49	894	--	5,717	31	6,642
Unspecified [2]	--	--	--	--	234	66	300
Total	95,041	1,820	100,438	4,611	283,497	31,692	[3] 420,238

[1] Includes Puerto Rico.
[2] Includes cement used at plant.
[3] Bulk shipments were 91.4 percent (383,936 barrels); container (bag) shipments were 8.6 percent (36,303 barrels).

Table 11.—Cement shipments by type of customer in 1971

(Quantities in thousand 376-pound barrels)

District	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscellaneous, including own use		Total [1]
	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	
New York and Maine	5.9	1,663	13.1	3,686	73.4	20,641	3.7	1,028	1.9	535	.1	14	1.9	544	28,111
Pennsylvania, eastern	20.3	6,266	21.9	6,738	50.7	15,618	6.2	1,920	.1	28	.1	20	.7	218	30,809
Pennsylvania, western	7.2	793	14.3	1,560	62.2	6,809	14.1	1,542	.3	33	--	1	1.9	207	10,944
Maryland and West Virginia	6.2	767	21.4	2,628	65.7	8,077	3.3	411	1.8	217	.6	67	1.0	120	12,287
Ohio	5.5	842	16.7	2,579	58.6	9,034	14.0	2,161	2.5	386	--	1	2.7	409	15,411
Michigan	6.3	2,052	13.4	4,341	64.1	20,831	11.6	3,786	.5	169	1.0	318	3.1	992	32,489
Indiana, Kentucky, Wisconsin	5.0	877	14.9	2,617	68.4	12,014	9.2	1,622	1.3	232	--	--	1.2	201	17,564
Illinois	8.7	657	7.7	585	75.8	5,742	6.0	455	1.3	103	.2	15	.3	21	7,578
Tennessee	6.0	543	17.7	1,613	64.6	5,887	7.2	658	.2	17	2.0	181	2.3	211	9,110
Virginia, North Carolina, South Carolina	8.3	1,076	14.9	1,939	64.8	8,423	10.2	1,330	1.5	192	.1	17	.2	23	12,999
Georgia	7.4	476	15.5	1,002	54.9	3,545	17.0	1,097	4.2	270	.9	59	.1	9	6,458
Florida	18.0	2,093	17.3	2,006	51.6	5,973	7.4	856	4.3	499	.7	76	.7	78	11,581
Alabama	9.2	1,120	13.8	1,676	63.9	7,761	4.7	571	7.8	943	.4	50	.2	28	12,149
Louisiana and Mississippi	2.1	172	14.7	1,216	45.0	3,727	21.2	1,762	11.8	980	.1	7	5.1	425	8,289
Minnesota, South Dakota, Nebraska	10.2	806	6.7	536	52.8	4,181	27.3	2,160	1.1	89	--	2	1.9	149	7,923
Iowa	3.7	477	28.1	3,574	54.0	6,871	13.3	1,687	.4	48	.3	45	.2	23	12,726
Missouri	4.3	1,031	6.2	1,491	73.1	17,546	14.2	3,417	1.2	294	.3	59	.7	178	24,017
Kansas	8.5	782	8.1	745	70.7	6,504	6.6	608	1.6	150	--	3	4.5	417	9,208
Oklahoma and Arkansas	6.9	861	8.9	1,116	59.8	7,512	17.9	2,256	4.3	545	--	4	2.2	278	12,572
Texas	5.5	2,131	10.2	3,905	65.1	24,916	8.6	3,282	3.3	1,267	.5	183	6.8	2,604	38,287
Wyoming, Montana, Idaho	4.5	223	6.4	317	57.1	2,847	7.8	390	21.1	1,052	.3	16	2.8	141	4,986
Colorado, Arizona, Utah, New Mexico	7.2	1,230	11.3	1,920	70.2	11,936	5.0	858	4.1	696	.2	35	2.0	339	17,014
Washington	9.9	604	12.3	754	46.2	2,827	5.8	352	19.5	1,189	.3	21	6.0	367	6,113
Oregon and Nevada	3.8	170	8.7	393	67.9	3,061	13.4	607	3.6	161	1.5	67	1.1	52	4,511
California, northern	5.8	954	7.9	1,305	64.8	10,708	10.9	1,800	5.0	834	.1	19	5.5	914	16,535
California, southern	8.9	2,856	12.3	3,925	66.4	21,210	8.3	2,641	3.6	1,146	.2	68	.3	111	31,958
Hawaii	5.7	114	10.9	218	78.0	1,555	1.3	25	2.4	47	.1	2	1.6	32	1,993
Puerto Rico	34.0	3,621	12.8	1,364	47.4	5,046	--	--	3.8	402	1.8	192	.2	17	10,642
Imports	4.6	277	13.0	780	76.5	4,568	5.4	320	--	--	--	--	.5	30	5,975
Total [1]	8.5	35,535	13.4	56,529	63.1	265,370	9.4	39,602	3.0	12,524	.4	1,542	2.2	9,138	420,238

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

Table 12.—Prepared masonry cement produced and shipped in the United States, by district

District	Plants active during year		Production (thousand 280-pound barrels)		Shipments from mills					
					1970			1971		
						Value			Value	
	1970	1971	1970	1971	Thousand 280-pound barrels	Total (thousands)	Average per barrel [1]	Thousand 280-pound barrels	Total (thousands)	Average per barrel [1]
New York and Maine	8	6	890	822	864	$2,260	$2.62	877	$2,966	$3.38
Pennsylvania, eastern	11	10	1,936	2,010	1,889	5,650	2.99	1,935	7,404	3.83
Pennsylvania, western	5	5	916	1,122	915	2,674	2.92	1,059	3,843	3.63
Maryland and West Virginia	4	3	811	903	788	2,082	2.64	895	2,685	3.00
Ohio	6	5	867	1,014	867	3,116	3.59	1,016	3,811	3.75
Michigan	4	4	1,431	1,631	1,519	5,253	3.46	1,704	5,872	3.45
Indiana, Kentucky, Wisconsin	5	5	2,814	3,195	2,781	8,165	2.94	3,263	10,151	3.11
Illinois	3	3	533	508	508	1,874	3.69	522	2,336	4.48
Tennessee	4	4	1,227	1,398	969	2,749	2.84	1,135	3,649	3.21
Virginia, North Carolina, South Carolina	5	5	2,125	2,320	2,098	7,711	3.68	2,374	9,409	3.96
Georgia	4	5	1,314	1,412	402	1,191	2.96	448	1,470	3.28
Florida					1,136	3,328	2.93	1,283	4,877	3.80
Alabama	8	8	2,090	2,490	2,402	7,601	3.16	2,493	8,657	3.47
Louisiana and Mississippi	4	4	r 296	266	337	974	2.89	377	1,237	3.28
Minnesota, South Dakota, Nebraska	4	4	201	219	193	699	3.62	226	860	3.81
Iowa	3	3	463	504	520	1,758	3.38	473	1,719	3.63
Missouri	6	6	401	526	402	1,234	3.07	518	1,629	3.14
Kansas	5	5	285	308	328	1,029	3.14	355	1,232	3.47
Oklahoma and Arkansas	5	5	546	717	550	1,735	3.15	717	2,382	3.32
Texas	12	12	1,102	1,301	1,006	3,769	3.75	1,209	4,514	3.73
Wyoming, Montana, Idaho	4	4	56	38	41	139	3.39	42	155	3.69
Colorado, Arizona, Utah, New Mexico	5	6	638	838	639	2,011	3.15	820	3,112	3.80
Washington	3	3	43	17	41	158	3.85	37	145	3.92
Oregon and Nevada	--	--	--	--	3	11	3.67	3	11	3.67
Hawaii	2	2	72	79	77	366	4.75	79	431	5.46
U.S. total [2]	120	117	21,056	23,638	21,275	67,537	3.17	23,860	84,555	3.54
Foreign countries [3]	NA	NA	NA	NA	NA	NA	NA	368	1,219	3.31
Grand total	120	117	21,056	23,638	21,275	67,537	3.17	24,228	85,774	3.54

r Revised NA Not available, data included in "U.S. total."
[1] Computed prior to rounding.
[2] Data may not add to total shown because of independent rounding.
[3] Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.

Table 13.—Shipments of prepared masonry cement from mills in the United States, by State [1]

(Thousand 280-pound barrels)

Destination	Masonry cement	
	1970	1971
Alabama	611	713
Alaska [2]	W	--
Arizona	W	W
Arkansas	316	407
California, northern [2]	--	--
California, southern [2]	--	--
Colorado	212	250
Connecticut [2]	132	123
Delaware [2]	53	60
District of Columbia [2]	200	199
Florida	1,710	1,966
Georgia	1,278	1,555
Hawaii	77	79
Idaho	12	13
Illinois	698	760
Indiana	677	762
Iowa	173	180
Kansas	159	142
Kentucky	584	694
Louisiana	339	430
Maine	81	77
Maryland	627	752
Massachusetts [2]	328	336
Michigan	1,085	1,268
Minnesota	345	344
Mississippi	407	449
Missouri	225	257
Montana	13	17
Nebraska	73	81
Nevada [2]	--	--
New Hampshire [2]	76	75
New Jersey [2]	580	558
New Mexico	74	90
New York, eastern	225	265
New York, western	239	250
New York, metropolitan [2]	324	347
North Carolina	1,458	1,655
North Dakota [2]	47	40
Ohio	1,313	1,482
Oklahoma	296	377
Oregon [2]	2	2
Pennsylvania, eastern	475	458
Pennsylvania, western	514	564
Rhode Island [2]	33	35
South Carolina	914	1,060
South Dakota	44	48
Tennessee	1,031	1,215
Texas	934	1,101
Utah [2]	5	5
Vermont [2]	38	41
Virginia	1,203	1,424
Washington	48	46
West Virginia	213	237
Wisconsin	392	427
Wyoming	12	13
U.S. total	20,905	[3] 23,725
Other countries [4]	370	503
Total shipped from cement plants	21,275	24,228

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."
[1] Includes imported cement shipped by domestic producers only.
[2] No cement producing plants.
[3] Data may not add to total shown, because of independent rounding.
[4] Direct shipments by producers to other countries and to Alaska (1970), Arizona and Nevada.

Table 14.—Average mill value in bulk, of cement in the United States [1]
(Per barrel)

Year	Portland cement [2]	Slag cement [2]	Prepared masonry cement [3] [4]	All classes of cement [5]
1967	$3.14	$3.87	$2.86	$3.17
1968	3.16	3.86	2.86	3.19
1969	3.20	3.84	2.97	3.23
1970	3.32	W	3.17	3.37
1971	3.52	W	3.54	3.57

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Puerto Rico.
[2] 376-pound barrels.
[3] Includes masonry cements made at portland, natural, and slag cement plants.
[4] 280-pound barrels.
[5] Includes masonry cement converted to 376-pound barrels, slag cement (1967–70).

Table 15.—U.S. exports of hydraulic cement, by country
(Thousand 376-pound barrels and thousand dollars)

Destination	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	1	$16	1	$33	2	$34
Australia	5	215	27	716	6	60
Bahamas	32	220	27	192	13	96
Belgium-Luxembourg	5	53	1	20	5	54
Bermuda	(1)	11	1	19	4	40
Bolivia	2	14	(1)	2	1	5
Brazil	3	43	2	12	5	42
Canada	200	980	460	2,235	309	1,351
Chile	5	79	3	26	2	46
Dominican Republic	1	21	1	30	1	40
Ecuador	3	25	13	103	3	37
France	1	13	2	22	2	21
French West Indies	79	146	75	130	41	71
Germany, West	4	84	2	85	3	112
Guatemala	1	5	1	8	1	26
Indonesia	10	91	2	15	3	26
Italy	1	5	2	21	1	9
Jamaica	5	42	4	26	3	27
Japan	11	228	12	309	20	299
Leeward and Windward Islands	130	266	88	171	68	130
Mexico	24	190	38	366	21	355
Mozambique	2	11	2	12	--	--
Netherlands	2	12	(1)	2	1	3
Netherlands Antilles	12	27	29	70	32	64
Nicaragua	4	33	11	83	3	24
Norway	3	13	4	20	3	23
Panama	1	20	1	17	80	8
Peru	1	15	1	15	1	14
Philippines	1	12	3	30	2	30
Saudi Arabia	1	7	1	17	1	29
Spain	3	15	2	23	(1)	12
Sweden	2	19	2	31	1	17
Switzerland	1	21	1	34	2	41
Taiwan	--	--	2	25	3	60
Turkey	(1)	6	1	9	1	24
United Kingdom	2	9	2	14	1	22
Venezuela	5	47	1	20	2	15
Vietnam, South	(1)	4	(1)	9	1	2
Other	r 26	r 171	r 22	r 239	15	198
Total	589	3,189	847	5,211	663	3,467

r Revised.
[1] Less than ½ unit.

Table 16.—U.S. imports for consumption of cement
(Thousand 376-pound barrels 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
1969	8,818	$21,852	608	$1,641	261	$883	9,687	$24,376
1970	11,437	28,596	2,136	4,320	239	1,260	13,812	34,176
1971	12,373	35,667	3,873	7,624	176	1,057	16,422	44,348

Table 17.—Hydraulic cement and clinker imported for consumption in the United States in 1971, by country and customs district [1]

(Thousand barrels and thousand dollars)

Customs district	Bahamas	Belgium-Luxembourg	Canada	Denmark	France	Germany, West	Japan	Mexico	Norway	Spain	United Kingdom	Venezuela	Yugoslavia	Total [2] Quantity	Total [2] Value
Anchorage	--	--	127	--	--	--	(3)	--	--	--	--	--	--	127	$472
Boston	--	--	106	--	--	--	--	--	--	--	--	--	--	106	418
Bridgeport	--	--	--	--	--	--	--	--	86	--	--	--	--	86	227
Buffalo	--	--	2,324	--	--	--	--	--	--	--	--	--	--	2,324	5,069
Charleston	--	--	610	--	--	--	--	--	--	--	--	--	--	610	1,442
Detroit	--	--	1,595	--	--	--	--	--	--	--	--	--	--	1,595	2,836
Duluth	--	--	1	--	--	--	--	--	--	--	--	--	--	1	14
El Paso	--	--	--	--	--	--	--	35	--	--	--	--	--	35	165
Galveston	--	--	--	--	--	(3)	--	--	--	--	37	--	--	37	232
Great Falls	--	--	12	--	--	--	--	--	--	--	--	--	--	12	49
Honolulu	--	--	--	(3)	--	--	83	--	--	--	--	--	--	83	148
Houston	--	--	--	--	--	(3)	--	--	--	--	--	--	--	(3)	12
Laredo	--	--	--	--	--	--	--	2	--	--	--	--	--	2	11
Los Angeles	--	--	--	--	--	1	4	--	--	(3)	7	--	--	11	87
Miami	1,699	5	--	--	--	--	--	147	--	--	182	--	--	2,034	5,482
Milwaukee	--	--	(3)	--	--	--	--	--	--	--	--	--	--	(3)	2
Mobile	--	--	--	--	--	--	--	--	--	--	2	--	--	2	2
New Orleans	--	--	--	--	--	--	--	--	--	14	--	--	--	14	93
New York	--	--	9	14	(3)	92	--	--	2,231	(3)	--	--	89	2,435	6,325
Norfolk	713	--	--	--	60	--	--	--	--	--	38	--	--	812	2,600
Ogdensburg	--	--	1,203	--	--	--	--	(3)	--	--	--	--	--	1,203	3,917
Pembina	--	--	173	--	--	--	--	--	--	--	--	--	--	173	697
Philadelphia	--	--	--	--	--	29	--	--	--	--	(3)	--	15	43	634
Portland, Maine	--	--	46	--	--	--	--	--	--	--	--	--	--	46	196
Portland, Oreg	--	--	(3)	--	--	--	(3)	--	--	--	1	--	--	2	14
Providence	--	--	89	--	--	--	--	--	--	--	--	--	--	89	329
St. Albans	--	--	455	--	--	--	--	--	--	--	(3)	--	--	455	1,862
San Juan	--	99	--	28	1	1	18	--	--	--	--	25	--	172	984
Savannah	--	--	--	--	3	(3)	--	--	--	--	1	--	--	4	34
Seattle	--	--	1,547	--	--	--	1	--	--	--	5	--	--	1,553	3,332
Tampa	1,706	10	--	--	--	--	--	619	--	--	--	--	--	2,335	6,614
Wilmington, N. C	--	--	--	--	--	--	--	--	--	--	21	--	--	21	49
Total: [2]															
Barrels	4,119	114	8,297	42	65	123	106	803	2,317	15	293	25	103	16,422	--
Value	$12,123	$714	$20,610	$215	$494	$786	$244	$1,859	$6,093	$94	$770	$55	$291	--	$44,348

[1] Includes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.

Table 18.—Statistical summary of cement in the United States, 1818-1971 [1] [2]

(Quantity, thousand barrels)

Year	Production [3]			Shipments from mills [3]						Imports [4]	Exports [4]	Number of active production plants			Portland cement manufacturing capacity [3]	
				Portland [11] [12] [13]			Natural, masonry, pozzolan [5] [6] [8] [9] [10]									
	Portland	Natural, masonry, and pozzolan [5] [6] [7] [8] [9] [10]	Total all cement	Quantity	Value: Thousand dollars	Value: Average per barrel	Quantity	Value: Thousand dollars	Value: Average per barrel			Portland	Natural, slag and pozzolan	Masonry [8] [9]	Quantity	Percent used [14] [15]
1818-29	--	300	300	--	--	--	300	$246	$0.82	--	--	--	NA	--	--	--
1830-39	--	1,000	1,000	--	--	--	1,000	850	.85	--	--	--	NA	--	--	--
1840-49	--	4,250	4,250	--	--	--	4,250	3,612	.85	--	--	--	NA	--	--	--
1850-59	--	11,000	11,000	--	--	--	11,000	9,350	.85	23	--	--	NA	--	--	--
1860-69	--	16,420	16,420	--	--	--	16,420	13,957	.85	22	--	--	NA	--	--	--
1870-79	82	22,000	22,082	82	$246	$3.00	22,000	18,700	.85	830	--	NA	NA	NA	NA	NA
1880	42	2,031	2,073	42	126	3.00	2,031	1,727	.85	187	--	NA	NA	NA	NA	NA
1881	60	2,440	2,500	60	150	2.50	2,440	2,379	.98	221	--	NA	NA	NA	NA	NA
1882	85	3,165	3,250	85	191	2.25	3,165	3,482	1.10	370	--	NA	NA	NA	NA	NA
1883	90	4,100	4,190	90	194	2.15	4,100	4,100	1.00	456	--	NA	NA	NA	NA	NA
1884	100	3,900	4,000	100	210	2.10	3,900	3,510	.90	586	--	NA	NA	NA	NA	NA
1885	150	4,000	4,150	150	292	1.95	4,000	3,200	.80	554	--	NA	NA	NA	NA	NA
1886	150	4,350	4,500	150	292	1.95	4,350	3,698	.85	915	--	NA	NA	NA	NA	NA
1887	250	6,693	6,943	250	488	1.95	6,693	5,187	.78	1,514	--	NA	NA	NA	NA	NA
1888	250	6,253	6,503	250	488	1.95	6,253	4,534	.73	1,836	--	NA	NA	NA	NA	NA
1889	300	6,532	6,832	300	500	1.67	6,532	4,703	.72	1,740	--	18	63	NA	NA	NA
1890	336	7,441	7,777	336	704	2.10	7,441	3,823	.51	1,940	--	17	67	NA	NA	NA
1891	455	7,768	8,223	455	968	2.13	7,768	3,671	.47	2,988	--	17	67	NA	NA	NA
1892	547	8,211	[16] 8,759	547	1,153	2.11	8,211	3,991	.49	2,441	--	16	68	NA	NA	NA
1893	591	7,412	[16] 8,002	591	1,158	1.96	7,412	3,252	.44	2,674	--	19	68	NA	NA	NA
1894	799	7,563	8,362	799	1,383	1.73	7,563	3,636	.48	2,638	--	24	68	NA	NA	NA
1895	990	7,741	8,731	990	1,587	1.60	7,741	3,895	.50	2,997	--	22	64	NA	NA	NA
1896	1,543	7,983	9,526	1,543	2,424	1.57	7,983	4,061	.51	2,990	--	26	70	NA	NA	NA
1897	2,678	8,360	11,038	2,678	4,316	1.61	8,360	3,910	.47	2,091	--	29	72	NA	NA	NA
1898	3,692	8,652	12,344	3,692	5,971	1.62	8,652	4,087	.47	1,153	--	31	79	NA	NA	NA
1899	5,652	10,203	15,855	5,652	8,074	1.43	10,203	5,083	.50	2,108	--	36	78	NA	NA	NA
1900	8,482	8,749	17,231	8,482	9,281	1.09	8,749	4,003	.46	2,387	100	50	64	NA	NA	NA
1901	12,711	7,358	20,069	12,711	12,532	.99	7,358	3,254	.44	939	374	56	60	NA	NA	NA
1902	17,231	8,523	25,754	17,231	20,864	1.21	8,523	4,502	.53	1,963	341	65	69	NA	NA	NA
1903	22,343	7,556	29,899	22,343	27,713	1.24	7,556	4,218	.56	2,252	285	76	73	NA	NA	NA
1904	26,506	5,169	31,675	26,506	23,355	.88	5,169	2,677	.52	968	775	81	69	NA	NA	NA
1905	35,247	4,855	40,102	35,247	33,246	.94	4,855	2,686	.55	897	898	89	67	NA	NA	NA
1906	46,463	4,537	51,000	46,463	52,466	1.13	4,537	2,836	.63	2,273	583	84	64	NA	NA	NA
1907	48,785	3,445	52,230	48,785	53,993	1.11	3,445	1,911	.55	2,033	901	94	59	NA	NA	NA
1908	51,073	1,838	[16] 52,910	51,073	43,548	.85	1,838	930	.51	842	847	98	29	NA	60,000	85.1

See footnotes at end of table.

Table 18.—Statistical summary of cement in the United States, 1818-1971 [1] [2]—Continued

(Quantity, thousand barrels)

Year	Production [3]			Shipments from mills [3]						Imports [4]	Exports [4]	Number of active production plants			Portland cement manufacturing capacity [3]	
				Portland [11] [12] [13]			Natural, masonry, pozzolan [5] [6] [8] [9] [10]									
					Value			Value								
	Portland	Natural, masonry, and pozzolan [5] [6] [7] [8] [9] [10]	Total all cement	Quantity	Thousand dollars	Average per barrel	Quantity	Thousand dollars	Average per barrel			Portland	Natural, slag and pozzolan	Masonry [8] [9]	Quantity	Percent used [14] [15]
1909	64,991	1,698	[16] 66,690	64,991	$52,858	$0.81	1,698	$752	$0.44	444	1,057	108	26	NA	93,500	69.5
1910	76,550	1,235	77,785	76,550	68,206	.89	1,235	546	.44	307	2,476	111	23	NA	97,670	78.4
1911	78,529	1,019	79,548	78,529	66,249	.84	1,019	456	.45	165	3,135	115	19	NA	112,500	69.8
1912	82,438	913	83,351	85,013	69,110	.81	913	445	.49	69	4,216	110	19	NA	110,000	74.9
1913	92,097	852	92,949	88,689	89,107	1.00	852	444	.52	85	2,964	113	17	NA	115,000	80.1
1914	88,230	820	89,050	86,438	80,118	.93	820	415	.51	121	2,140	110	16	NA	115,000	76.7
1915	85,915	794	[16] 86,708	86,892	74,757	.86	794	398	.50	42	2,565	106	15	NA	129,800	66.2
1916	91,521	842	92,363	94,552	104,258	1.10	842	431	.51	2	2,564	113	13	NA	133,680	68.5
1917	92,814	639	[16] 93,454	90,703	122,775	1.35	639	435	.68	2	2,586	117	10	NA	136,750	67.9
1918	71,082	433	71,515	70,916	113,316	1.60	433	401	.93	(17)	2,252	114	9	NA	137,601	51.7
1919	80,778	529	81,307	85,613	146,735	1.71	529	584	1.10	9	2,464	111	8	NA	134,093	60.2
1920	100,023	767	[16] 100,791	96,312	194,439	2.02	767	1,151	1.50	525	2,986	117	9	NA	146,400	68.5
1921	98,842	539	99,381	95,507	180,778	1.89	539	897	1.66	122	1,181	115	9	NA	144,354	68.5
1922	114,790	889	115,679	117,701	207,170	1.76	889	1,294	1.45	356	1,128	118	9	NA	146,203	78.5
1923	137,460	1,272	138,732	135,912	257,684	1.90	1,272	1,947	1.53	1,767	1,002	126	10	NA	161,858	84.9
1924	149,358	1,418	[16] 150,777	146,048	264,047	1.81	1,418	2,007	1.41	2,024	879	132	10	NA	175,100	85.3
1925	161,659	1,729	163,388	157,295	278,524	1.77	1,752	2,552	1.46	3,667	1,020	138	10	NA	193,558	83.5
1926	164,530	2,105	166,635	162,187	277,965	1.71	2,032	2,820	1.39	3,244	974	140	11	NA	215,300	76.4
1927	173,207	2,124	[16] 175,330	171,865	278,855	1.62	2,158	2,881	1.33	2,066	817	153	11	NA	227,080	76.3
1928	176,299	2,210	178,509	175,838	275,973	1.57	2,214	2,910	1.31	2,302	825	156	11	NA	243,702	72.3
1929	170,646	2,209	[16] 172,856	169,868	252,154	1.48	2,159	2,951	1.37	1,745	885	163	11	NA	258,917	65.9
1930	161,197	1,792	162,989	159,059	228,780	1.44	1,787	2,470	1.38	985	756	163	11	NA	270,044	59.7
1931	125,429	1,242	126,671	127,150	140,960	1.11	1,227	1,620	1.32	470	430	160	12	NA	271,850	46.1
1932	76,740	457	[16] 77,198	80,843	82,022	1.01	525	696	1.33	468	375	160	15	NA	271,308	28.3
1933	63,473	511	63,984	64,283	85,584	1.33	478	645	1.35	477	680	152	13	NA	269,387	23.6
1934	77,748	672	[16] 78,419	75,901	116,921	1.54	678	961	1.42	266	566	150	11	NA	262,709	29.6
1935	76,742	1,006	77,748	75,233	113,372	1.51	1,011	1,438	1.42	619	416	150	13	NA	261,915	29.3
1936	112,650	1,819	114,469	112,850	170,415	1.51	1,761	2,362	1.34	1,659	335	149	12	NA	255,504	44.1
1937	116,175	1,901	[16] 118,075	113,805	168,835	1.43	1,873	2,579	1.38	1,804	379	150	12	NA	255,223	45.5
1938	105,357	1,821	107,178	106,324	153,977	1.45	1,868	2,726	1.46	1,727	558	151	12	NA	255,697	41.2
1939	122,259	2,439	124,698	122,651	180,893	1.47	2,405	3,362	1.40	1,914	1,146	150	12	NA	256,422	47.7
1940	130,217	2,535	[16] 132,751	130,350	190,078	1.46	2,515	3,387	1.35	538	1,668	152	12	NA	254,145	51.2
1941	164,030	2,876	[16] 166,907	167,439	246,622	1.47	2,926	3,968	1.36	45	2,556	155	11	NA	247,359	66.3
1942	182,781	2,560	[16] 185,342	185,301	283,237	1.53	2,508	3,668	1.46	1	1,101	155	10	NA	248,851	73.5
1943	133,424	1,830	135,254	127,632	200,103	1.57	1,847	2,357	1.28	14	1,732	153	9	NA	242,460	55.0
1944	90,906	1,247	[16] 92,152	94,272	150,358	1.59	1,320	1,639	1.24	(17)	4,040	151	9	NA	240,532	37.8
1945	102,805	1,484	104,289	106,354	173,337	1.63	1,480	2,094	1.42	(17)	6,475	145	9	NA	241,631	42.5
1946	164,064	2,475	166,539	169,568	292,396	1.72	2,533	4,155	1.64	4	5,163	153	9	NA	241,622	67.9

1947	186,519	2,951	189,470	187,492	356,214	1.90	2,928	5,764	1.97	5	6,771	150	9	NA	249,107	74.9
1948	205,448	3,440	[16] 208,889	204,305	445,678	2.18	3,375	7,734	2.29	283	5,922	150	9	NA	254,272	80.8
1949	209,727	3,185	[16] 212,913	206,080	473,177	2.30	3,234	8,006	2.48	110	4,562	150	9	NA	258,948	81.0
1950	226,026	4,246	230,272	227,757	535,321	2.35	4,219	10,630	2.52	1,410	2,418	150	9	NA	268,273	84.3
1951	246,022	3,449	[16] 249,472	241,153	613,170	2.54	3,475	9,833	2.83	922	2,933	155	8	NA	281,532	87.4
1952	249,256	3,402	252,658	251,369	638,512	2.54	3,447	8,752	2.83	476	3,174	156	8	NA	284,014	87.8
1953	264,181	3,488	267,669	260,879	697,263	2.67	3,459	10,341	2.99	386	2,551	156	8	NA	291,798	90.5
1954	272,353	3,504	275,857	274,872	759,862	2.76	3,513	13,215	3.76	450	1,859	157	6	NA	298,026	91.4
1955	297,453	17,460	314,913	292,765	837,526	2.86	17,480	59,362	3.40	5,220	1,795	157	6	119	315,299	94.3
1956	316,438	17,034	333,472	308,678	940,020	3.05	16,972	63,278	3.72	4,456	1,981	160	5	122	349,442	90.6
1957	298,424	15,332	313,756	289,698	921,959	3.18	15,043	56,772	3.77	4,427	1,331	164	5	125	380,386	78.5
1958	311,471	14,881	326,352	307,068	997,701	3.25	14,943	56,146	3.75	3,390	641	168	4	132	402,786	77.3
1959	339,091	16,643	355,734	335,452	1,099,244	3.28	16,615	62,605	3.76	5,265	277	172	4	134	420,395	80.7
1960	319,009	15,121	334,130	312,292	1,045,246	3.35	14,795	58,434	3.94	4,108	187	176	4	140	432,941	73.7
1961	324,114	14,514	338,628	320,751	1,065,778	3.32	14,623	56,705	3.88	3,621	286	175	4	143	443,022	73.2
1962	336,488	15,444	351,932	331,823	1,090,389	3.29	15,295	59,016	3.86	5,633	380	178	4	144	468,974	71.8
1963	352,543	15,863	368,406	349,253	1,117,974	3.20	15,988	61,006	3.82	4,030	460	181	4	143	477,585	73.8
1964	368,633	16,753	385,386	366,304	1,168,987	3.19	16,962	64,362	3.79	3,633	713	181	4	138	479,618	76.9
1965	371,422	17,425	388,847	374,086	1,177,863	3.15	17,601	67,006	3.81	5,505	748	181	3	134	482,439	77.0
1966	384,632	17,139	401,771	380,694	1,187,261	3.12	16,766	63,822	3.81	7,066	1,069	184	3	134	495,171	77.7
1967	369,399	16,449	385,848	374,017	1,175,605	3.14	16,254	62,528	3.85	5,913	980	188	2	134	508,952	72.6
1968	394,909	17,364	412,273	397,448	1,255,519	3.16	17,338	66,591	3.84	7,289	942	183	2	126	509,058	77.6
1969	399,602	17,287	416,889	409,826	1,312,520	3.20	17,402	69,433	3.99	9,687	589	181	2	122	507,286	78.7
1970	389,190	15,680	404,870	390,461	1,298,233	3.32	15,843	67,537	4.26	13,812	847	181	2	120	445,079	88.4
1971	409,617	17,603	427,220	420,239	1,480,696	3.52	18,043	85,774	4.75	16,422	663	174	2	117	456,336	87.7

NA Not available.
[1] Source: 1818–1923 U.S. Geological Survey; 1924–1971, U.S. Bureau of Mines. Includes Puerto Rico, (1939–1971); Hawaii (1945–1946) (1960–1971).
[2] The data for 1890 and previous years were estimates made at the close of each year and are believed to be substantially correct. Since 1890 the official data are based on returns from all producers.
[3] Quantity in units of 376-pound barrels.
[4] Data prior to 1955 not comparable due to changes in tabulating procedures by the Department of Commerce.
[5] Separate data for natural and pozzolan cements are available for the years 1896–1915. Pozzolan cement not included prior to 1896.
[6] Prior to 1921 the quantity of natural and pozzolan cements reported by producers was not converted to equivalent barrels of 376-pounds each. Up to and including 1920, the weight ranged from 276 to 320 pounds per barrel.
[7] Production data not collected before 1925. Data for prior years represents shipments.
[8] The term "Masonry Cement" was first introduced in 1922 and data were included with natural cements.
[9] Separate production and shipment data for masonry cement were collected for the first time in 1955. These data include masonry cement from all domestic portland, natural, and slag cement manufacturers.
[10] Excludes natural and pozzolan cement (1970–1971).
[11] Data up to and including 1911 are for production. Shipment data not collected before 1912.
[12] Does not include portland cement used in making masonry cement (1955–1971).
[13] Includes cement imported by domestic producers (1966–1971).
[14] Calculated prior to rounding. Capacity based on production of finished portland cement (1908–1969).
[15] Clinker capacity (1970–1971). Calculated on individual company data; (365 days, minus average days for maintenance, times the reported 24 hour capacity).
[16] Data may not add to totals shown because of independent rounding.
[17] Less than 500 barrels.

Table 19.—Hydraulic cement: World production by country

(Thousand 376-pound barrels)

Country	1969	1970	1971 p
North America:			
Bahamas	4,764	4,887	4,878
Canada (sold or used by producers)	r 43,883	42,266	50,713
Costa Rica	r 956	1,096	1,249
Cuba	4,573	e 4,700	e 5,000
Dominican Republic	2,287	2,885	3,536
El Salvador	833	979	979
Guatemala	r 1,313	1,472	e 1,470
Haiti	r 322	381	e 380
Honduras	774	786	e 790
Jamaica	2,427	2,680	2,526
Mexico	39,795	42,609	43,154
Nicaragua	639	797	434
Panama	1,020	e 1,060	1,126
Trinidad and Tobago	1,425	1,589	1,519
United States (including Puerto Rico)	r 416,889	404,870	427,220
South America:			
Argentina	r 25,488	27,710	32,553
Bolivia	469	674	1,208
Brazil	45,869	52,782	57,479
Chile	r 8,420	7,910	8,027
Colombia	r 14,031	16,265	17,256
Ecuador	r 2,680	2,685	e 2,760
Paraguay	217	369	475
Peru	6,667	6,708	e 6,740
Uruguay	r 2,709	2,938	2,275
Venezuela	r 12,548	15,538	e 15,800
Europe:			
Albania	1,923	e 2,110	e 2,110
Austria	26,725	28,179	32,196
Belgium	36,757	39,455	40,639
Bulgaria	20,827	21,507	22,750
Czechoslovakia	39,478	43,395	42,650
Denmark	15,286	15,268	16,025
Finland	r 10,501	10,783	10,619
France	161,495	169,205	169,727
Germany, East	43,447	46,831	e 46,900
Germany, West	205,675	224,713	191,667
Greece	28,379	28,730	32,518
Hungary	15,034	16,247	15,907
Iceland	545	498	586
Ireland	r 7,452	5,037	8,097
Italy	r 183,805	194,200	186,044
Luxembourg	1,214	1,437	1,536
Netherlands	19,326	22,457	23,717
Norway	14,611	15,450	15,960
Poland	69,364	71,416	76,704
Portugal	11,938	13,673	14,412
Romania	44,063	47,652	50,003
Spain (including Canary Islands)	r 95,661	96,957	99,636
Sweden	23,207	23,418	22,439
Switzerland	26,584	28,127	30,607
U.S.S.R.	r 526,530	558,192	588,095
United Kingdom	102,151	100,011	104,931
Yugoslavia	23,242	25,793	29,047
Africa:			
Algeria	5,570	e 5,900	e 5,900
Angola	2,246	2,586	3,108
Cape Verde Islands	106	e 120	e 120
Egypt, Arab Republic of (formerly United Arab Republic)	21,184	21,659	22,767
Ethiopia	973	1,061	1,237
Ghana	2,392	2,592	e 2,600
Ivory Coast	2,275	2,345	2,932
Kenya	3,764	4,644	4,714
Liberia	r 428	516	e 530
Libya	375	557	422
Malagasy Republic	440	440	451
Malawi [1]	446	410	381
Morocco	r 6,831	8,332	8,648
Mozambique	1,788	2,257	e 2,500
Niger	147	205	e 205
Nigeria	3,319	3,495	3,893
Rhodesia, Southern	2,240	2,779	e 2,900
Senegal	1,214	1,413	e 1,400
Sierra Leone	258	e 180	--
South Africa, Republic of	r 29,932	33,726	34,365
Sudan	r 991	915	991
Tanzania	997	979	1,044
Tunisia	3,536	3,201	3,424

See footnotes at end of table.

Table 19.—Hydraulic cement: World production by country—Continued

(Thousand 376-pound barrels)

Country	1969	1970	1971 p
Africa—Continued			
Uganda	1,014	1,120	1,173
Zaire (formerly Congo-Kinshasa)	1,888	2,081	e 2,110
Zambia	r 1,941	2,210	e 2,760
Asia:			
Afghanistan [2]	r 610	551	e 530
Burma	1,073	915	1,032
Ceylon	1,659	1,911	2,258
China, People's Republic of e	58,600	58,600	70,400
Cyprus	r 1,442	1,589	1,807
Hong Kong	2,216	2,521	3,002
India	77,748	79,407	87,329
Indonesia	r 3,137	3,242	3,348
Iran [2]	13,732	15,098	e 24,600
Iraq	8,097	e 8,200	e 8,200
Israel	r 7,693	8,115	8,238
Japan	301,300	335,320	315,156
Jordan	r 2,820	2,216	2,345
Khmer Republic (formerly Cambodia)	e 350	e 350	346
Korea, North	r 16,406	e 23,500	e 28,100
Korea, South	r 28,308	34,136	40,293
Lebanon	7,347	7,851	8,789
Malaysia	5,705	6,039	6,426
Mongolia	422	393	e 410
Pakistan	15,702	15,444	15,550
Philippines	17,297	14,342	18,276
Qatar e	e 300	e 600	423
Ryukyu Islands e	1,500	1,500	1,500
Saudi Arabia	r 3,459	3,958	4,175
Singapore	3,653	4,257	3,594
Syrian Arab Republic	r 5,471	5,652	5,330
Taiwan	23,969	25,259	25,569
Thailand	14,090	15,403	16,294
Turkey	33,984	37,373	44,227
Vietnam, North e	2,900	2,900	2,900
Vietnam, South	1,448	1,677	e 1,640
Oceania:			
Australia	r 25,259	26,960	27,666
Fiji Islands	322	352	451
New Zealand	4,708	4,861	4,826
Total	r 3,185,240	3,353,592	3,460,674

e Estimate. p Preliminary. r Revised.
[1] Sales.
[2] Year beginning March 21 of that stated.

Chromium

By John L. Morning [1]

Consumption of chromite in the United States decreased 22 percent compared with that of 1970. Most of the decreased chromite usage in the metallurgical industry resulted from a record-breaking level of imports of chromium alloys, although reported consumption of chromium alloys decreased 6 percent from that of 1970. Chromite usage in the refractory industry continued to decline as the quantity of steel produced in open-hearth furnaces, the principle consumer of chromite refractories, accounted for 29 percent of total steel production compared with 37 percent in 1970.

With an off year in demand for metallurgical-grade chromite, stocks in the metallurgical industry rose 72 percent compared with those in 1970. The chemical and refractory industries maintained an adequate level of stocks.

Legislation and Government Programs.—The Office of Emergency Preparedness (OEP) in June established a chromium metal objective of 3,775 tons and at the same time eliminated the subobjectives for aluminothermic and electrolytic chromium metal carried under the chemical-grade and metallurgical-grade chromite objectives. As a result of this action, the chemical-grade chromite objective was reduced from 260,000 to 250,000 tons and the basic material equivalent for metallurgical-grade chromite was reduced from 3,100,000 to 3,086,800 tons.

Various grades and quantities of chromite were offered for sale during the year by General Services Administration (GSA). A total of 8,779 tons of metallurgical-grade chromite and 29,348 tons of refractory-grade chromite were sold, but no chemical-grade chromite was disposed of. For the refractory-grade chromite sold, 21,048 tons were for nonrefractory use and 8,300 tons for refractory use. GSA chromite deliveries for the year were as follows: metallurgical-grade, 79,342 tons; chemical-grade, 23,823 tons; and refractory-grade, 42,288 tons.

On August 15, the President announced a 10-percent surcharge on import duties up to the statutory limit (Presidential proclamation 4074). Chromite was unaffected as chromite enters the country free. However, the duty on low-carbon ferrochromium was established at 15 percent ad valorem and high-carbon ferrochromium at 0.625 cent per pound of contained chromium plus 10 percent ad valorem. The surcharge was rescinded on December 20, 1971.

In November, Congress passed and the President signed a military procurement bill (Public Law 92–156) with an amendment stipulating that after January 1, 1972, the President could not bar the importation into the United States of strategic or critical materials from a free world country. Early in 1972, the U.S. Department of Treasury published regulations on removal of import controls on Rhodesian strategic and critical materials.[2]

[1] Physical scientist, Division of Ferrous Metals.
[2] Federal Register, v. 37, No. 16, Jan. 25, 1972, p. 1108.

Table 1.—Salient chromite statistics
(Thousand short tons)

	1967	1968	1969	1970	1971
United States:					
Exports	8	13	49	41	35
Reexports	157	126	150	73	145
Imports for consumption	1,240	1,084	1,106	1,405	1,299
Consumption	1,355	1,316	1,411	1,403	1,093
Stocks Dec. 31: Consumer	1,197	912	675	733	1,019
World: Production	5,041	5,444	5,865	6,672	6,936

Table 2.—U.S. Government chromium stockpile material inventories and objectives
(Thousand short tons)

	Objective	Inventory by program, Dec. 31, 1971			
		National stockpile	Defense Production Act	Supplemental stockpile	Total
Chromite, chemical-grade	250	559	--	11	570
Chromite, refractory-grade	368	997	--	180	1,177
Chromite, metallurgical-grade	2,911	2,216	901	323	3,440
Ferrochromium, high-carbon	71	126	--	277	403
Ferrochromium, low-carbon	0	128	--	191	319
Ferrochromium-silicon	0	26	--	33	59
Chromium metal	4	1	--	7	8

Table 3.—U.S. Government chromium stockpile material, sold but unshipped [1]
(Thousand short tons)

	Inventory by program, Dec. 31, 1971			
	National stockpile	Defense Production Act	Supplemental stockpile	Total
Chromite, chemical-grade	--	--	455	455
Chromite, refractory-grade	8	--	--	8
Chromite, metallurgical-grade	175	--	--	175

[1] Not included in table 2.

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 Division, Air Reduction Co. Inc	Calvert City, Ky. Niagara Falls, N.Y. Charleston, S.C.
Chromium Mining and Smelting Corp	Woodstock, Tenn.
Foote Mineral Co	Vancoram, Ohio Graham, W.Va.
Interlake Inc	Beverly, Ohio
Ohio Ferro-Alloys Corp	Brilliant, Ohio Tacoma, Wash.
Shieldalloy Corp	Newfield, N.J.
Union Carbide Corp	Niagara Falls, N.Y. Marietta, Ohio Alloy, W.Va.
Refractory industry:	
The Babcock & Wilcox Co	Augusta, Ga.
Basic, Inc	Maple Grove, Ohio
Corhart Refractories Co., Inc	Buckhannon, W. Va. Louisville, Ky.
E. J. Lavino & Co. (Division of IMC)	Newark, Calif. Plymouth Meeting, Pa.
General Refractories Co	Baltimore, Md. Lehi, Utah.
H. K. Porter Co., Inc	Pascagoula, Miss.
Harbison-Walker Refractories Co. (Div. of Dresser Industries, Inc.)	Hammond, Ind. Baltimore, Md.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif. Columbiana, Ohio.
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. Painsville, Ohio
Imperial Color & Chemical Department, Hercules, Inc	Glens Falls, N.Y.
PPG Industries, Inc	Corpus Christi, Tex.

At yearend, H. K. Porter sold its Pascagoula, Miss., refractory plant to Corchem, Inc. (an affiliate of Corhart Refractories Co. Inc. and Corning Glass Works). Also at yearend, E. J. Lavino & Co. permanently closed its Newark, Calif., refractory plant.

Diamond Shamrock Corp. started production of chromium chemicals at its new plant at Castle Haynes, N.C., late in the year. At the same time, the Painsville, Ohio, plant was phased out and plans were made to close the Kearny, N.J., plant early in 1972.

CONSUMPTION AND USES

Domestic consumption of 1,093,000 tons of chromite ore and concentrate containing about 340,000 tons of chromium was 22 percent less than in 1970. Of the total chromite consumed, the metallurgical industry used 66 percent, the refractory industry 18 percent, and the chemical industry 16 percent. The metallurgical industry consumed 720,000 tons of chromite containing 236,000 tons of chromium in producing 354,000 tons of chromium alloys and chromium metal. About 71 percent of the metallurgical grade ore had a chromium-to-iron ratio of 3:1 and over; 17 percent had a ratio between 2:1 and 3:1; and 12 percent had a ratio of less than 2:1.

Producers of chromite-bearing refractories consumed 193,000 tons of ore containing 48,000 tons of chromium. The chemical industry consumed 180,000 tons of chromite, containing 56,000 tons of chromium in producing 145,000 tons of chemicals (sodium bichromate equivalent).

Table 4.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

(Thousand short tons)

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Averge Cr_2O_3 (percent)
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	[1] 1,316	45.4
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

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

Table 5.—Production, shipments, and stocks of chromium ferroalloys and chromium metal

(Short tons)

Alloy	Production		Shipments	Producer stocks Dec. 31
	Gross weight	Chromium content		
1970: [r]				
Low-carbon ferrochromium	128,104	90,575	126,245	12,053
High-carbon ferrochromium	149,654	100,337	174,038	22,690
Ferrochromium-silicon	99,311	39,445	101,327	10,836
Other [1]	15,631	12,365	15,562	2,512
Total	392,700	242,722	417,172	48,091
1971:				
Low-carbon ferrochromium	111,861	78,056	104,143	26,730
High-carbon ferrochromium	132,169	88,977	146,643	28,370
Ferrochromium-silicon	92,145	35,983	86,020	19,823
Other [1]	17,426	13,069	15,899	4,851
Total	353,601	216,085	352,705	79,774

[r] Revised.
[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Table 6.—U.S. consumption, by end uses, and consumer stocks of chromium ferroalloys and metal in 1971

(Short tons, gross weight)

End use	Low-carbon ferro-chromium	High-carbon ferro-chromium	Ferro-chro-mium-silicon	Other [1]	Total
Steel:					
Carbon	1,501	3,922	726	W	6,149
Stainless and heat resisting	94,724	69,732	49,127	164	213,747
Alloy (excludes stainless and heat resisting)	16,661	37,599	6,808	2,761	63,829
Tool	480	1,717	190	W	2,387
Cast irons	723	6,863	103	514	8,203
Superalloys	7,884	1,179	655	1,880	11,598
Alloys (excludes alloy steel and superalloys):					
Welding and alloy hard-facing rods and materials	556	831	W	244	1,631
Other alloys [2]	915	893	22	1,597	3,427
Miscellaneous and unspecified	3,638	3,375	145	4,548	11,706
Total	127,082	126,111	57,776	11,708	322,677
Chromium content	87,145	81,671	22,230	7,236	198,282
Consumer stocks Dec. 31,1971	10,500	9,475	3,040	1,382	24,397

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1] Includes chromium metal.
[2] Includes magnetic and nonferrous alloys.

STOCKS

Chromite stocks in the metallurgical industry increased 72 percent compared with 1970 as supply (imports plus GSA deliveries) exceeded consumption. Yearend chromite stocks in the refractory industry were revised for 1970 and at yearend 1971, were at the same level as for the previous year. Stocks in the chemical industry were maintained at about 6- to 8-month supply.

An off year for chromium producers resulted in producer stocks of chromium alloys increasing 61 percent compared with 1970 as consumer stocks of alloys decreased 28 percent. Combined producer and consumer stocks of alloys rose 24 percent during the year.

Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants increased from 11,504 tons (revised figure) in 1970 to 14,271 tons in 1971.

Table 7.—Consumer stocks of chromite, Dec. 31

(Thousand short tons)

Industry	1967	1968	1969	1970	1971
Metallurgical	459	396	296	r 387	667
Refractory	486	309	301	r 235	233
Chemical	252	207	143	111	119
Total	1,197	912	740	r 733	1,019

r Revised.

PRICES

Metallurgical-grade chromite prices for 1971 delivery rose $8 to $12 per long ton over those of 1970. The price advance continued the trend initiated in 1967 and reflected the continuation of United Nations economic sanctions on Southern Rhodesia, the limited available supply, and increased shipping costs. U.S.S.R. chromite, 48 percent Cr_2O_3, 4 to 1 ratio, was priced at $51.50 to $55.00 per metric ton f.o.b. loading port. On a comparable basis for previous years, it was estimated that the price was equivalent to $64 per long ton delivered Atlantic ports. The price for the 55 percent Cr_2O_3 grade on a prorata basis was estimated at $70 per long ton delivered Atlantic ports. Turkish metallurgical-grade chromite, 48 percent Cr_2O_3, 3 to 1 ratio, rose to $55 to $56 per long ton delivered Atlantic ports from $47.50 to $48.50 in 1970. South African Transvaal chromite, 44 percent Cr_2O_3 (no ratio), price was unchanged during the year at $25 to $27 per long ton delivered Atlantic ports.

GSA sold refractory-grade chromite by competitive sealed bids at prices ranging from $23 to $29.40 per short ton. Prices at the lower range reflected refractory-grade chromite for metallurgical use.

Most chromium alloy prices remained unchanged during the year. In June high-carbon and charge ferrochromium prices were reduced 2 cents per pound of chromium, and in July the price of electrolytic chromium metal rose 15 cents per pound. Imported chromium alloys ranged from 1 to 2½ cents per pound of chromium below prices for domestic alloys. Selected chromium alloy prices published by Metals Week were as follows:

Material	Jan. 2, 1971	Dec. 30, 1971
	Cents per pound of chromium	
High-carbon ferrochromium	28.7	26.7
Charge chromium (63 to 71 percent chromium)	25.0	23.0
Low-carbon ferrochromium (0.025 percent carbon)	39.5	39.5
Blocking chromium (10 to 14 percent silicon)	27.6	27.6
	Cents per pound product	
Electrolytic chromium metal	115	130
Aluminothermic chromium metal	115	115

FOREIGN TRADE

Exports of chromite decreased 15 percent to 35,000 tons compared with 1970, but reexports of chromite returned to the level of 1969 and were nearly double those of 1970. Among the six countries receiving exports, Mexico accounted for 53 percent and Canada for 38 percent. Reexports were to Canada, 78 percent; Mexico, 12 percent; and France, 9 percent.

Ferrochromium exports were substantially lower than in previous years totaling 9,164 tons, valued at $3,619,949. Exports were shipped to 17 countries of which the United Kingdom, France, and Canada received 90 percent of the total. Canada received 96 percent of the 625 tons of ferrochromium reexports.

Chromium and chromium alloys (wrought and unwrought) and waste and scrap exports totaled 176 tons, valued at $226,638. Canada received 63 percent of the shipments and the balance was dispersed among 22 other countries.

Exports of nonpigment-grade chromium chemicals totaled 498 tons, valued at $989,107. Canada and Mexico were the leading recipients, accounting for 53 percent of the total; the balance was distributed among 23 other countries. Exports of pigment-grade chromium chemicals totaled 176 tons valued at $226,638. Canada received 63 percent, South Vietnam 17 percent, and 21 other countries the balance.

Exports of sodium chromate and dichromate totaled 3,072 tons, valued at $776,917. Canada received 74 percent of the shipments.

Imports of chromite decreased 9 percent compared with 1970, but value was about the same as in the previous year. Although imports decreased, they were sufficient to supply domestic demand. A significant shift in source of supply occurred as Turkish imports rose 31 percent and U.S.S.R. imports decreased 35 percent compared with those of 1970.

Imports of ferrochromium reached a record high as 85,187 tons valued at $22,697,000 were received for consumption. The Republic of South Africa supplied 36 percent and Japan 18 percent of the low-carbon ferrochromium. High-carbon ferrochromium was supplied by Japan, 29 percent; Finland, 24 percent; and the Republic of South Africa, 16 percent.

Sweden supplied all of the ferrochromium-silicon imports, totaling 772 tons and valued at $206,693.

Chromium carbide supplied by West Germany totaled 107 tons, valued at $228,260.

Imports of chromium-containing pigments were as follows: Chrome green, 290 tons; chromium yellow, 6,224; chromium oxide green, 855 tons; hydrated chromium oxide green, 241 tons; molybdenum orange, 331 tons; strontium chromate, 21 tons; and zinc yellow, 1,084 tons. Total value of these products was $4.5 million, 17 percent higher than in 1970. Chromium yellow accounted for 64 percent of total value, of which Japan supplied 72 percent.

Sodium chromate and dichromate imports totaled 6,377 tons valued at $1,284,229, whereas potassium chromate and dichromate imports totaled 14 tons valued at $4,721. The sodium chromate imports were 76 percent higher compared with those of 1970, returning to the level imported in 1969. Imports were principally supplied by Japan, 35 percent; Italy, 22 percent; U.S.S.R., 20 percent; and the Republic of South Africa, 15 percent.

Table 8.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1969	49	$1,915	150	$5,806
1970	41	2,582	73	2,572
1971	35	2,094	145	6,081

Table 9.—U.S. imports for consumption of ferrochromium, by countries

(Short tons and thousand dollars)

Year and country	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Quantity		Value	Quantity		Value
	Gross weight	Chromium content		Gross weight	Chromium content	
1970:						
Finland	--	--	--	5,919	3,347	$638
France	28	21	$9	--	--	--
Germany, West	2,579	1,910	922	4,458	3,037	902
Japan	310	210	71	347	236	73
Mozambique	--	--	--	560	298	69
Norway	3,387	2,362	1,081	489	352	121
South Africa, Republic of	19,735	r 12,158	4,517	560	322	71
Sweden	2,933	2,192	1,146	--	--	--
Total	28,972	r 18,853	7,746	12,333	7,592	1,874
1971:						
Belgium-Luxembourg	--	--	--	110	71	25
Brazil	--	--	--	1,382	847	291
Canada	184	111	43	515	360	159
Finland	--	--	--	10,903	5,772	1,138
France	1,086	773	425	4,255	2,927	1,125
Germany, West	5,033	3,728	2,343	6,738	4,392	1,620
India	2,260	1,623	800	--	--	--
Japan	7,390	4,882	2,943	12,992	8,363	2,924
Norway	3,458	2,409	1,460	300	211	85
South Africa, Republic of	14,633	8,661	3,459	7,174	3,871	956
Sweden	5,434	4,036	2,492	220	151	52
Turkey	1,120	750	357	--	--	--
Total	40,598	26,973	14,322	44,589	26,965	8,375

r Revised.

Table 10.—U.S. imports for consumption of chromite, by grades and countries

(Thousand short tons and thousand dollars)

Country	Not more than 40 percent Cr_2O_3			More than 40 percent but less than 46 percent Cr_2O_3			46 percent 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
1970:												
Iran	--	--	--	--	--	--	31	15	$948	31	15	$948
Pakistan	--	--	--	--	--	--	31	15	1,005	31	15	1,005
Philippines	190	62	$3,574	20	9	$425	--	--	--	210	71	3,999
South Africa, Republic of	3	1	43	307	136	3,545	97	45	1,264	407	182	4,852
Turkey	61	25	1,377	61	27	1,674	135	64	4,259	257	116	7,310
U.S.S.R.	57	22	837	3	1	54	409	225	12,800	469	248	13,691
Total	311	110	5,831	391	173	5,698	703	364	20,276	1,405	647	31,805
1971:												
Finland	--	--	--	(1)	(1)	1	--	--	--	(1)	(1)	1
Iran	--	--	--	--	--	--	12	5	381	12	5	381
Pakistan	--	--	--	--	--	--	35	17	1,013	35	17	1,013
Philippines	147	48	3,055	12	5	207	--	--	--	159	53	3,262
Rhodesia, Southern	--	--	--	--	--	--	26	12	768	26	12	768
South Africa, Republic of	11	4	134	271	120	3,177	140	65	1,961	422	189	5,272
Turkey	83	32	1,894	75	33	2,313	180	85	6,056	338	150	10,263
U.S.S.R.	33	13	804	--	--	--	274	151	10,343	307	164	11,147
Total	274	97	5,887	358	158	5,698	667	335	20,522	1,299	590	32,107

[1] Less than ½ unit.

Table 11.—U.S. import duties

Tariff classification	Articles	Rate of duty, Jan. 1, 1972 [1]
	CHROMIUM ORES AND METAL PRODUCTS	
601.15	Chromium ore	Free.
607.30	Ferrochromium, less than 3 percent carbon	4 percent ad valorem.
607.31	Ferrochromium, over 3 percent carbon	0.625 cent per pound on chromium content.
632.18	Unwrought chromium other than alloys: waste and scrap [2]	5 percent ad valorem.
	CHROMIUM CHEMICAL AND RELATED PRODUCTS	
420.08	Potassium chromate and dichromate	1.1 cent per pound.
420.98	Sodium chromate and dichromate	0.87 cent per pound.
422.92	Chromium carbide	6 percent ad valorem
	CHROMIUM PIGMENTS	
473.10	Chrome green	5 percent ad valorem.
473.12	Chrome yellow	Do.
473.14	Chromium oxide green	Do.
473.16	Hydrated chromium oxide green	Do.
473.18	Molybdenum orange	Do.
473.19	Strontium chromate	Do.
473.20	Zinc yellow	Do.

[1] Not applicable to Communist countries.
[2] Duty temporarily suspended on waste and scrap.

WORLD REVIEW

Australia.—Mt. Coora Mining N.L. and Austral-Pacific Mining Corp. Ltd. announced discovery of a chromite deposit of refractory-grade ore in the Marlborough area of Queensland.

Brazil.—Cia. de Ferro Ligas da Bahia S.A. (FERBASA), the largest chromite producer in Brazil, reported total production of 30,442 tons in 1970: 19,288 tons of chemical-grade and 11,154 tons of metallurgical-grade. In addition, 6,472 tons of high-carbon ferrochromium was produced at the company's plant at Pojuca. Bahia is the largest chromium producing State in Brazil, and FERBASA is the principal producer.

Plans call for expanding the output of ore almost threefold and for doubling ferrochromium production. Negotiations were underway with Japanese groups on expanding mining capacity, perhaps eventually to 100,000 tons per year, half of which would be exported to Japan. The remainder would be used to produce ferrochromium in a plant to be constructed using Japanese technology. The FERBASA facility supplies most of Brazil's chromium requirements.

India.—Chromite production in India in 1970 continued to increase, reaching 298,593 tons. Exports during the year totaled 173,659 tons, all of which were shipped to Japan. Shipments by grade of ore were as follows: 48 to 56 percent Cr_2O_3, 102,677 tons; 38 to 48 percent Cr_2O_3, 35,087 tons; and below 38 percent Cr_2O_3, 35,895 tons.

Ferrochromium production increased significantly from 5,720 tons in 1969 to 14,708 tons in 1970. The private sector company, Ferroalloy Corp. Ltd. became the largest producer with 56 percent of the output. Other firms contributing to total production were two public sector companies, Mysore Iron and Steel Works and Orissa State Industrial Development Corp., and two private sector companies, Tota Iron and Steel Co. and Electric Control Gear (P) Ltd. Japan, West Germany, and the United Kingdom accounted for most of India's 1970 ferrochromium exports.

Japan.—Indications were that Japanese chromite demand for metallurgical use exceeded 1 million tons in 1971. Forecasts by the Japanese Ferroalloy Association for the supply and demand of ferrochromium in 1971 were 290,000 tons of high- and medium-carbon ferrochromium; 130,000 tons of low-carbon ferrochromium; and 140,000 tons of ferrochromium-silicon. Japanese exports of ferrochromium to the United States in 1971 rose from 657 tons in 1970 to 20,382 tons.

Japan's Showa Denko K.K. started up a new 60,000-ton-per-year ferrochromium plant early in the year. The new plant was operated by Shunan Denko K.K., a joint venture of Showa Denko, Tokuyama Soda, and Nisshin Steel Works.

Philippines.—Output of chromite decreased 24 percent compared with that of

Table 12.—Chromite: World production by countries
(Thousand short tons)

Country [1]	1969	1970	1971 [p]
Albania	473	516	[e] 590
Brazil	17	30	[e] 31
Colombia	(2)	(2)	1
Cyprus	26	37	45
Finland	79	133	123
Greece [3]	[r] 27	29	27
India	[r] 250	299	288
Iran [e]	[r] 165	220	220
Japan	33	36	35
Malagasy Republic	88	[4] 144	[e] 155
Pakistan	25	32	27
Philippines	[r] 517	624	476
Rhodesia, Southern [e]	400	400	400
South Africa, Republic of	1,320	1,573	1,812
Sudan	[r] 28	52	23
Turkey	500	[e] [r] 572	[e] 665
U.S.S.R.[e]	1,874	1,930	1,980
Yugoslavia	43	45	38
Total	[r] 5,865	6,672	6,936

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Bulgaria, Cuba, North Korea and North Vietnam also produce chromite, but available information is inadequate to make reliable estimates of output levels.
[2] Less than ½ unit.
[3] Series revised to reflect salable output of concentrates rather than run of mine ore, which was reported in previous editions of this chapter.
[4] Exports.

1970; 80 percent was classified as refractory-grade and 20 percent metallurgical-grade. Exports of refractory-grade chromite totaled 328,591 tons. The United States received 38 percent, the United Kingdom received 24 percent, and Japan 12 percent; the balance was shipped to 11 other countries. Japan received all of the 69,707 tons of metallurgical-grade chromite exported.

In 1970, Acoje Mining Co. Inc., the metallurgical-grade chromite producer, mined 312,000 tons of ore from which 111,000 tons of concentrate was shipped. At yearend, chromite stocks totaled 2,887 tons. Further exploration of the Acoje ore body was conducted by tunneling and diamond drilling. Ore reserve at the start of 1971 totaled 1.9 million tons, averaging 22 percent Cr_2O_3.

Also in 1970, Consolidated Mines Inc., a refractory-grade chromite producer, mined and processed 417,836 tons of ore from the Coto area and 353,939 tons of ore from the Zambales Mineral Reservation. Shipments of refractory chromite ore products by the firm included: lump ore, 155,624 tons; plus 10 mesh, 127,064 tons; minus 10 mesh 202,901 tons; and plus 65 mesh, 7,440 tons. The company continued its development programs and also acquired adjoining properties in an effort to increase existing chromite ore reserves. Ore reserve at the beginning of 1971 totaled 8.6 million tons.

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. Latest available firm chromite production data was published for 1965.

The Minister of Mines administers a Government program that offers exclusive prospecting orders for prospecting in certain areas of Southern Rhodesia. Rhodesia Chrome Mines Ltd. at yearend had in effect six orders covering 620 square miles for prospecting for chromium and other metals. Other firms having exclusive orders for chromium prospecting were: Central African Trading Co. (Pvt.) Ltd.; Rio Tinto Rhodesia Ltd.; and Gladstone Mines (Pvt.) Ltd.

South Africa, Republic of.—Production of chromite in the Republic of South Africa increased 15 percent compared with that of 1970, reaching a record high of 1.8 million tons. Of the total, 564,000 tons was listed as less than 44 percent Cr_2O_3; 1,137,000 tons from 44 to 48 percent Cr_2O_3; and 111,000 tons as over 48 percent Cr_2O_3. Distribution of chromite was as follows: local sales, 445,000 tons; exports of chromite ore or concentrate, 1,281,000 tons; and chromite sand, 27,700 tons.

African Metal Corp. Ltd. (Amcor) announced a $42 million expansion program for production of ferroalloys. One ferrochromium and two ferromanganese furnaces together with antipollution facilities compose the expansion which will make Amcor one of the world's largest ferroalloy producers. Subsidiaries, Metalloys Ltd. and Ferrometals Ltd., reportedly concluded contracts running up to 15 years for delivery of sizeable quantities of chromium and manganese alloys to major world steel mills.

Other announcements concerning expanded South African ferrochromium production include a 4,000-ton-per-month plant under construction by The Associated Manganese Mines of South Africa, Inc., and United States Steel Corp. at Machadodorp and a new-furnace expansion at Southern Cross Steel Co. (Pty.) Ltd. for production of chromium alloys for export.

Turkey.—A memorandum of understanding was signed between Etibank and Japan Metals and Chemicals Co. for the Japanese firm to construct and supply technology for a new ferrochromium plant to be completed in 1973. The plant would have an annual capacity of 25,000 tons of low-carbon ferrochromium, 25,000 tons of high-carbon ferrochromium, and 17,000 tons of ferrochromium-silicon. A separate agreement between the Governments of Japan and Turkey provided for supplying 1 million tons of Turkish chromite to Japan over an 11-year period.

Yugoslavia.—The Yugoslavia state-owned ferroalloy producer Hemisko Elektrometalurski Kombinati-Jugohrom planned to expand and modernize its plant at Jegunovci. Production capacity for high- and low-carbon ferrochromium was expected to reach 30,000 tons annually by yearend.

TECHNOLOGY

Chlorination of Barramyia (Egypt) chromite ore and concentrate was studied.[3] The ore and concentrate was subjected to a chlorination process in which time, temperature, carbon ratio, and chlorine flow rates were controlled. Iron oxides were selectively chlorinated resulting in an upgraded product with higher chromium to iron ratios.

Showa Denko K.K. (Japan) developed a new process for ferrochromium production.[4] The new process features the solid-state reduction of chromium ores in which the ore is partially reduced in the solid-state and immediately charged to an electric furnace while hot, in contrast to the conventional method in which chromium ore is reduced in the molten state.

Results of using sintered chromite fines as feed to a ferrochromium alloy furnace was published.[5] The use of sinter provided stable furnace operations and increased furnace efficiencies such as improved power consumption, throughput, and reduced dust emissions.

The technology and use of chromite sand for foundry molding and coremaking was described.[6] Key advantages of chromite sand over other types of sand in foundry applications were as follows: chromite has superior chill characteristics; chromite is inert and therefore does not react with other metallic oxides; chromite has low linear expansion; chromite eliminates metal penetration; chromite is versatile and can be used with all bonding processes; and chromite has none of the adverse health effects of silica.

The use of chromite sand for foundry use has been growing at a rapid rate since 1958, but most is discarded after being contaminated with other sands or materials. Bureau of Mines researchers as part of the Bureau's Solid Waste program developed a method to clean foundry sand particles and recover the valuable components by using physical separation techniques.[7] A simple scrubbing followed by an oxidizing roast and magnetic separation produced quality sands which can be reused.

Chromium plated steel, which has had a significant growth rate since 1966, was estimated to have captured 40 percent of the

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[3] Hussein, M. Kamal, and K. El-Barawi. Study of the Chlorination and Beneficiation of Egyptian Chromite Ores. Inst. of Min. and Met. (London), v. 80, No. 772, March 1971, pp. C7–C11.

[4] Kanoh, Yasuhisa. Solid-State Reduction of Chrome Ores. Metal Bulletin (London), Ferro Alloys Special Issue, 1971, pp. 83 and 85.

[5] Naruse, Wataru. Production by The Sintering Process. Metal Bulletin (London), Ferro Alloys Special Issue, 1971, pp. 89, 91.

[6] Murphy, Maurice T. How to Use Chromite Sand. Foundry, v. 99, No. 3, March 1971, pp. 59–61.

[7] Barnard, P. G., R. A. Ritchey, and H. Kenworthy. Recovery of Chromite and Silica From Steel Foundry Waste Molding Sands. BuMines TPR 36, July 1971, 21 pp.

beer and beverage can market and represents over 2,000,000 tons of tin free steel annually. Two operating lines of one manufacturer of tin free chromium plated steel were described.[8]

Patent activity concerned solvent extraction of chromium ions from aqueous solutions, electrolytic production of low-carbon ferrochromium, and direct reduction of chromite.[9]

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[8] Dippold, M. W. New Chrome Plating Facilities at Sparrows Point. Iron and Steel Eng., v. 48, No. 3, pp. 62–67.

[9] Burrows, R. C. (assigned to Ashland Oil and Refining Co.). Extraction of Metal Ions From Acidic Aqueous Solutions Using an Amine and a Carboxylic Acid. U.S. Pat. 3,558,288, Jan. 26. 1971.

Winand, R. (assigned to Universite Libre de Bruxelles). Process for the Production of Chromium of Low-Carbon Content by Means of Fused Electrolytic Extraction and Chromium Alloy Obtained Thereby. U.S. Pat. 3,589,988, June 29, 1971.

Bouchet, J. (assigned to Soc. Métallurgie d'Imphy). Process of Direct Reduction of Minerals. U.S. Pat. 3,573,033, March 30, 1971.

Fourt, P. M. F. Process and Plant for Reducing Metallic Oxides. U.S. Pat. 3,593,894, April 6, 1971.

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, 5.8 million tons; Texas, 4.6 million tons; and Ohio, 4.0 million tons; followed in order by North Carolina, Alabama, and California. Georgia also led in total value of clay output with $119.1 million; Wyoming was second with $17.4 million. Compared with 1970 figures, clay production increased in 27 States and value increased in 25 States. Total quantity of clays sold or used by domestic producers in 1971 was approximately 3 percent higher in tonnage and 2 percent higher in total value. The total value of clays produced was an alltime high. Modest increases in value per ton were reported for all clays except fuller's earth, which declined slightly in value.

Kaolin in 1971 accounted for only 9 percent of the total clays but for 46 percent 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)

	1967	1968	1969	1970	1971
Domestic clays sold or used by producers	54,664	57,348	58,694	54,853	56,666
Value	$223,987	$246,938	$264,415	$267,912	$274,431
Exports	1,149	1,519	1,574	2,076	1,973
Value	$32,432	$44,134	$45,767	$66,116	$65,329
Imports for consumption	108	97	82	87	64
Value	$2,235	$1,951	$1,750	$1,802	$1,501
Clay refractories, shipments (value)	$225,116	$229,660	$257,507	$256,384	$236,563
Clay construction products, shipments (value)	$538,110	$590,776	$608,982	$554,431	$641,567

[1] Excludes Puerto Rico.

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin in 1971 decreased less than 1 percent while the reported total value increased 9 percent. The average unit value for all grades of kaolin in 1971 was $25.79, $2.22 higher than in 1970. Kaolin was produced from mines in 20 States. Two States, Georgia (76 percent) and South Carolina (9 percent), accounted for 85 percent of the total U.S. production in 1971. Ohio ranked third with 5 percent, Arkansas fourth with 3 percent, and Alabama fifth with 1 percent. Output in 1971 declined in Alabama, Arkansas, Georgia, South Carolina, Texas, and Utah. Increased production was noted in California, Florida, Idaho, North Carolina, and Pennsylvania. New producing States in 1971 were Arizona, Indiana, Maine, Maryland, Missouri, Nevada, New Jersey, Ohio, and Oregon.

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.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Clays sold or used by producers in the United States in 1971, by State [1]

(Short tons)

State	Quantity: Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Common clay and shale	Total	Total value
Alabama	64,440	--	299,954	W	--	2,550,806	[2] 2,915,200	[2] $6,912,844
Arizona	65	--	--	W	--	119,003	[2] 119,068	[2] 84,398
Arkansas	W	--	--	--	--	936,048	[3] 936,048	[3] 1,499,500
California	48,191	W	36,559	33,932	W	2,702,046	2,825,848	7,146,128
Colorado	--	--	42,512	1,548	--	581,174	625,234	1,334,498
Connecticut	--	--	--	--	--	174,165	174,165	322,069
Delaware	--	--	--	--	--	13,918	13,918	8,351
Florida	W	--	--	--	432,689	559,853	[3] 992,542	[3] 12,833,664
Georgia	3,682,305	--	W	--	348,043	1,760,374	[4] 5,790,722	[4] 119,096,298
Hawaii	--	--	--	--	--	W	W	W
Idaho	W	--	W	W	--	W	51,347	W
Illinois	--	--	89,725	--	W	1,621,661	[5] 1,711,386	[5] 3,188,913
Indiana	76	--	W	--	--	1,324,294	[4] 1,324,370	2,307,747
Iowa	--	--	W	--	--	1,027,654	[4] 1,027,654	[4] 1,702,207
Kansas	--	--	--	--	--	879,426	879,426	1,151,078
Kentucky	--	W	112,884	--	--	843,411	[6] 956,295	[6] 1,377,382
Louisiana	--	--	--	--	--	1,073,417	1,073,417	1,606,173
Maine	W	--	--	--	--	42,180	[3] 42,180	[3] 56,077
Maryland	2,426	W	--	--	--	1,024,989	[6] 1,027,415	[3,6] 1,558,148
Massachusetts	--	--	--	--	--	185,732	185,732	376,883
Michigan	--	--	--	--	--	2,457,593	2,457,593	3,365,678
Minnesota	--	--	--	--	--	223,144	223,144	334,717
Mississippi	--	W	--	280,635	W	1,860,323	2,278,242	8,500,953
Missouri	W	--	871,631	42,503	--	1,439,738	[3] 2,353,872	[2,3] 7,454,187
Montana	--	--	W	228,624	--	34,898	[4] 263,522	[4] 1,712,299
Nebraska	--	--	--	--	--	69,401	69,401	82,358
Nevada	1,500	--	--	W	--	W	[2,7] 1,500	W
New Hampshire	--	--	--	--	--	36,725	36,725	33,812
New Jersey	W	W	W	--	--	134,377	201,065	863,903
New Mexico	--	--	W	--	--	76,139	[4] 76,139	[4] 114,142
New York	--	W	--	--	--	1,588,012	[6] 1,588,012	[6] 1,742,467
North Carolina	W	--	W	--	--	3,502,879	[3,4] 3,502,879	[3,4] 3,801,769
North Dakota	--	--	--	--	--	W	W	W
Ohio	260,217	--	658,229	--	--	3,054,644	3,973,090	11,379,777
Oklahoma	--	--	--	W	--	844,617	[2] 844,617	[2] 1,254,585
Oregon	213	--	--	845	--	155,922	156,980	255,337
Pennsylvania	W	--	559,128	--	--	1,766,279	[3] 2,325,407	[3] 8,940,288
Puerto Rico	--	--	--	--	--	341,726	341,726	358,449
South Carolina	449,522	--	W	--	--	1,599,291	[4] 2,048,813	[4] 10,201,317
South Dakota	--	--	--	W	--	150,071	[2] 150,071	[2] 127,589
Tennessee	--	377,421	23	--	W	1,159,550	[5] 1,536,994	[5] 6,594,844
Texas	W	W	74,814	W	W	4,374,219	4,615,191	10,431,789
Utah	W	--	W	4,051	2,580	W	198,474	1,063,834
Virginia	--	--	--	--	--	1,709,859	1,709,859	1,799,879
Washington	--	--	W	--	--	255,203	[4] 255,203	[4] 548,547
West Virginia	--	--	W	--	--	232,178	[4] 232,178	[4] 335,565
Wisconsin	--	--	--	--	--	4,025	4,025	7,645
Wyoming	--	--	--	1,751,858	--	45,696	1,797,554	17,377,529
Undistributed	377,238	225,203	298,772	321,763	230,602	258,558	[8] 1,093,696	[8] 13,543,577
Total	4,886,193	602,624	3,044,231	2,665,759	1,013,914	44,795,218	57,007,939	274,789,194

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes Puerto Rico.
[2] Excludes bentonite.
[3] Excludes kaolin.
[4] Excludes fire clay.
[5] Excludes fuller's earth.
[6] Excludes ball clay.
[7] Excludes common clay and shale.
[8] Incomplete total; remainder included in State totals.

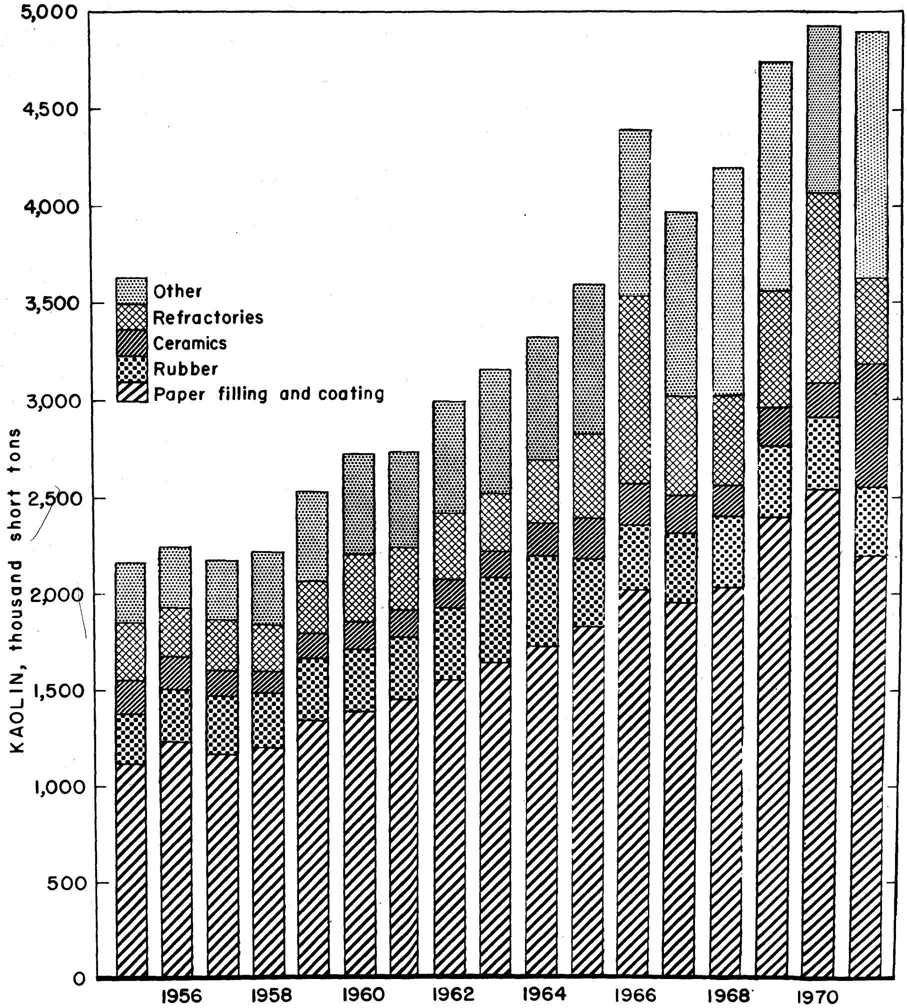

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

During 1971 Engelhard Minerals and Chemicals Corp. added a new spray dryer to their production facilities at McIntyre, Ga., and commenced operating a new kaolin mine and its supporting mill and pipelines. These new installations were to permit the more efficient operations of their noncontiguous kaolin deposits. Theile Kaolin Co. completed a new air-float plant for producing filler-grade kaolin near Wrens, Ga. Freeport Kaolin Co. continued expanding its delaminated kaolin producing capacity by an additional 25 percent and Georgia Kaolin enlarged their bagging facilities at Gordon, Ga. American Industrial Clays Co. of Sandersville increased their processing capacity for producing their special high-brightness coating clay near Sandersville, Ga. Anglo-American Clay Corp. and Union-Camp joined in an exploration venture on the latter's land around Sandersville. Babcock & Wilcox installed a new $250,000 pollution control system at its Albion facility near Hephzibah, Ga. Mulcoa, a Division of Combustion Engineering, Inc., expanded its refractory grog production from 100,000 to well over 250,000 tons per year at their Andersonville, Ga., plant. The expansion program included adding new kilns to their facility.

Port Royal Clay Co. announced plans to expand their kaolin clay export facility in Port Royal, Beaufort County, S.C. Interpace Corp. completed a $2.5 million expansion at its Ione, Calif., kaolin clay plant. The expansion included an additional rotary kiln for increasing the production capacity of calcined kaolin to over 100,000 tons per year. Universal Acceptance Corp. has acquired California Nonmetallics, an Orange County, Calif., producer of kaolin clay products.

Kaolin prices quoted in the trade journals rose in 1971 from 5 to 18 percent. Oil, Paint and Drug Reporter, December 27, 1971, quoted prices as follows:

Water washed, fully calcined, bulk carload lots, f.o.b. Georgia, per ton	$68.00
Partially calcined, same basis, per ton	59.00
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	19.50
Delaminated, water washed, uncalcined, paint-grade, 1-micron average, same basis, per ton	67.00
Dry-ground, airfloated, 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 $25.79 per ton, an increase of $2.22 above the 1970 value.

Exports of kaolin, as reported by the U.S. Department of Commerce, decreased from 816,000 short tons valued at $27.3 million in 1970 to 673,000 tons valued at $26.1 million in 1971. The tonnage exported was 18 percent below that shipped in 1970, but the value declined only 4 percent. The unit value per ton increased $5.37. This decrease in kaolin exports was attributed to both the general worldwide recession and the return of the United Kingdom's china clay industry to normalcy.

Kaolin was exported to 53 countries. The recipients were West Germany, 24 percent; Italy and Canada, 22 percent each; Japan, 12 percent; and the remaining countries, 20 percent. Generally, exports to all countries decreased, except for those to West Germany, Italy, and Venezuela, which increased 90, 13, and 11 percent, respectively. The kaolin producers reported the end use of their exports were paper coating, 69 percent; paper filling and rubber, 9 percent each; and others, including firebrick, paint, and plastics, 13 percent.

Kaolin imports in 1971 continued the downward trend reported for a number of years, to 44,622 short tons valued at $907,000 from 65,335 tons valued at $1.25 million. The United Kingdom supplied over 95 percent; West Germany, 4 percent; and Canada, Japan, and New Zealand, the remaining 1 percent.

Table 3.—Kaolin sold or used by producers in the United States, by State

(Short tons)

State	1970		1971	
	Quantity	Value	Quantity	Value
Alabama	W	W	64,440	$646,619
Arizona [1]	--	--	65	1,350
Arkansas	202,568	$1,839,780	W	W
California	12,884	187,329	48,191	494,881
Georgia	3,749,432	100,278,251	3,682,305	108,864,013
Indiana [1]	--	--	76	608
Maryland [1]	--	--	2,426	W
Nevada [1]	--	--	1,500	W
Ohio [1]	--	--	260,217	2,222,712
Oregon [1]	--	--	213	5,020
South Carolina	519,247	8,010,838	449,522	7,954,113
Other States [2]	441,488	5,792,804	377,238	5,833,513
Total	4,925,619	116,109,002	4,886,193	126,022,829

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

[1] Formerly included with fire clay.

[2] Includes Florida, Idaho, Maine (1971), Missouri (1971), New Jersey (1971), North Carolina, Pennsylvania, Texas, Utah, and data indicated by symbol W.

Table 4.—Georgia kaolin sold or used by producers, by use

(Short tons)

Use	1970	1971
Paper coating	[1] 2,491,230	1,370,468
Paper filling	(2)	801,084
Firebrick and block	354,232	260,073
Whiteware	99,980	140,555
Rubber	104,475	128,436
Fiberglass	NA	105,614
Paint	100,866	99,239
Plastics	W	78,365
Other chemicals	W	38,391
Exports	NA	512,106
Other uses [3]	598,649	147,974
Total	3,749,432	3,682,305

NA Not available, not canvassed. W Withheld to avoid disclosing individual company confidential data; included with "Other uses."

[1] Includes paper filling.

[2] Included with paper coating.

[3] Includes cement, catalysts, floor and wall tile, other pottery, mortar (1970), high-alumina brick (1970), other refractories, insecticides and fungicides, foundries and steelworks, and kiln furniture.

Table 5.—South Carolina kaolin sold or used by producers, by use

(Thousand short tons)

Use	1970	1971
Rubber	262	226
Firebrick and block	19	W
Insecticide and fungicide	20	8
Paint	5	7
Exports	NA	49
Other uses [1]	213	160
Total	519	450

NA Not available, not canvassed. W Withheld to avoid disclosing individual company confidential data; included with "Other uses."

[1] Includes building brick (1970), fertilizers, paper, floor and wall tile, pottery and whiteware, drilling mud (1971), chemicals (1971), fiberglass (1971), animal feed (1971), vitrified sewer pipe (1970), drain tile (1970), other uses, and uses indicated by symbol W.

BALL CLAY

Production and value reported for domestically mined ball clay in 1971 declined 15 percent in tonnage and 5 percent in value. Tennessee mines provided 63 percent of the Nation's output, followed in order of output by Kentucky, Mississippi, Texas, Maryland, California, New York, and New Jersey. Production in Kentucky and Maryland increased over that reported for 1970.

Ball clay is defined as a plastic, white-firing clay used principally for bond in ceramic ware. The clays are of sedimentary origin and consist mainly of the clay mineral kaolinite and sericite micas.

The average unit value for ball clay reported by domestic producers rose 12 percent in 1971 to $15.95 per ton, an increase of $1.65 per ton. Oil, Paint and Drug Reporter, December 27, 1971, listed ball clay prices as follows:

Domestic, airfloated, 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, airfloated, bags, carload lots, Atlantic ports, per ton	70.00
Imported, lump, bulk, Great Lakes, per ton	40.50

Ball clay exports in 1971 amounted to 77,000 short tons valued at $1.5 million compared with 22,000 tons worth $613,000 in 1970. Exports increased over three times that shipped in 1970 while the value was only about double. The unit value of ball clay exported declined $8.32 per ton. These shipments were made to 20 countries. The major recipients were Canada, 66 percent, and Mexico, 26 percent; 18 countries accounted for the remaining 8 percent.

FIRE CLAY

Fire clay sold or used by domestic producers in 1971 was reported at 3,044,231 short tons valued at $19.0 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 1971 from mines in 22 States. The first four States in rank, Missouri, Ohio, Pennsylvania, and Alabama, accounted for 78 percent of the total domestic output.

During 1971 A. P. Green Refractories completed its new manufacturing facility for its Pyro Division in Oak Hill, Ohio. Castables, wet and dry mortars, and gunning mixes will be produced. Granada Clay Products Co. acquired Harbison-Walker's Ione plant in Los Angeles, Calif.

Exports of fire clay decreased from 167,000 short tons worth $3.5 million in 1970 to 162,000 tons valued at $3.6 million in 1971. Fire clay exports declined 3 percent in tonnage and increased in value approximately 3 percent. The price of exported fire clay increased $1.27 to $22.00 per ton.

Fire clay was exported to 17 countries, with Canada and Mexico receiving 49 and 33 percent, respectively. The other 15 countries received the remaining 18 percent. No imports of fire clay were reported during 1971.

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 17 percent from $5.34 in 1970 to $6.24 per ton.

Table 6.—Ball clay sold or used by producers in the United States, by State

(Short tons)

State	1970		1971	
	Quantity	Value	Quantity	Value
Tennessee	410,078	$5,662,005	377,421	$5,455,628
Other States [1]	299,653	4,487,396	225,203	4,156,589
Total	709,731	10,149,401	602,624	9,612,217

[1] Includes California, Kentucky, Maryland, Mississippi, New Jersey (1971), New York (1971), and Texas.

Table 7.—Fire clay sold or used by producers in the United States, by State

(Short tons)

State	1970 Quantity	1970 Value	1971[1] Quantity	1971[1] Value
Alabama	395,609	$2,635,587	299,954	$2,736,448
Arizona	10	300	--	--
California	399,924	1,275,531	36,559	121,520
Colorado	238,769	950,815	42,512	242,084
Illinois	182,079	1,502,988	89,725	513,504
Indiana	75,403	202,167	W	4,466
Kentucky	160,085	916,330	112,884	533,311
Missouri	926,670	4,854,184	871,631	4,895,960
New Jersey	W	518,148	W	W
Ohio	1,889,083	6,054,646	658,229	3,567,757
Oklahoma	405	4,050	--	--
Pennsylvania	1,208,987	10,544,132	559,128	4,172,685
Tennessee	--	--	23	46
Texas	351,231	1,334,418	74,814	W
Utah	7,109	24,492	W	W
Other States[2]	623,147	3,693,209	298,772	2,217,061
Total	[3] 6,458,511	34,510,997	[3] 3,044,231	19,004,842

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

[1] Refractory uses only.

[2] Includes Georgia (1971), Idaho, Iowa (1971), Kansas (1970), Maine (1970), Maryland (1970), Mississippi (1970), Montana (1971), New Mexico, North Carolina (1971), Oregon (1970), South Carolina (1971), Washington, West Virginia, and data indicated by symbol W.

[3] Short tons sold by producers 2,312,498 (1970) and 1,008,248 (1971).

BENTONITE

Bentonite production in 1971 increased 5 percent in tonnage and 9 percent in value from the 1970 figures. A general decline in domestic consumption, particularly in iron ore pelletizing and for filtering uses, was offset by increased exports.

Bentonite was produced in 15 States, an increase of two States over that reported in 1970. The new producing States were Idaho and Missouri. Increased bentonite production was reported for all States except Nevada, Texas, and Wyoming.

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.

New bentonite drying plants for handling bulk materials were established by Wyo-Ben Products, Inc. at Lovell, Wyo., and Hallett Minerals Co., near Dodson, Mont. Dust collection and control equipment were installed by Dresser Industries, Inc., Wyo-Ben Products, Inc., Federal Bentonite Co., and Benton Clay Co. in their Wyoming plants.

Oil, Paint and Drug Reporter, December 27, 1971, quoted bentonite prices as follows: Domestic, 200 mesh, bags, carload lots, f.o.b. mines, $14.00–$14.40 per ton; and imported Italian, white, high-gel, bags, 5-ton lots, ex-warehouse, $116.60 per ton. The average unit value reported by producers of domestic bentonite sold or used in 1971 was $10.46, a slight increase from the $10.07 average of the previous year. Per-ton values reported in the various producing States ranged from $5 to $31, but as in 1970, the average value reported by the larger producers was near the Wyoming average figure of $9.86.

Bentonite exports in 1971 increased from 496,000 short tons in 1970 valued at $12.6 million to 663,000 tons valued at $16.2 million. Tonnage exported increased 34 percent from that shipped in 1970, but the value rose only 29 percent. In addition, the unit value decreased nearly $1.00 per ton. Bentonite was exported to 75 countries. The major recipients were Canada, 54 percent; Australia, 14 percent; West Germany, 10 percent; United Kingdom, 7 percent; and others, 15 percent.

Bentonite imports in 1971, including chemically activated and special-purchase Italian material, totaled 2,393 short tons valued at $194,000 compared with 2,244 tons valued at $172,000 in 1970. The 2,327 tons of chemically activated bentonite was imported from six countries, with Canada supplying 53 percent; West Germany, 18 percent; Japan and Mexico, 14 percent each; and United Kingdom and France the remaining 1 percent. Imports of Italian bentonite in 1971 decreased from 123 short tons in 1970 to 66 short tons.

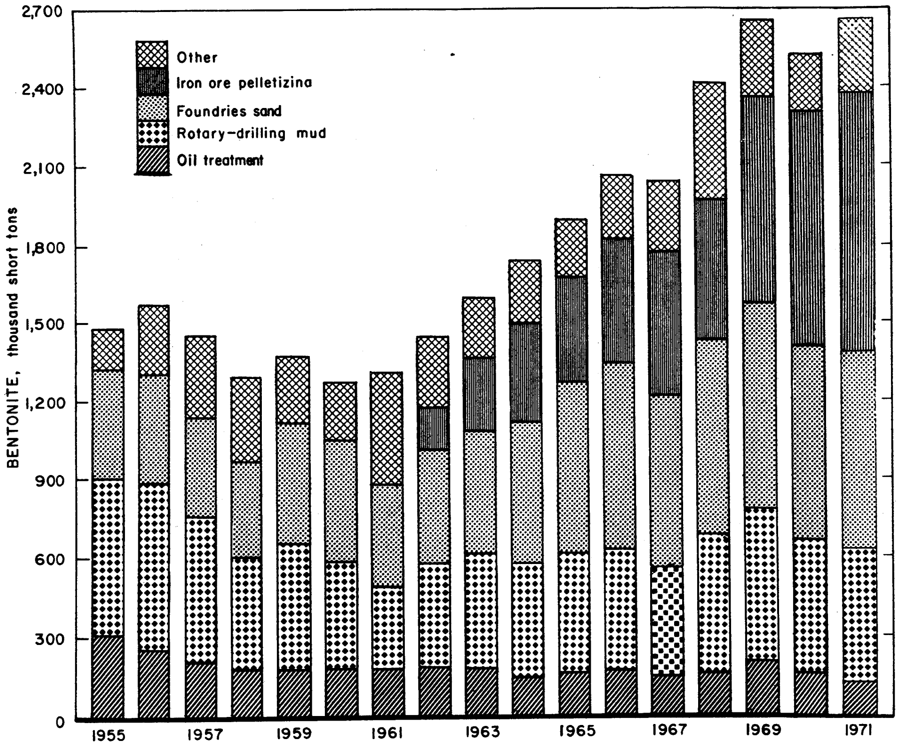

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

Table 8.—Bentonite sold or used by producers in the United States, by State

(Short tons)

State	1970 Quantity	1970 Value	1971 Quantity	1971 Value
California	W	W	33,932	$1,047,583
Colorado	W	W	1,548	7,742
Mississippi	261,949	$3,123,862	280,635	3,396,447
Missouri	--	--	42,503	W
Montana	W	W	228,624	1,663,732
Oregon	697	8,364	845	10,140
Texas	73,531	838,825	W	W
Utah	W	27,478	4,051	30,652
Wyoming	1,905,844	18,725,195	1,751,858	17,267,091
Other States [1]	290,824	2,790,223	321,763	4,468,428
Total	2,532,845	25,513,947	2,665,759	27,891,815

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

[1] Includes Alabama, Arizona, Idaho (1971), Nevada, Oklahoma, South Dakota, and data indicated by symbol W.

FULLER'S EARTH

Production of fuller's earth in 1971 increased 3 percent while the total value increased less than 1 percent. The unit value assigned by domestic producers decreased $0.66 in 1971 to $23.69 per ton. This decrease in value was due primarily to the low values reported by Georgia producers. Florida producers reported modest increases in unit value.

Fuller's earth production was reported from operations in eight States. The top two producing States, Florida (43 percent) and Georgia (34 percent) accounted for 77 percent of the domestic production. The other six States accounted for the remaining 23 percent. Florida, Georgia, Mississippi, and Texas showed gains in production while Illinois, Tennessee, and Utah declined. California reported production in 1971 and Missouri production ceased.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate decolorizing and purifying properties.

Production from the region that includes Attapulgus (Decatur County), Ga., and Quincy (Gadsden County), Fla., is composed predominantly of the distinct lath-shaped montmorillonite clay mineral attapulgite. Most of the fuller's earth produced in the other areas of the United States contain varieties of montmorillonite.

Prices for fuller's earth were not publicly quoted in 1971, but the per-ton values reported by producers ranged from $14 to about $29. The average was $23.69, compared with $24.35 in 1970.

During 1971 the Georgia-Tennessee Mining and Chemical Co., Wrens, Ga., in response to a drastic jump in natural gas prices and interrupted service, installed a 2- to 3-million-gallon-per-year waste oil refinery. The company had partially converted to an oil-burning kiln operation and was considering plans for expanding their present refinery to a capacity of 5 to 6 million gallons per year. Total conversion to an oil-burning operation was planned. The Oil Dri Corp. of America put a new facility, operated by its Cairo Production Co., Inc. subsidiary, near Cairo, Ga., on-stream.

Exports of fuller's earth to 37 countries, decreased from 37,000 short tons in 1970 to 27,000 tons valued at $1.2 million in 1971. Export tonnage decreased 27 percent and its value declined nearly 25 percent. The unit value of exported fuller's earth rose nearly $1.40 per ton. The major recipients were Canada, 37 percent; United Kingdom, 19 percent; and other countries, the remaining 44 percent.

Imports of fuller's earth in 1971 were 35 short tons valued at $2,000 all from the United Kingdom. Imports declined nearly 53 percent.

COMMON CLAY

The domestic production of common clay and shale in 1971 totaled 44.8 million short tons valued at $68.2 million. Common clay and shale represented 79 percent of the quantity and 25 percent of the value of all the clay and shale produced domestically in 1971. In addition, Puerto Rican production was reported at 341,726 tons valued at $358,449. Domestic output in 1971 increased 13 percent over that reported for 1970.

Common clays and shales are for the most part used by the producer in fabricating or manufacturing a product. Less than 9 percent 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 1971 was $1.52 per short ton, $0.05 more than in the previous year. 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 claylike material which is sufficiently plastic to permit ready molding and vitrification below 1,100° C. Shale is a consolidated sedimentary rock composed chiefly of clay minerals which has been both laminated and indurated during burying 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.

During 1971 Marblehead Lime Co., a subsidiary of General Dynamics, built a second kiln at its Powell and Minnock shale pit in Ravena, N.Y. The new kiln was a part of their planned twofold increase in lightweight aggregate production capacity. The Shalite Corp. near Knoxville, Tenn., was also constructing a second sintering machine to eventually permit them to double their capacity for producing lightweight aggregates. Bay Prairie Aggre-

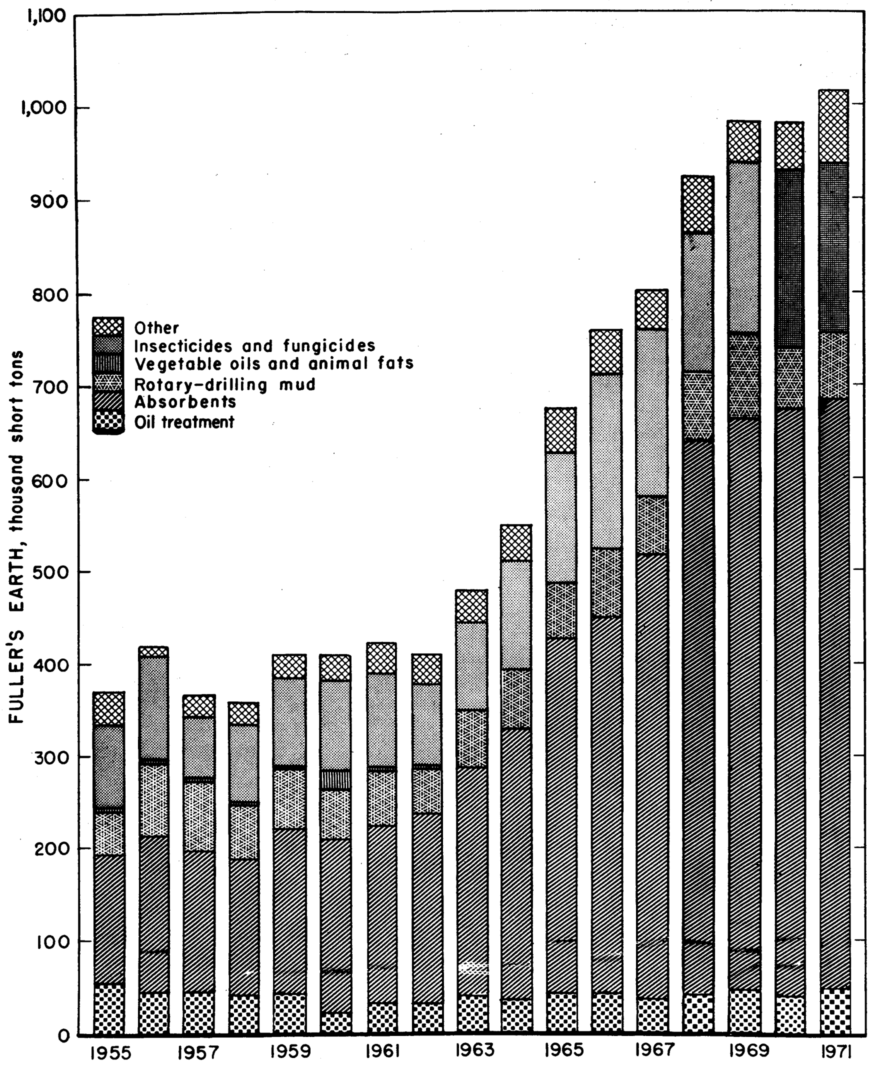

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

Table 9.—Fuller's earth sold or used by producers in the United States, by State

(Short tons)

State	1970		1971	
	Quantity	Value	Quantity	Value
Florida	422,150	$11,656,763	432,689	$12,220,273
Georgia	334,426	7,674,542	348,043	7,729,590
Utah	2,586	46,639	2,580	50,591
Other States [1]	222,728	4,529,093	230,602	4,019,162
Total	981,890	23,907,037	1,013,914	24,019,616

[1] Includes California (1971), Illinois, Mississippi, Missouri (1970), Tennessee, and Texas.

Table 10.—Common clay and shale sold or used by producers in the United States, by State [1]

(Short tons)

State	1970		1971	
	Quantity	Value	Quantity	Value
Alabama	2,045,619	$2,779,859	2,550,806	$3,529,777
Arizona	W	W	119,003	83,048
Arkansas	811,904	1,062,680	936,048	1,499,500
California	2,396,726	4,820,623	2,702,046	5,419,459
Colorado	397,811	552,412	581,174	1,084,672
Connecticut	170,503	385,849	174,165	322,069
Delaware	11,000	11,000	13,918	8,351
Georgia	1,600,585	2,196,192	1,760,374	2,502,695
Hawaii	2,500	11,250	W	W
Idaho	13,240	28,200	W	W
Illinois	1,493,746	2,358,587	1,621,661	2,675,409
Indiana	1,259,495	1,936,432	1,324,294	2,302,673
Iowa	1,181,469	1,823,011	1,027,654	1,702,207
Kansas	712,919	945,755	879,426	1,151,078
Kentucky	860,330	876,534	843,411	844,071
Louisiana	1,079,658	1,574,676	1,073,417	1,606,173
Maine	41,060	55,430	42,180	56,077
Maryland	1,128,826	1,432,799	1,024,989	1,558,148
Massachusetts	284,379	582,438	185,732	376,883
Michigan	2,479,777	2,886,622	2,457,593	3,365,678
Minnesota	227,354	334,975	223,144	334,717
Mississippi	973,679	1,007,908	1,860,323	2,138,984
Missouri	1,201,130	1,625,521	1,439,738	2,558,227
Montana	40,726	71,439	34,898	48,567
Nebraska	90,457	147,147	69,401	82,358
New Hampshire	40,375	31,700	36,725	33,812
New Jersey	W	471,640	134,377	391,783
New York	1,707,361	1,897,374	1,588,012	1,742,467
North Carolina	3,317,781	3,101,514	3,502,879	3,801,769
Ohio	2,030,819	4,045,059	3,054,644	5,589,308
Oklahoma	768,608	1,115,741	844,617	1,254,585
Oregon	133,605	172,035	155,922	240,177
Pennsylvania	1,455,538	5,301,090	1,766,279	4,767,603
Puerto Rico	428,885	486,285	341,726	358,449
South Carolina	1,454,675	1,866,784	1,599,291	2,247,204
South Dakota	W	W	150,071	127,589
Tennessee	990,581	1,461,404	1,159,550	1,139,170
Texas	3,549,687	4,945,263	4,374,219	7,097,936
Virginia	1,633,461	1,672,493	1,709,859	1,799,879
Washington	240,310	436,452	255,203	548,547
West Virginia	190,550	238,052	232,178	335,565
Wisconsin	7,576	14,120	4,025	7,645
Wyoming	43,747	103,510	45,696	110,438
Other States [2]	1,174,739	1,339,705	894,550	1,393,148
Total [3]	39,673,191	58,207,560	44,795,218	68,237,895

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Puerto Rico.
[2] Includes Florida, Nevada New Mexico, North Dakota, Utah, Vermont (1970), and data indicated by symbol W.
[3] Sold by producers 1,375,178 short tons (1970), and 3,843,890 short tons (1971).

gate Corp. announced completion of their expansion program to their present 700-yard-per-day capacity.

Sun Valle Tile Kilns opened a second plant, equipped with both tunnel and shuttle kilns, in Corona, Calif. The new facility will permit Sun Valle to expand its product line in addition to increasing their production of mission, barrel and one-piece mission tiles. Marion Brick Corp., Marion, Ohio, was acquired by the Wallace-Murray Corp. Marion Brick manufactures decorative face brick.

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 material.

CONSUMPTION AND USES

The manufacturing of heavy clay products (building brick, sewer pipe, drain tile), portland cement and clinker, and lightweight aggregate accounted for 40 percent, 20 percent, and 18 percent, respectively, of the total 1971 domestic consumption of clays. In summary, 78 percent of all clay produced in 1971 was consumed in the manufacture of these clay- and shale-based construction materials. The above clay tonnage relationships were similar to those reported for 1970. The utilization of clays in 1971 for heavy clay products and portland cement increased 10 percent and 4 percent, respectively, over that reported in 1970. This increased clay consumption in building products reflected the general increase in construction activity.

Heavy Clay Products.—The values reported for shipments of heavy clay products in 1971 rose by 16 percent to $642 million from the 1970 value of $554 million. The trends in corresponding quantities were less consistent. Thousand-unit counts for building brick, floor and wall tile, and the tonnage of vitrified sewer pipe increased 17 percent, 10 percent, and 6 percent respectively, over that shipped in 1970. Shipments in 1971 of unglazed structural tile and facing tile showed decreases in quantities ranging from 9 percent to over 50 percent compared with those figures listed for 1970.

Lightweight Aggregate.—Consumption of clay and shale in the making of lightweight aggregate increased in 1971 to an alltime high of 10,184,049 short tons. The total clay and shale consumed in 1971 for aggregate production increased 6 percent over the 9.6 million short tons used in 1970.

The tonnage of raw material mentioned in table 11 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 1971, a total of 824,787 short tons of slate was expanded for lightweight aggregate, an increase of 10 percent over the estimated 1970 figure of 750,000 tons. In addition, the National Slag Association reported the amount of slag used as lightweight concrete aggregate and in block manufacture decreased 25 percent in 1971, from 1,829,000 short tons in 1970 to 1,377,000 tons.

Refractories.—All types of clay, with the exception of fuller's earth and common clay and shale, were used in manufacturing refractories. Fire clay and kaolin accounted for 84 percent and 12 percent of the total clays used for this purpose. Minor tonnages of ball clay (3 percent) and bentonite (1 percent) were also used, primarily as bonding agents.

The total tonnage used for refractories in 1971 declined from 9 percent in 1970 to 6 percent of the total clays produced. This decline in the use of clay-based refractories, a pattern set for a number of years, continues to reflect industry's growing divergence from these conventional-type refractories.

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.

A total of 6 percent of the clay produced in 1971 was used in filler applications. Kaolin accounted for 90 percent and fuller's earth for 7 percent of all the clay used for these purposes. The other clays accounted for the remaining 3 percent. The consumption of kaolin, except for paint which increased 14 percent, decreased in the amount used ranging from 2 percent to 58 percent. Kaolin used in paper filling and coating decreased 13 percent, in rubber 2 percent, in fertilizer 38 percent, and in insecticides 58 percent. Total quantity of fuller's earth used in insecticides and fungicides decreased 7 percent.

Absorbent Uses.—Absorbent uses for clays, 636,017 short tons, consumed slightly over 1 percent of the total 1971 clay production. Demand for absorbents in 1971 increased 12 percent over that reported for 1970. Fuller's earth was the principal clay used in absorbent application; bentonite was used to a lesser degree. Sixty-three percent of the entire fuller's earth output was consumed for these purposes. Demand for clays in animal litter, representing 44 percent of the 1971 absorbent demand, increased 18 percent over that reported for 1970. Demand for use in floor absorbents, chiefly to absorb hazardous oily substances, represented the remaining 56 percent of absorbent demand; this rose 8 percent above the 1970 figure.

Drilling Mud.—Demand for clays in rotary-drilling fluids declined 14 percent in 1971 from 676,000 short tons used in 1970 to 583,712 tons. Drilling muds consumed slightly more than 1 percent of the entire 1971 clay production. Swelling-type bentonite is the principal clay used in drilling mud mixes, although fuller's earth or the nonswelling bentonite is also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100 percent of total amount of clay used for this purpose. Small amounts of kaolin and ball clay were used in specialized formulations.

Floor and Wall Tile.—Kaolin, ball clay, common clay and shale, and fire clay, in order of demand, were used in manufacturing floor, wall, and quarry tile. This tile end-use category accounted for less than 1 percent of the total clay production in 1971. Demand in 1971, approximately 500,000 short tons, increased over 15 percent of that shown for 1970.

Pelletizing Iron Ore.—Bentonite is used as a binder in forming iron ore pellets prior to the blast furnace operation. Demand, following a general trend for several years, increased in 1971 to an alltime high of 992,809 short tons. This new high includes 218,337 tons of bentonite exported which was also used in pelletizing iron ores. Of the total bentonite produced, about 37 percent of the swelling variety was consumed for this purpose. United States deposits are currently the major source for swelling bentonites.

Pottery.—The total demand for clays in the manufacture of pottery, whiteware, and related products, excluding clay flower pots, accounted for less than 1 percent of the total 1971 clay output. The total clay demand, principally ball and kaolin clays, rose in 1971 about 1 percent from 584,000 short tons in 1970 to 591,167 tons.

WORLD REVIEW

Argentina.—A new blast furnace complex was under construction at the San Nicolás steelworks, in Buenos Aires Province. The firm of Sociedad Mixta Siderúrgia Argentina has contracted with Chas. Taylor & Sons Co., the NL Industries subsidiary, to supply the new plant with high-alumina refractories worth in excess of $1 million. Gr-Stein Refractories of the United Kingdom won an additional contract to supply another $1.5 million in refractory linings.[2]

Australia.—Petromin NL and King Mountain Mining NL have been proving out their kaolin discoveries in Western Australia. The Petromin deposit, near Norseman, was reported to have reserves of 20 million tons. The average thickness of the kaolin deposit was 70 feet with about 20 feet of overburden. Initial tests indicated that the clay was suitable for ceramics and refractories. Further tests were planned to determine its suitability for paper filling or coating.

The King Mountain deposit, near Perth, was reported to contain about 12 million tons of kaolin reserves. Tests were underway to determine the quality of the clay.[3]

Pacific Mining Ltd. completed drilling their kaolin deposit in Dunnstown, Victoria. Both the ore body and basalt capping were reportedly delineated.[4]

Belgium.—Chas. Taylor Sons, S.A., announced plans to build their first European plant at Langerbrugge. Startup was expected in early 1972. The principal products will be refractory cements, moldables, castables, patches, and ramming mixtures for use in both induction and conventional melting furnaces by the metal, glass, and chemical processing industries.[5]

Canada.—Indusmin Ltd. continued exploratory work on their sodium bentonite deposits at Avonlea in Saskatchewan. The company was scheduled to determine in 1972, after completion of work, whether or not to proceed with an initial 100,000-ton-per-year-capacity plant. The bentonite is intended for use in iron ore pelletizing and foundry applications.[6]

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[2] Industrial Minerals. No. 49, October 1971, p. 56.
[3] Industrial Minerals. No. 48, September 1971, p. 33.
[4] Industrial Minerals. No. 42, February 1971, p. 53.
[5] Industrial Minerals. No. 47, August 1971, p. 24.
[6] The Northern Miner. Aug. 5, 1971, p. 17.

Table 11.—Clay sold or used as reported by producers in the United States in 1971, 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)	54,332	--	[3] 54,332
Alum, aluminum phosphate, and other chemicals	--	(4)	116	19,200	(4)	129,973	7,178	156,467
Animal feed	--	90,349	--	--	242	25,809	--	116,400
Animal litter	--	(2)	--	--	281,549	--	--	[3] 281,549
Building brick	--	(2)	19,614,820	--	--	--	--	[3] 19,614,820
Catalysts (oil refining)	(4)	(4)	--	--	(4)	55,323	5,038	60,361
Cement, portland	--	(2)	11,621,895	--	--	68,783	--	[3] 11,690,678
Drain tile	--	--	664,368	--	--	--	--	664,368
Drilling mud	(2)	512,275	--	--	71,047	(2)	--	583,322
Enamel, glazes, and glass	--	--	--	--	--	9,415	--	9,415
Fertilizer	--	2,672	--	--	51,252	58,412	--	112,336
Fiberglass	--	--	--	--	--	125,349	--	125,349
Filtering, clarifying, and decolorizing	--	122,878	--	--	47,737	--	--	170,615
Firebrick and block	(4)	(4)	--	2,355,868	--	431,633	110,837	[3] 2,898,338
Floor absorbents	--	(2)	--	--	354,468	--	--	[3] 354,468
Floor, wall, and quarry tile	136,440	--	82,878	(2)	--	279,453	--	[3] 498,771
Flower pots	--	--	59,772	--	--	--	--	59,772
Flue linings	--	--	57,993	--	--	--	--	57,993
Foundry sand	--	753,663	--	448,712	--	--	--	1,202,375
Gypsum products	--	(4)	--	--	(4)	11,928	660	12,588
Insecticides and fungicides	(2)	4,563	--	--	180,769	14,977	--	200,309
Lightweight aggregate	--	--	10,227,249	--	(2)	--	--	[3] 10,227,249
Mortar and cement, refractory	(2)	--	--	58,491	--	--	--	[3] 58,491
Oil well sealing	--	5,242	--	--	--	1,284	--	6,526
Paint	--	(4)	(4)	--	(4)	122,439	4,165	126,604
Paper coating	--	--	--	--	(2)	1,370,568	--	[3] 1,370,568
Paper filling	(4)	(4)	--	--	--	822,634	14,460	837,094
Pelletizing(iron ore)	--	774,472	--	--	--	--	--	774,472
Plastics	--	(4)	(4)	--	--	79,300	303	79,603
Roadstone	--	--	79,795	--	--	--	--	79,795
Roofing tile	--	--	45,576	--	--	--	--	45,576
Rubber	(2)	--	--	--	--	361,819	--	[3] 361,819
Sewer pipe, vitrified	--	--	2,165,254	5,000	--	--	--	2,170,254
Structural tile	--	--	81,097	--	--	--	--	81,097
Water sealing and waterproofing	--	120,696	--	--	--	--	--	120,696
Whiteware	324,570	--	--	--	--	215,853	--	540,423
Other:								
Filler	(4)	968	(4)	--	--	20,399	3,239	24,606
Heavy clay products	--	--	91,651	--	--	--	--	91,651
Pottery	16,814	--	--	15,821	--	18,109	--	50,744
Refractory	35,320	--	--	127,188	--	523	--	163,031
Miscellaneous	9,001	4,320	--	13,951	1,538	46,506	--	75,316
Undistributed [1]	80,479	55,324	2,754	--	25,312	--	--	--
Exports	(4)	[5] 218,337	--	(2)	(4)	561,372	17,989	[3] 797,698
Grand total	602,624	2,665,759	44,795,218	3,044,231	1,013,914	4,886,193	--	57,007,939

[1] Total of clays indicated by (4).
[2] Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[3] Incomplete figure; remainder included with "Miscellaneous."
[4] Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[5] For iron ore pelletizing.

Table 12.—Shipments of refractories in the United States, by kind

Product	Unit of quantity	Shipments			
		1970		1971	
		Quantity	Value (thousands)	Quantity	Value (thousands)
CLAY REFRACTORIES					
Fire clay (including semisilica) brick and shapes, except superduty.	1,000 9-inch equivalent	224,857	$51,078	209,900	$46,916
Superduty fire clay brick and shapes	do	78,177	27,867	60,930	22,060
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	66,416	40,673	61,872	39,244
Insulating firebrick and shapes	do	55,285	17,368	41,452	13,320
Ladle brick	do	193,567	28,130	178,883	26,550
Sleeves, nozzles, runner brick and tuyeres	do	49,873	15,803	43,510	14,743

Table 12.—Shipments of refractories in the United States, by kind—Continued

Product	Unit of quantity	Shipments 1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Clay Refractories—Continued					
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks.[1 2]					
Hot-top refractories	Short tons	29,717	2,352	23,261	1,914
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.		NA	9,060	NA	9,686
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short tons	69,507	9,681	62,408	9,675
Refractory bonding mortars, except air-setting types.[3]	do	12,106	1,529	8,817	1,162
Plastic refractories and ramming mixes.[3]	do	170,624	15,579	159,648	15,196
Castable refractories (hydraulic-setting)	do	178,987	21,766	173,068	20,733
Insulating castable refractories (hydraulic setting)	do	44,576	6,819	42,716	6,510
Other clay refractory materials sold in lump or ground form.[4 5]	do	330,835	8,679	310,294	8,854
Total clay refractories		XX	256,384	XX	236,563
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent	45,395	15,251	33,637	12,147
Magnesite and magnesite-chrome brick and shapes (magnesite predominating) (excluding molten cast and fused magnesia.)	do	92,912	108,126	77,039	93,572
Chrome and chrome-magnesite brick and shapes (chrome predominating) (excluding molten-cast).	do	16,850	17,831	15,153	16,703
Graphite crucibles, retorts, stopper heads, and other shaped refractories containing natural graphite.	Short tons	15,957	14,732	14,823	14,323
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten-cast).	1,000 9-inch equivalent	6,106	10,879	5,839	9,821
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten-cast).	do	3,171	9,207	3,006	9,299
Silicon carbide brick and shapes made predominantly of silicon carbide (including kiln furniture).	do	3,589	13,745	3,410	13,472
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	1,788	6,614	1,953	6,914
Forsterite, pyrophyllite, molten-cast, dolomite, dolomite-magnesite, and other nonclay brick and shapes including carbon refractories except those containing natural graphite.	do	25,032	49,323	27,281	48,202
Mortars:					
Basic bonding mortars (magnesite or chrome ore predominating).	Short tons	90,283	8,803	94,774	9,782
Other nonclay refractory mortars	do	25,282	4,888	30,347	6,097
Nonclay refractory castables (hydraulic-setting)	do	41,769	10,358	40,995	10,235
Plastic refractories and ramming mixes (wet and dry types):					
Basic (magnesite, dolomite, or chrome ore predominating).	do	147,321	23,014	121,214	17,822
Other nonclay plastic refractories and ramming mixes	do	73,004	15,614	73,883	16,370
Dead-burned magnesia or magnesite	do	159,883	12,571	102,270	8,511
Nonclay gunning mixes	do	219,580	24,440	193,667	25,973
Other nonclay refractory materials sold in lump or ground form.[4]	do	255,141	9,580	213,676	7,993
Total nonclay refractories		XX	354,976	XX	327,236
Grand total refractories		XX	611,360	XX	563,799

NA Not available. XX Not applicable.

[1] Excludes data for mullite and extra-high alumina refractories. These products are included with mullite and extra-high alumina brick and shapes in the nonclay refractories section.

[2] Now included with fireclay (including semisilica) brick and shapes, except superduty.

[3] Includes data for bonding mortars which contain up to 60 percent Al_2O_3, dry basis. Bonding mortars which contain more than 60 percent Al_2O_3, dry basis, are included in the nonclay refractories section.

[4] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractories producers for the manufacture of brick and other refractories.

[5] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.

Table 13.—Shipments of principal structural clay products in the United States

Product	1967	1968	1969	1970	1971
Unglazed brick (building) 1,000 standard brick	7,117,353	7,556,809	7,289,669	6,495,995	7,569,726
Value thousands	$285,630	$318,365	$318,892	$287,131	$346,390
Unglazed structural tile short tons	234,517	191,067	241,509	r 181,046	156,981
Value thousands	$4,900	$4,169	$6,875	r $5,903	$4,432
Vitrified clay sewer pipe and fittings short tons	1,572,167	1,705,528	1,783,546	1,622,339	1,720,597
Value thousands	$97,330	$109,465	$120,420	$119,048	$133,067
Facing tile, ceramic glazed, including glazed brick 1,000-brick equivalent	230,064	211,223	200,074	167,070	152,536
Value thousands	$21,274	$19,708	$19,188	$15,661	$14,904
Facing tile, unglazed & salt glazed 1,000-tile, 8- by- 5 by 12-inch, equivalent	3,352	3,032	2,965	1,915	950
Value thousands	$837	$750	$729	$469	$129
Clay floor and wall tile and accessories, including quarry tile 1,000 square feet	257,532	274,512	284,780	250,405	276,112
Value thousands	$128,139	$138,319	$142,878	$126,219	$142,645
Total value thousands	$538,110	$590,776	$608,982	r $554,431	$641,567

r Revised.

Table 14.—U.S. exports of clay by country and class in 1971

(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	93	$1,999	3	$149	1	$31	1	$60	(1)	$3	13	$584	111	$2,826
Brazil	10	414	1	33	(1)	13	3	356	(1)	21	7	414	21	1,251
Canada	355	5,712	79	890	10	435	149	4,385	51	939	79	2,595	723	14,956
Finland	6	203	(1)	6	--	--	3	125	--	--	1	54	10	388
France	7	295	1	115	2	99	19	847	(1)	1	17	1,049	46	2,406
Germany, West	63	1,583	1	126	2	86	160	5,911	--	--	23	904	249	8,610
Italy	2	163	3	153	2	60	150	5,690	(1)	2	15	978	172	7,046
Japan	3	536	8	617	(1)	9	83	4,598	(1)	12	79	3,554	173	9,326
Mexico	1	63	54	853	(1)	9	26	1,014	20	356	20	346	121	2,641
Netherlands	20	591	1	55	2	73	26	847	(1)	1	20	960	69	2,527
Sweden	(1)	68	(1)	2	(1)	2	10	456	(1)	4	2	76	12	608
United Kingdom	48	1,623	6	217	5	164	1	37	(1)	8	9	707	69	2,756
Venezuela	13	420	1	24	(1)	10	10	470	1	23	3	137	28	1,084
Other	42	2,528	4	326	3	187	32	1,329	5	135	83	4,399	169	8,904
Total	663	16,198	162	3,566	27	1,178	673	26,125	77	1,505	371	16,757	1,973	65,329

[1] Less than ½ unit.

Table 15.—U.S. exports of kaolin as reported by producers in 1971, by use

(Short tons)

Paper coating	388,984
Paper filling	50,492
Rubber	49,806
Other [1]	72,090
Total	561,372

[1] Includes firebrick and block, paint, plastics, and other uses.

Table 16.—U.S. imports for consumption of clay in 1971

(Short tons and thousand dollars)

Kind	Quantity	Value
China clay or kaolin, whether or not beneficiated:		
Canada	347	$19
Germany, West	1,628	22
Japan	62	12
New Zealand	7	1
United Kingdom	42,578	853
Total	44,622	907
Fuller's earth: United Kingdom	35	2
Bentonite: Italy	66	3
Common blue and other ball clay, not beneficiated:		
Germany, West	1,626	24
United Kingdom	10,355	165
Total	11,981	189
Common blue clay or ball clay, wholly or partly beneficiated:		
Argentina	447	30
United Kingdom	3,420	106
Total	3,867	136
Clays, n.e.c. not beneficiated:		
Canada	21	1
Germany, West	11	1
Total	32	2
Clays, n.e.c. wholly or partly beneficiated:		
Canada	54	5
Germany, West	158	11
United Kingdom	907	55
Total	1,119	71
Clays artificially activated with acid:		
Canada	1,240	60
France	(1)	(1)
Germany, West	427	40
Japan	319	64
Mexico	318	23
United Kingdom	23	4
Total	2,327	191
Grand total	64,049	1,501

[1] Less than ½ unit.

Greece.—Ideal-Standard, a subsidiary of American Standard of New York, revealed plans for a $2.5 million facility to produce white refractory materials, adjacent to their Athenian sanitaryware plant. The new plant is scheduled to begin operating in early 1973 with an initial production capacity of 18,000 metric tons per year. The domestic market for refractories was placed at about 40,000 metric tons annually and is growing at 12 percent per year. Consumption of domestic and imported materials was planned.

Guyana.—The Japanese have agreed to participate in a joint venture to exploit known kaolin deposits. The entire planned production of 300 tons a month was scheduled for export to Japan.

Ireland.—The Ministry of Commerce granted an exploration license to English China Clays for ball clay prospecting, over a 7 square mile area of County Tyrone.[7]

Iran.—The Geological Survey of Iran announced the location of a kaolin deposit at Dopolain in the Zagros, West of Esfahan. Pilot-scale tests by a local company have succeeded in producing a refractory brick acceptable to the National Iranian Steel Co. (NISC). The NISC was reported to require 35,000 tons of high-alumina clay annually.

Italy.—Construction of a new bentonite and barite plant at the port of San Antioco in Sardinia was announced by Industria Chemica Carlo Laviosa SpA. The planned 200,000 tons per year of bentonite

[7] Industrial Minerals. No. 48, September 1971, p. 46.

were scheduled for export, mainly for use in iron ore pelletizing.[8]

Netherlands.—Sphinx-Ceramique and Mosa the two largest domestic porcelain and earthenware manufacturers, announced merger plans.

Poland.—The Government announced setting up a ceramic industry with an accompanying scientific and research center near Bokeslawiec in the southwest near the Neisse River. These plans resulted from a successful prospecting program during which several large and high quality kaolin deposits were discovered. The domestic ceramic industry was expected to require 30,000 metric tons of kaolin initially.[9]

South Africa, Republic of.—A bricklaying machine was developed requiring only one operator and a few unskilled laborers. A prototype machine laid over 2,000 bricks per hour. The machine was capable of remote control and laying brick within a framework. Vertical alignment was automatic for walls up to 3 meters high.[10]

Thailand.—A Thai-Japanese venture to export 4,000 tons per year of kaolinite from Nong Kae in Saraburi Province to Japan has been announced. Thailand's Industrial Finance Corp. advanced 148 million yen for constructing a new plant by Thai Refractories Co. Ltd.[11]

United Kingdom.—English Clays Lovering Pochin and Co. Ltd. (ECLP) applied for permission to extend their operations at Lee Moor on the southwest fringe of the Dartmoor National Park and installed a new kiln at Parkandillick in Cornwall.[12] ECLP maintained that production of china clay at Lee Moor, about 400,000 tons per year, was insufficient to meet the expected demand by 1974, 625,000 tons.[13]

Their new kiln was reported to double the production capacity of Molochite to 80,000 tons per year. Molochite is a trade name for a refractory aggregate produced from selected china clay. Production of Molochite for 1970 was reported to be 20 percent above rated capacity.

Cornish clay and mining interests joined to form Compagnie Miniere Pochin SA in Paris to examine and survey the distribution of local kaolin and other mineral deposits.[14]

TECHNOLOGY

Production of metallurgical-grade alumina from clays, shales, and schist by an acid technique was described in a patent granted to Cie. Pechiney.[15] The patent involves two-stage leaching and crystallization. Initially the ore is digested with hot sulfuric acid, and the iron, magnesium, and potassium sulfates are crystallized. Subsequent treatment with hydrochloric acid gives hydrated aluminum chloride, and the acid is distilled and recycled. The aluminum chloride is calcined to alumina. Yield rates were 90 percent of the aluminum present and 80 percent of the iron and magnesium, as oxide, and potassium as a sulfate. Another patent covering a method for the direct reduction of aluminum from clays was issued to the Applied Aluminum Research Corp., Westwego, La.[16] The method involves the blast furnacing of pelletized clays in the presence of carbon and manganese chloride at temperatures up to 1,400° C. The resulting aluminum trichloride and metallic manganese are further treated to produce molten aluminum, and gaseous manganese chloride is condensed and recycled to the blast furnace.

A British process for aluminum from coal mine waste shales was revealed.[17] The process appears to begin by furnace-reducing coal shale with carbon to yield an aluminum-ferro-silicon alloy which is then reacted with aluminum trichloride to form the subhalide. The subhalide is decomposed to metallic aluminum and the chloride is recycled.

[8] Industrial Minerals. No. 51, December 1971, pp. 31–32.
[9] Industrial Minerals. No. 44, May 1971, p. 48.
[10] Brick and Clay Record. V. 159, No. 5, November 1971, p. 7.
[11] Industrial Minerals. No. 48, September 1971, p. 45.
[12] The Quarry Managers' Journal. V. 55, No. 11, November 1971, p. 403.
[13] Industrial Minerals. No. 50, November 1971, pp. 20–21.
[14] Industrial Minerals. No. 47, August 1971, p. 48.
[15] Maurel, P., and P. Duhart. Process for the Acid Treatment of Aluminous Ores for the Recovery of Alumina. U.S. Patent 3,620,671, Nov. 16, 1971, British Pat. 1,250,178; Canadian Pat. 388,089.
[16] Toth, Charles. Process for Producing Aluminum. U.S. Pat. 3,615,359, Oct. 26, 1971.
[17] Chemical Engineering. Chementator. V. 78, No. 23, Oct. 18, 1971, p. 75.

Table 17.—Kaolin: World production, by country

(Thousand short tons)

Country [1]	1969	1970	1971 p
North America:			
Mexico	99	87	80
United States [2]	4,739	4,926	4,886
South America:			
Argentina	89	82	e 83
Chile	49	53	46
Colombia	97	102	106
Ecuador	r 1	1	e 1
Paraguay	(3)	1	1
Peru	2	2	e 2
Europe:			
Austria (marketable)	107	108	e 97
Belgium e	110	110	110
Bulgaria	134	140	e 143
Czechoslovakia	378	405	e 413
Denmark e	20	20	20
France [4]	r 471	e 463	e 463
Germany, West (marketable)	480	493	461
Greece	r 68	53	59
Hungary	66	79	e 80
Italy:			
Crude	r 125	113	100
Kaolinitic earth	r 18	11	e 10
Portugal	49	58	50
Romania e	55	55	55
Spain (marketable)	302	5 192	5 e 193
Sweden	32	e 33	e 33
U.S.S.R. e	2,000	2,000	2,100
United Kingdom	3,368	3,509	3,054
Africa:			
Angola	1	2	1
Arab Republic of Egypt (formerly United Arab Republic)	86	25	e 33
Ethiopia	14	12	11
Kenya	2	2	e 2
Malagasy Republic	e 1	1	2
Mozambique	1	2	e 2
Nigeria	1	1	(8)
South Africa, Republic of	37	41	43
Swaziland	2	2	2
Tanzania	1	1	1
Asia:			
Ceylon	3	2	3
Hong Kong	5	4	3
India:			
Salable crude	200	225	231
Processed	113	109	101
Indonesia (kaolin powder) e	3	10	11
Iran [6]	47	50	53
Japan	214	243	388
Korea, Republic of (South)	149	215	211
Malaysia	2	4	13
Pakistan	--	10	3
Taiwan [7]	12	e 11	e 11
Thailand	(8)	3	11
Vietnam, South e	1	1	1
Oceania:			
Australia [9]	72	99	e 100
New Zealand	11	13	22
Total	r 13,837	14,184	13,905

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, Brazil, People's Republic of China, East Germany, Israel, Lebanon, Southern Rhodesia, and Yugoslavia also produce kaolin but information is inadequate to make reliable estimates of output levels. In addition 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] Figure apparently represents marketed output, including some crude kaolin and some washed kaolin.

[6] Year beginning March 21 of that stated.

[7] Data given are for ceramic and pottery and paper filler clays; in 1969, reported quantities were ceramic and pottery 7,292 short tons and paper filler 4,960 short tons.

[8] Production unreported but small if any.

[9] Includes ball clay.

The U.S. kaolin industry reported several new products and processing advances during 1971. Freeport Kaolin Co. announced the development of the OX process for modifying the surface of kaolin products to make them more easily dispersible in organic systems. This increased affinity for hydrocarbons should increase the use of kaolin by the plastics industry.[18] J. M. Huber Corp. announced their new DFF clay. This new product was reported to be an airfloated filler clay offered in a unique physical form to permit ease in handling. Compared with normal clay, the clay was higher in bulk density and was dustless during loading and unloading and in plant use. A method for improving the brightness of beneficiated and unbeneficiated kaolin clay-water slurries by magnetically removing the remaining ilmenite and magnetite contaminated kaolin particles was also developed and put on stream by the J. M. Huber Corp. The new method involves subjecting the slurry, within a specified retention time, to a specially constructed high-intensity wet magnetic separator.[19]

Ansilex, a new kaolin-derived pigment for extending titanium dioxide in white printing papers, was introduced by Engelhard Minerals and Chemicals Corp. The product was reported to be low in cost and have unique brightness, and opacity-imparting properties. Anglo-American Clays Corp. offered its new Alphacote, a special high brightness paper coating clay. A detailed discussion of the formation of unreactive to reactive silane-modified kaolin pigments and their performance was published.[20] The silanes reportedly enter into crosslinking reactions with the host rubber matrices thereby becoming an integral part of the polymer system. This characteristic reportedly had opened up an entirely new approach to the field of high-performance compounding.

Comprehensive articles on the domestic kaolin industry and world wide china clays processing were published.[21] [22]

The article on the domestic kaolin industry surveyed the geology, mineralogy, production and uses of the Georgia and South Carolina clays. The other china clay paper stressed the separation technology practiced by the worldwide industry. Detailed processing flowsheets comparing the industries in the United States and the United Kingdom were included.

A detailed work discussing the major phases in developing a lightweight aggregate rotary kiln facility was presented. The emphasis in these articles was given to raw materials, plant design, selection of equipment and rotary kiln operation.[23] Research into the production of fine aggregates for high-strength, lightweight concrete was covered in a detailed paper. Lightweight aggregates expanded from montmorillonite-shale mixtures were found to be superior in strength to their montmorillonite-clay counterparts.[24]

The effects of composition, water content, porosity and microstructure on the traverse strength of ball clay containing 0 to 50 weight-percent of ground quartz (potter's flint) were published.[25] The modulus of rupture of the test extruded cylinders of the kaolinite-mica clay showed that the green strength of cylinders decreased with increasing quartz and water content due to increased porosity.

The results of the preliminary factors affecting the use of over 300 sampled sites of Pennsylvania clay and shales were reported.[26] The paper not only stressed their potential use but also lithology, physical and fired properties, and major element chemical and quantitative five-component X-ray mineralogical analyses. Test data indicated that nearly 80 percent of the samples evaluated were potentially useful in medium to superduty refractories and lightweight aggregates.

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[18] Chemical Engineering. Chementator. V. 78, No. 19, Aug. 23, 1971, p. 27.

[19] Iannicelli, J., N. Millman, and W. J. D. Stone. Process for Improving the Brightness of Clays. U.S. Pat. 3,471,011, Oct. 17, 1971.

[20] Grillo, T. A. Silane-Modified Kaolin Pigments. Rubber Age, v. 103, No. 8, August 1971, pp. 37–42.

[21] Industrial Minerals. No. 51, December 1971, p. 9.

[22] Ward, A. S. China Clay Processing. Filtration and Separation Jour., Croydon, England, May/June 1971, pp. 283–288.

[23] Reedy, R. W. Lightweight Aggregates. Part I—Raw Materials. Pit and Quarry, v. 63, No. 7, January 1971, pp. 111–118; Part II—Plant Design, v. 63, No. 10, April 1971, pp. 108–112; Part III—Selection of Equipment, v. 64, No. 2, August 1971, pp. 87–91; Part IV—Rotary Kiln Operation, v. 64, No. 5, November 1971, pp. 103–106.

[24] Kolarova, M. Research into Production of Lightweight Fine Aggregates Based on Clayey Raw Materials. Building Science Abstracts, v. 45, No. 1, January 1972, Item 72–16001.

[25] Kennard, F. L., III, and W. O. Williamson. Transverse Strength of Ball Clay. Bull. Am. Ceram. Soc. v. 50, No. 9, September 1971, pp. 745–748.

[26] Lapham, D. M., and K. V. Hoover. Preliminary Evaluation of the Factors Affecting the Use Potential of Clays and Shales in Pennsylvania. Soc. Mining Eng. Trans. AIME, v. 25, December 1971, pp. 292–295.

Detailed geologic and laboratory studies of 31 montmorillonite, bentonite, and fuller's earth deposits were included in a Nevada State publication.[27] Each deposit was individually described and categorized as to end use. Data on selected fundamental aspects and industrial uses for the fuller's earth minerals, palygorskite, attapulgite, pilolite, and lassalite, were added to the technical literature. The work discussed the nomenclature, structure, chemical composition and analyses, X-ray analysis, differential thermal analysis and dehydration data, electron microscopy, occurrence, and origin and distribution.[28]

Union Carbide announced the development of a series of zeolite molecular adsorption sieves that reportedly can expectively control emissions of sulfur oxide and nitrogen oxide off-gases to below proposed Federal ceilings. Total operating costs for sieve units were reported to be around $1 per ton of acid produced.[29]

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[27] Papke, K. G. Montmorillonite, Bentonite, and Fuller's Earth Deposits in Nevada. Nevada Bureau of Mines Bull. 76, Reno, Nev., 1970, 47 pp.

[28] Aneesuddin, M. The Clay Mineral Palygorskite. J. Mines, Metals and Fuels, v. 19, No. 6, June 1971, pp. 165–172.

[29] Chemical Engineering. Chementator. V. 78, No. 27, Nov. 29, 1971, pp. 18–19.

Coal—Bituminous and Lignite

By L. W. Westerstrom [1]

Production of bituminous coal and lignite declined from 602.9 million tons in 1970 to 552.2 million tons in 1971. This was due principally to the work stoppage from October 1 to November 14 pending the negotiation of a new wage agreement in the industry. The strike was the longest industry interruption since 1950.

The strike had little impact on coal consumption at electric utility plants since most plants had stocked heavily in anticipation of the stoppage. Utility stockpiles reached the highest level in recent years, equaling 108 days supply by October 1, 1971. This compared very favorably with a 1970 high point of 81 days average inventory. By the time full production was resumed in mid-November, 60 of 350 power plant stockpiles had reached critically low levels. However, there was no significant shortage of electricity or fuel during the 44-day strike. On the other hand, exports declined from 70.9 million tons to 56.6 million tons. Consumption of coal at oven-coke plants declined from 94.6 million tons to 81.5 million tons, and all other manufacturing and industrial plants consumed only 68.7 million tons in 1971, compared with 82.9 million tons in 1970.

In all major coal producing States, underground production declined. The total output of 275.9 million tons was nearly 63 million tons lower than that of 1970. Strip mining production, although curtailed by the contract strike in October and November, was 15 million tons higher than that of 1970. Although production from auger mining declined nearly 3 million tons, strip and auger production combined accounted for one-half of total production in 1971.

Few new underground mines were opened in 1971, and scores of existing deep mines were closed because of increased production costs of operating under regulations imposed by the Federal Coal Mine Health and Safety Act of 1969. The total number of deep mines declined from 2,939 in 1970 to 2,268 in 1971, and the number of strip mines increased from 2,103 to 2,290.

In transportation, the rail cost of transporting coal increased substantially. The Interstate Commerce Commission imposed an 8-percent freight rate increase per ton in November 1970, and in March 1971 granted the railroads an additional 6-percent increase in the rate they could charge. As a result, the average rail freight rate per ton of coal increased 29 cents in 1971.

This chapter includes all bituminous coal and lignite produced in the United States except California and Texas lignite and bituminous coal and lignite from mines that produced less than 1,000 tons per year. Approximately 2½ million tons of lignite were produced in Texas and about 25,000 tons in California. Details of the California and Texas mining operations are excluded from this survey in order that individual company operations are not revealed. All quantity figures represent net tons of marketable coal and exclude washery and other refuse. Statistics are final and are based upon detailed annual reports of production and mine operation furnished by producers. For production not directly reported (chiefly that of small mines), accurate data were obtained from the records of the various 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. Inclusion of many small mines that produce less than 1,000 tons per year was not attempted.

The monthly and weekly estimates of production, summarized in tables 4 and 9, are based upon railroad carloadings of coal reported daily and weekly by railroads, ship-

[1] Industry economist, Division of Fossil Fuels.

ments on the Allegheny and Monongahela Rivers reported by the U.S. Army Corps of Engineers, direct reports from mining companies, and monthly production statements compiled by certain local operators associations and State mine departments.

DISTRIBUTION AND SHIPMENTS

Shipments of bituminous coal and lignite, summarized by districts of origin, States of destination, type of consumer use, and by methods of transportation, show the participation of the bituminous coal and lignite industry in various local and national markets.

The distribution data by consumer use do not necessarily conform to the consumption data because the latter represent actual use at consumers' facilities, whereas the distribution data represent shipments from the mines, some of which were in transit or in consumers' storage.

Total shipments declined from 598.0 million tons in 1970 to 553.1 million tons in 1971. The largest decreases occurred in shipments overseas, to oven-coke plants, and to all other industrial markets. Receipts of coal by consumers in these categories were down 14.0, 15.8, and 13.5 million tons, respectively. Electric utilities, despite the 6-week work stoppage, increased their receipts by 2.3 million tons. Shipments to retail dealers were down 3.6 million tons. Miscellaneous items such as railroad fuel, mine fuel, Canadian and United States Great Lakes dock storage accounts, and net changes in mine inventory decreased 0.3 million tons.

The distribution data in tables 36–39 are based on reports submitted quarterly to the Bureau of Mines voluntarily by producers, sales agents, distributors, and wholesalers, who normally produce or sell 100,000 tons or more annually; the unprecedented cooperation of these respondents resulted in their reporting about 94 percent of all coal produced or shipped. To account for total industry shipments, estimates for the remaining shipments are included, based on data from coal trade and other reliable coal statistical reporting agencies.

Additional details of bituminous coal and lignite distribution for 1970 are presented in a Bureau of Mines report.[2]

FOREIGN TRADE

In 1971, the United States exported 56.6 million tons of coal, a decrease of 14.3 million tons from that of 1970. The drop in exports came as a result of lower demand abroad because of reduced requirements by the steel industry, rising coal prices, and an improvement in the world coking coal supply.

Japan maintained its position as the principal U.S. foreign market with a 34.8 percent share of total U.S. coal exports. Shipments of coal to Canada, Europe, and South America accounted for 31.5 percent, 28.9 percent, and 4.7 percent, respectively.

Although the United States was still the world's largest coal exporter in 1971 and exports are expected to grow, its share of the steadily expanding total international trade in coal is expected to decline as consuming countries seek to diversify sources of supply and as additional competitive new coal mining capacity comes into production. The larger world market and the search for increasingly diversified supplies at the lowest cost has led to expansion of consumer large bulk carrier shipping units, which also points to a more stable international coal trade in the future. The larger fluctuations in demand and the buying of surplus coals for the immediate future are probably destined to account for a progressively smaller share of the market as more large-scale, long-term coal contracts from assured suppliers come on stream during the balance of the decade.

WORLD REVIEW

World production of bituminous coal and lignite in 1971 is estimated at 3,110 million tons, an increase of only four-

[2] Bureau of Mines. Bituminous Coal and Lignite Distribution, Calendar Year 1971. Mineral Industry Survey, Apr. 10, 1972, 39 pp.

tenths of one percent over the previous year. Except for the sharp decline in U.S. coal production, production in most major coal producing countries was higher in 1971 compared with 1970.

In Europe, production increased from 1,764 million tons to 1,803 million tons. Production of bituminous coal and lignite in the U.S.S.R., the largest coal producing country in the world, was estimated at 615 million tons in 1971, an increase of 3.2 percent from the revised 1970 tonnage. Coal production in Asia increased 3.5 percent in 1971. Mainland China, the third largest coal producing country in the World, increased its production from 400 million tons in 1970 to 430 million tons in 1971.

TECHNOLOGY

Greater use was made of continuous miners in 1971. Nearly 56 percent of total underground production was achieved with these machines. A greater number of stationary rotary head units appeared in more powerful designs and contributed to new production records. Greater use was also made of battery-powered front-end loaders, which can load coal or haul men and supplies. In a new development, an ultrasmall front-end loader is being used in a clean-up and utility capacity. The unit is powered by a 15-horsepower electric motor, which receives power through a 500-foot trailing cable. The machine, because of its higher maneuverability, can get into corner and next to walls to pick up coal left by continuous miners.

During 1971, more mines were using bulk-handling techniques and pressurized systems for carrying and distributing rockdust. Most underground mining operations are finding that the use of trickle dusters is an effective means of insuring the incombustible content of return airways.

Continued efforts were expended in 1971 to improve methods of controlling dust and suppressing fires. A new foam generation method developed last year demonstrated its ability to suppress fires. The foam is thick and dry and its expansion reportedly lies between current low-and high-expansion types. A secondary use for this new foam is suppressing dust on beltlines and transfer points. Atomizing sprays (compressed air and water) have been tried and seem to offer promise for increased efficiency in dust suppression.

Emphasis in coal research by the Bureau of Mines in 1971 was placed on the production of clean-burning fuels from coal to help satisfy the rapidly expanding needs for energy while protecting the quality of the environment.

Design of a prototype plant to demonstrate the SYNTHANE coal gasification process was completed and plans were formulated for construction of the plant. The pilot plant will be capable of processing 70 tons of raw coal per day into pipeline-quality gas. In another approach to produce a high-Btu gas from coal, the Hydrane Process was further developed. This process offers potential advantages over other advanced coal gasification schemes since no pretreatment of coal and less process hydrogen are required, and over 90 percent of the product methane results from the direct reaction of hydrogen with the coal. Construction of a 10 pound-per-hour reactor was completed and testing of the Hydrane process begun. In related work to produce a clean-burning low-Btu gas suitable for industrial fuel, run-of-mine bituminous coal was successfully processed for the first time in the fixed-bed gasifier. The Bureau's gasifier employs a stirrer to break up coke formations, which permits caking coals to be handled. Historically, the preferred feed for fixed-bed gasifiers has been coal particles no smaller than 3/4 inch and no larger than 2 inches. In the new tests, run-of-mine coal containing up to 50 percent of particles smaller than ¼ inch was successfully gasified. These findings are significant since the preparation costs involved in sizing the coal would be reduced substantially, as would the ultimate cost of the product fuel gas.

Two promising processes for producing low-ash, low-sulfur oil from coal were further developed. In the one process a mixture of 30 percent coal and 70 percent coal-derived oil, together with hydrogen, is passed through a fixed bed of pelleted catalyst at 450° C and 2000 to 4000 pounds pressure under turbulent flow conditions. Coal containing over 3 percent sulfur is converted to a fuel oil of 0.3 percent sulfur. During the year, the laboratory reactor was operated continuously for the first time, with recycling of the vehicle oil and the unconsumed hydrogen. In the second process, coal was successfully liquefied by the action of carbon monoxide and water at about 400° C and 4000 pounds pressure. By proper selection of operating conditions conversions of near 90 percent were obtained using either lignite or high-volatile bituminous coal. Both sulfur and ash contents are reduced significantly. In a related study of organic waste, animal manure was successfully converted to a low-sulfur oil by treatment with carbon monoxide and steam.

The technology for gasifying coal in place was reassessed in a study completed by an independent engineering firm. The study requested by the Bureau of Mines concluded that underground gasification of coal is technically feasible, but that the economic viability in the United States needs to be determined. Valuable data on permeability of the coal bed and on the strata overlying coal beds were obtained by examination of cores supplied by a private coal company. The studies are aimed at learning whether up-to-date technology developed by the oil and gas industries is applicable in the preparation of underground coal gas generators.

In studies of the combustion process, the fate of trace element pollutants was determined. Contrary to most previous assumptions, not all the mercury in coal vaporizes up the stack when coal is burned. Fly ash samples taken from laboratory combustors (operated under controlled conditions) and several powerplants all contained mercury. The amount varied from 9 to 70 percent of the original mercury in the coal. In another study, related to the emission of nitrogen oxides from powerplants, tests showed that from 40 to 80 percent of the nitrogen in coal was converted to nitrogen oxides during combustion.

Wet-scrubbing tests were made to reduce the sulfur dioxide content of flue gas produced in an experimental 75-pound-per-hour furnace. Up to 70 percent of the sulfur dioxide in the flue gas was removed when high-alkaline fly ash was added to tap water used as the scrubbing medium.

The advantages of preheating coal before charging it to a coke oven was demonstrated in a cooperative study with a steel company. Preheating permitted reducing the amount of expensive low-volatile coal in the coking blend from 20 to 10 weight percent with essentially no change in coke quality, coking time was reduced by 20 percent, and liquor make was cut in half.

A feasibility study was made by an independent engineering firm of the Bureau's three stage combustion technique for producing a hot clean gas from coal for use in advanced power cycles such as MHD (Magneto Hydro Dynamics). As a result of a favorable review, the Bureau is proceeding with construction of a pilot facility to test the concept.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1967	1968	1969	1970	1971
Production ------- thousand short tons --	552,626	545,245	560,505	602,932	552,192
Value ------------------ thousands --	$2,555,378	$2,546,340	$2,795,509	$3,772,662	$3,904,562
Consumption ----- thousand short tons --	480,416	498,830	507,275	515,619	494,862
Stocks at end of year:					
Industrial consumers and retail yards ------------- do ----	93,128	85,525	80,482	92,275	89,985
Stocks on upper lake docks -- do ----	2,280	1,937	1,484	1,468	1,205
Exports [1] ------------------ do ----	49,528	50,637	56,234	70,944	56,633
Imports [1] ------------------ do ----	227	224	109	36	111
Price indicators, average per net ton:					
Cost of coking coal at merchant coke ovens ----------------	$10.33	$10.58	$10.75	$12.28	$15.32
Railroad freight charge [2] ----------	$3.00	$3.01	$3.10	$3.41	$3.70
Value f.o.b. mines (sold in open market) ----------------	$4.34	$4.38	$4.65	$5.89	$6.66
Value f.o.b. mines -------------	$4.62	$4.67	$4.99	$6.26	$7.07
Method of mining:					
Hand-loaded underground thousand short tons --	19,219	14,755	11,700	9,599	4,992
Mechanically loaded underground do ----	329,914	329,387	r 335,431	329,189	270,896
Percentage mechanically loaded ----	94.5	95.7	96.6	97.2	98.2
Percentage cut by machine --------	49.1	48.4	46.2	46.1	40.6
Mined by stripping thousand short tons --	187,134	185,836	197,023	244,117	258,972
Percentage mined by stripping -----	33.9	34.1	35.2	40.5	46.9
Mined at auger mines thousand short tons --	16,360	15,267	16,350	20,027	17,332
Percentage mined at auger mines ---	2.9	2.8	2.9	3.3	3.1
Mechanically cleaned thousand short tons --	349,402	340,923	334,761	323,452	271,401
Percentage mechanically cleaned -------	63.2	62.5	59.7	53.6	49.1
Number of mines -------------------	5,873	5,327	5,118	5,601	5,149
Capacity at 280 days thousand short tons --	707,000	694,000	694,000	740,000	NA
Average number of men working daily: [3]					
Underground mines --------------	107,432	102,940	99,269	107,808	NA
Strip mines --------------------	21,439	22,358	22,323	28,395	NA
Auger mines --------------------	2,652	2,596	2,940	3,937	NA
Total --------------------	131,523	127,894	124,532	140,140	NA
Average number of days worked: [3]					
Underground mines --------------	216	217	224	229	NA
Strip mines --------------------	248	243	247	236	NA
Auger mines --------------------	133	145	139	148	NA
Total --------------------	219	220	226	228	NA
Production per man per day:					
Underground mines ---- short tons --	15.07	15.40	15.61	13.75	NA
Strip mines -------------- do ----	35.17	34.24	35.71	35.96	NA
Auger mines -------------- do ----	46.48	40.46	39.88	34.26	NA
Total ---------------- do ----	19.17	19.37	19.90	18.84	NA

r Revised. NA Not available.
[1] Bureau of the Census, U.S. Department of Commerce.
[2] Interstate Commerce Commission.
[3] Based on data supplied by Accident Analysis Branch, U.S. Bureau of Mines.

Table 2.—Coal reserves of the United States, January 1, 1970, by State

(Million short tons)

State	Date of publication of estimate	Estimated original reserves: Bituminous coal	Estimated original reserves: Subbituminous coal	Estimated original reserves: Lignite	Estimated original reserves: Anthracite and semianthracite	Total	Reserves depleted to Jan. 1, 1970: Production [1]	Reserves depleted to Jan. 1, 1970: Production plus loss in mining [2]	Remaining reserves, Jan. 1, 1970	Recoverable reserves Jan. 1, 1970, assuming 50-percent recovery
Alabama	1958	[3] 13,754	--	20	--	13,774	[4] 167	334	13,440	6,720
Alaska	1967	19,429	[5] 110,696	([5])	--	130,125	20	40	130,085	65,042
Arkansas	1960	1,816	--	350	456	2,622	102	204	2,418	1,209
Colorado	1959	63,203	18,492	--	90	81,785	552	1,104	80,681	40,340
Georgia	1946	24	--	--	--	24	3	6	18	9
Illinois	1965	[6] 140,000	--	--	--	140,000	[4] 314	628	139,372	69,686
Indiana	1953	37,293	--	--	--	37,293	1,314	2,628	34,665	17,332
Iowa	1965	7,237	--	--	--	7,237	362	724	6,513	3,257
Kansas	1957	[7] 18,706	--	([8])	--	18,706	[4] 14	28	18,678	9,339
Kentucky	1963	72,318	--	--	--	72,318	3,494	6,988	65,330	32,665
Maryland	1967	[9] 1,200	--	--	--	1,200	[4] 18	36	1,164	582
Michigan	1950	297	--	--	--	297	46	92	205	103
Missouri	1967	23,977	--	--	--	23,977	319	638	23,339	11,670
Montana	1949	2,363	132,151	87,533	--	222,047	175	350	221,697	110,848
New Mexico	1950	10,948	50,801	--	6	61,755	149	298	61,457	30,729
North Carolina	1949	112	--	--	--	112	1	2	110	55
North Dakota	1953	--	--	350,910	--	350,910	128	256	350,654	175,327
Ohio	1960	46,488	--	--	--	46,488	2,457	4,914	41,574	20,787
Oklahoma	1957	3,673	--	([8])	--	3,673	191	382	3,291	1,645
Oregon	1965	50	--	--	--	50	4	8	42	21
Pennsylvania	B–1928 A–1945	75,093	290	--	22,805	98,188	14,358	28,716	69,472	34,736
South Dakota	1952	--	--	2,033	--	2,033	1	2	2,031	1,016
Tennessee	1959	[10] 2,748	--	--	--	2,748	[4] 71	142	2,606	1,303
Texas	B–1967 L–1955	6,100	--	7,070	--	13,170	128	256	12,914	6,457
Utah	1967	32,678	156	--	--	32,834	305	610	32,224	16,112
Virginia	1952	11,696	--	--	355	12,051	1,112	2,224	9,827	4,914
Washington	1960	1,869	4,194	117	5	6,185	1	2	6,183	3,091
West Virginia	1940	116,618	--	--	--	116,618	7,733	15,466	101,152	50,576
Wyoming	1950	13,235	[11] 108,319	([11])	--	121,554	434	868	120,686	60,343
Other States	1967	[12] 620	[13] 4,065	[14] 50	--	4,735	7	14	4,721	2,360
Total	--	723,545	429,164	448,083	23,717	1,624,509	[15] 33,980	67,960	1,556,549	778,274

[1] Production, 1800 through 1885, from "The First Century and a Quarter of American Coal Industry," by H. N. Eavenson, privately printed, Pittsburgh, 1942; production, 1886 through 1923, from U.S. Geological Survey Mineral Resources, annual volumes; production, 1924 through 1969, from Bureau of Mines, Minerals Yearbook, annual volumes, augmented for some States by records of State mine inspectors.
[2] Assuming past losses equal past production.
[3] Remaining reserves Jan. 1, 1958.

[4] Production from year that remaining reserves were estimated through 1969.
[5] Small resources and production of lignite included under subbituminous coal.
[6] Remaining reserves Jan. 1, 1965.
[7] Remaining reserves Jan. 1, 1957.
[8] Small reserves of lignite in beds generally less than 30 inches thick.
[9] Remaining reserves Jan. 1, 1950.
[10] Remaining reserves Jan. 1, 1959.
[11] Small reserves and production of lignite included under subbituminous coal.
[12] Arizona, California, Idaho, Nebraska, and Nevada.
[13] Arizona, California, and Idaho.
[14] California, Idaho, Louisiana, Mississippi, and Nevada.
[15] Less than total recorded cumulative production of about 38 billion tons. See footnotes 3, 4, 6, 7, 9, and 11.

Source: Averitt, Paul. Coal Resources of the United States, Jan. 1, 1967. Geological Survey Bulletin 1275, pp. 10–11.

Table 3.—Annual average unit heat value of bituminous coal and lignite produced and consumed in the United States, 1955–71 [1]

(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	r 14,820	r 12,290	r 515,619	r 12,488	r 12,110
1971	552,192	13,451	12,180	494,862	11,887	12,010

r Revised.

[1] Prior to 1971, the average heat content of the annual output of bituminous coal and lignite was measured at 13,100 Btu's 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 65 percent of total domestic coal consumption. The averages for United States 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 4.—Production of bituminous coal and lignite in the United States, with estimates by weeks

(Thousand short tons)

Week ended	Production 1970	Maximum number of working days	Average production per working day	Week ended	Production 1971	Maximum number of working days	Average production per working day
Jan. 3	2,735	[1] 2	[2] 1,368	Jan. 2	478	[1] 0.3	[2] 478
Jan. 10	9,382	6	1,564	Jan. 9	11,697	6	1,950
Jan. 17	11,550	6	1,925	Jan. 16	12,717	6	2,120
Jan. 24	10,853	6	1,809	Jan. 23	12,588	6	2,098
Jan. 31	12,165	6	2,028	Jan. 30	12,300	6	2,050
Feb. 7	11,096	6	1,849	Feb. 6	10,996	6	1,833
Feb. 14	11,885	6	1,981	Feb. 13	11,398	6	1,900
Feb. 21	11,722	6	r 1,954	Feb. 20	12,119	6	2,020
Feb. 28	12,375	6	2,063	Feb. 27	12,516	6	2,086
Mar. 7	11,562	6	1,927	Mar. 6	11,742	6	1,957
Mar. 14	12,125	6	2,021	Mar. 13	12,693	6	2,116
Mar. 21	12,285	6	2,048	Mar. 20	12,467	6	2,078
Mar. 28	12,250	6	2,042	Mar. 27	13,188	6	2,198
Apr. 4	10,746	5.3	r 2,028	Apr. 3	11,743	5.3	2,216
Apr. 11	12,195	6	2,033	Apr. 10	12,504	6	2,084
Apr. 18	11,650	6	1,942	Apr. 17	12,741	6	2,124
Apr. 25	11,795	6	r 1,966	Apr. 24	12,504	6	2,084
May 2	10,854	6	1,809	May 1	12,355	6	2,059
May 9	11,556	6	1,926	May 8	12,642	6	2,107
May 16	11,598	6	1,933	May 15	12,360	6	2,060
May 23	11,782	6	r 1,964	May 22	10,990	6	1,832
May 30	11,674	5.1	2,289	May 29	13,769	6	2,295
June 6	11,668	6	1,945	June 5	11,215	5.1	2,199
June 13	12,042	6	2,007	June 12	12,649	6	2,108
June 20	11,970	6	1,995	June 19	9,346	6	1,558
June 27	10,683	6	1,781	June 26	12,289	6	2,048
July 4	6,845	r 3.5	r 1,956	July 3	6,922	3.9	1,775
July 11	6,504	r 3.4	r 1,913	July 10	4,746	2.3	2,063
July 18	10,706	r 6	r 1,784	July 17	10,789	6	1,798
July 25	10,610	6	1,768	July 24	11,077	6	1,846
Aug. 1	10,616	6	1,769	July 31	9,802	6	1,634
Aug. 8	11,984	6	r 1,997	Aug. 7	11,560	6	1,927
Aug. 15	12,595	6	2,099	Aug. 14	13,214	6	2,202
Aug. 22	12,104	6	r 2,017	Aug. 21	13,184	6	2,197
Aug. 29	12,366	6	2,061	Aug. 28	13,229	6	2,205
Sept. 5	12,630	6	2,105	Sept. 4	13,506	6	2,251
Sept. 12	11,395	5	2,279	Sept. 11	11,450	5	2,290
Sept. 19	12,664	6	2,111	Sept. 18	12,807	6	2,135
Sept. 26	12,706	6	2,118	Sept. 25	12,770	6	2,128
Oct. 3	12,265	6	2,044	Oct. 2	11,244	6	1,874
Oct. 10	12,852	6	2,142	Oct. 9	2,715	1.5	1,810
Oct. 17	12,613	6	r 2,102	Oct. 16	2,565	1.4	1,832
Oct. 24	12,474	6	2,079	Oct. 23	2,121	1.2	1,768
Oct. 31	12,605	6	2,101	Oct. 30	2,126	1.2	1,772
Nov. 7	12,886	6	r 2,148	Nov. 6	2,660	1.5	1,773
Nov. 14	11,869	5.3	r 2,239	Nov. 13	2,927	1.7	1,722
Nov. 21	13,205	6	2,201	Nov. 20	7,028	4.0	1,757
Nov. 28	10,723	r 5.1	r 2,103	Nov. 27	9,047	5.1	1,774
Dec. 5	13,192	6	2,199	Dec. 4	12,620	6	2,103
Dec. 12	11,792	6	1,965	Dec. 11	12,881	6	2,147
Dec. 19	13,235	6	2,206	Dec. 18	12,834	6	2,139
Dec. 26	9,075	r 4.7	r 1,931	Dec. 25	10,978	5	2,196
Jan. 2	8,223	r [1] 4.3	r 1,912	Jan. 1	11,384	[1] 5	2,277
Total	602,932	r 301.7	r 1,998	Total	552,192	271.5	2,034

r Revised.

[1] Figures represent output 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.

Table 5.—Production of bituminous coal and lignite in the United States, by State and underground, strip, and auger mining

(Thousand short tons)

State	Under-ground	Strip	Auger	Total [1]
Alabama	6,751	11,121	73	17,945
Alaska	--	698	--	698
Arizona	--	1,146	--	1,146
Arkansas	41	236	--	276
Colorado	3,329	2,008	--	5,337
Illinois	29,446	28,956	--	58,402
Indiana	1,765	19,631	--	21,396
Iowa	418	571	--	989
Kansas	--	1,151	--	1,151
Kentucky:				
Eastern	37,353	24,981	9,236	71,569
Western	15,863	31,786	170	47,819
Total [1]	53,216	56,766	9,406	119,389
Maryland	176	1,365	102	1,644
Missouri	--	4,036	--	4,036
Montana:				
Bituminous	20	6,717	--	6,737
Lignite	--	327	--	327
Total	20	7,044	--	7,064
New Mexico	977	7,198	--	8,175
North Dakota (lignite)	--	6,075	--	6,075
Ohio	12,862	37,595	973	51,431
Oklahoma	193	2,039	2	2,234
Pennsylvania	44,289	28,002	544	72,835
Tennessee	3,543	5,412	316	9,271
Utah	4,620	6	--	4,626
Virginia	21,631	7,168	1,829	30,628
Washington	32	1,102	--	1,134
West Virginia	92,437	21,747	4,074	118,258
Wyoming	141	7,899	12	8,052
Total [1]	275,888	258,972	17,332	552,192

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

Table 6.—Production of bituminous coal and lignite in the United States, by district and underground, strip, and auger mining

(Thousand short tons)

District	Under-ground	Strip	Auger	Total [1]
1. Eastern Pennsylvania	20,024	23,290	498	43,812
2. Western Pennsylvania	26,073	7,179	148	33,400
3. Northern West Virginia	27,184	7,965	140	35,289
4. Ohio	12,862	37,595	973	51,431
5. Michigan	--	--	--	--
6. Panhandle	7,113	282	--	7,395
7. Southern Numbered 1	25,716	4,776	425	30,916
8. Southern Numbered 2	92,421	44,530	14,866	151,817
9. West Kentucky	15,863	31,786	170	47,819
10. Illinois	29,446	28,956	--	58,402
11. Indiana	1,765	19,631	--	21,396
12. Iowa	418	571	--	989
13. Southeastern	7,650	11,774	97	19,521
14. Arkansas-Oklahoma	234	575	2	811
15. Southwestern	--	6,886	--	6,886
16. Northern Colorado	474	--	--	474
17. Southern Colorado	3,831	2,008	--	5,840
18. New Mexico	--	8,343	--	8,343
19. Wyoming	141	7,899	12	8,052
20. Utah	4,620	6	--	4,626
21. North-South Dakota	--	6,075	--	6,075
22. Montana	20	7,044	--	7,064
23. Washington	32	1,800	--	1,832
Total [1]	275,888	258,972	17,332	552,192

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

Table 7.—Number of mines, production, and value, at bituminous coal and lignite mines, by State

State	Number of active mines	Production (thousand short tons): Shipped by rail or water [1]	Shipped by truck	Mine-mouth generating plants	All other [2]	Total [3]	Average value per ton [4]
Alabama	115	13,888	3,393	665	--	17,945	$8.15
Alaska	4	562	16	120	--	698	8.18
Arizona	1	--	--	--	1,146	1,146	W
Arkansas	7	263	13	--	--	276	10.30
Colorado	41	4,056	680	599	2	5,337	6.34
Illinois	64	49,723	4,764	3,842	73	58,402	5.46
Indiana	38	16,456	2,422	2,497	22	21,396	5.18
Iowa	13	494	495	--	--	989	4.66
Kansas	4	1,075	76	--	--	1,151	5.72
Kentucky:							
Eastern	1,625	65,922	5,386	178	82	71,569	7.60
Western	120	38,895	1,175	7,727	23	47,819	4.83
Total	1,745	104,817	6,561	7,906	105	119,389	6.49
Maryland	55	799	845	--	--	1,644	6.25
Missouri	10	1,826	575	518	1,117	4,036	4.87
Montana:							
Bituminous	8	6,656	81	--	--	6,737	1.79
Lignite	2	325	2	--	--	327	2.27
Total	10	6,981	83	--	--	7,064	1.82
New Mexico	3	1,510	--	6,665	--	8,175	3.26
North Dakota (lignite)	15	3,086	214	2,709	66	6,075	1.91
Ohio	302	30,080	15,416	5,930	4	51,431	5.24
Oklahoma	11	2,224	8	--	2	2,234	6.72
Pennsylvania	765	50,017	14,841	7,667	311	72,835	8.52
Tennessee	186	5,055	4,131	82	3	9,271	6.40
Utah	22	3,763	501	330	32	4,626	7.37
Virginia	670	29,340	1,276	--	12	30,628	8.32
Washington	4	--	41	1,093	--	1,134	6.72
West Virginia	1,050	110,274	3,932	3,854	198	118,258	9.54
Wyoming	14	4,729	40	3,251	31	8,052	3.39
Total	5,149	441,018	60,323	47,727	3,124	552,192	7.07

W Withheld to avoid disclosing individual company confidential data.
[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, and used by mine employees.
[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.

Table 8.—Number of mines, production, and value, at bituminous coal and lignite mines, by districts

District	Number of active mines	Production (thousand short tons)					Average value per ton [4]
		Shipped by rail or water [1]	Shipped by truck	Mine-mouth generating plants	All other [2]	Total [3]	
1. Eastern Pennsylvania	591	27,353	9,444	6,726	288	43,812	$8.12
2. Western Pennsylvania	252	25,884	6,432	1,062	23	33,400	8.78
3. Northern West Virginia	295	33,461	1,688	127	13	35,289	7.36
4. Ohio	302	30,080	15,416	5,930	4	51,431	5.24
5. Michigan	--	--	--	--	--	--	--
6. Panhandle	16	3,728	61	3,605	2	7,395	6.55
7. Southern Numbered 1	339	29,659	1,104	--	153	30,916	13.21
8. Southern Numbered 2	2,813	140,169	11,263	260	124	151,817	8.18
9. West Kentucky	120	38,895	1,175	7,727	23	47,819	4.83
10. Illinois	64	49,723	4,764	3,842	73	58,402	5.46
11. Indiana	38	16,456	2,422	2,497	22	21,396	5.18
12. Iowa	13	494	495	--	--	989	4.66
13. Southeastern	160	15,042	3,812	665	3	19,521	7.97
14. Arkansas-Oklahoma	13	796	13	--	3	811	10.53
15. Southwestern	19	4,592	659	518	1,117	6,886	5.16
16. Northern Colorado	3	196	277	--	2	474	5.25
17. Southern Colorado	39	4,837	403	599	1	5,840	6.71
18. New Mexico	3	533	--	6,665	1,146	8,343	2.62
19. Wyoming	14	4,729	40	3,251	31	8,052	3.39
20. Utah	22	3,763	501	330	32	4,626	7.37
21. North-South Dakota	15	3,086	214	2,709	66	6,075	1.91
22. Montana	10	6,981	83	--	--	7,064	1.82
23. Washington	8	562	57	1,213	--	1,832	7.27
Total [3]	5,149	441,018	60,323	47,727	3,124	552,192	7.07

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, and used by mine employees.
[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.

Table 9.—Production of bituminous coal and lignite, by State, with estimates by months [1]

(Thousand short tons)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Alabama	1,597	1,623	1,566	1,577	1,700	1,535	1,289	1,734	1,846	843	1,125	1,510	17,945
Alaska	37	41	67	67	69	54	65	48	47	56	65	82	698
Arizona	72	72	86	142	138	150	82	81	81	80	80	82	1,146
Arkansas	22	23	26	27	24	27	25	32	22	13	10	25	276
Colorado	560	560	565	449	487	404	337	489	500	114	314	558	5,337
Illinois	5,419	5,007	6,124	5,984	5,509	5,455	4,541	6,022	5,732	263	2,682	5,664	58,402
Indiana	1,953	1,805	2,364	2,106	2,049	1,974	1,578	2,306	2,137		985	2,139	21,396
Iowa	74	71	94	97	74	89	74	103	104	--	57	114	989
Kansas	102	105	115	105	108	103	82	130	114	38	58	120	1,151
Kentucky:										9			
Eastern	5,913	5,871	7,306	6,192	6,405	6,204	5,087	7,168	7,240	3,216	4,258	6,712	71,569
Western	3,950	3,922	4,881	4,137	4,279	4,145	3,399	4,789	4,837	2,149	2,845	4,484	47,819
Total	9,863	9,793	12,187	10,329	10,684	10,349	8,486	11,957	12,077	5,365	7,103	11,196	[2] 119,389
Maryland	97	99	125	130	125	199	197	230	179	19	70	174	1,644
Missouri	320	293	369	367	301	349	283	553	388	131	233	449	4,036
Montana:													
Bituminous	399	380	480	527	389	483	707	874	763	267	450	1,018	6,737
Lignite	19	19	23	26	19	23	34	42	37	13	23	49	327
Total	418	399	503	553	408	506	741	916	800	280	473	1,067	7,064
New Mexico	675	680	869	765	796	832	625	914	937	252	318	512	8,175
North Dakota (lignite)	505	430	533	576	421	514	442	603	609	270	430	742	6,075
Ohio	4,555	3,899	4,930	5,306	4,657	4,811	4,480	5,020	4,635	975	2,535	5,628	51,431
Oklahoma	208	192	251	254	225	220	154	178	190	28	128	206	2,234
Pennsylvania	7,142	6,420	7,630	7,440	6,668	6,672	5,517	7,146	7,070	906	2,764	7,460	72,835
Tennessee	765	690	866	853	750	868	472	975	1,074	472	595	891	9,271
Utah	460	473	495	462	440	383	203	439	455	93	276	447	4,626
Virginia	2,850	2,661	3,211	3,176	2,830	2,731	1,702	3,167	2,959	632	1,506	3,203	30,628
Washington	4	4	4	10	32	58	153	172	202	214	87	194	1,134
West Virginia	11,399	11,096	13,169	12,787	11,342	10,313	7,600	12,238	11,650	406	3,648	12,610	118,258
Wyoming	683	593	771	774	605	702	409	732	641	398	785	959	8,052
Total	49,780	47,029	56,920	54,336	50,442	49,298	39,537	56,185	54,449	11,857	26,327	56,032	552,192

[1] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monongahela Rivers, supplements 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.

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

Table 10.—Number and production of bituminous coal and lignite mines, 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	4	4,392	6	2,006	2	318	--	--	1	24	3	11	16	6,751
Strip	2	2,063	10	3,610	22	3,394	15	1,090	32	906	14	57	95	11,121
Auger	--	--	--	--	--	--	--	--	3	67	1	6	4	73
Total	6	6,455	16	5,616	24	3,712	15	1,090	36	997	18	74	115	17,945
Alaska: Strip	1	650	--	--	--	--	--	--	2	46	1	2	4	698
Arizona: Strip	1	1,146	--	--	--	--	--	--	--	--	--	--	1	1,146
Arkansas:														
Underground	--	--	--	--	--	--	--	--	1	41	--	--	1	41
Strip	--	--	--	--	--	--	2	136	4	100	--	--	6	236
Total	--	--	--	--	--	--	2	136	5	141	--	--	7	276
Colorado:														
Underground	1	510	6	1,922	4	608	1	51	10	201	10	38	32	3,329
Strip	3	1,738	--	--	1	134	2	113	1	17	2	4	9	2,008
Total [1]	4	2,248	6	1,922	5	743	3	164	11	218	12	42	41	5,337
Illinois:														
Underground	20	28,311	2	723	1	167	2	179	2	66	--	--	28	29,446
Strip	19	27,186	4	1,337	1	182	1	147	2	63	8	41	36	28,956
Total	39	55,497	6	2,060	2	349	3	326	4	129	8	41	64	58,402
Indiana:														
Underground	2	1,620	--	--	--	--	2	145	--	--	--	--	4	1,765
Strip	12	18,624	2	454	1	117	5	307	5	87	9	43	34	19,631
Total	14	20,243	2	454	1	117	7	452	5	87	9	43	38	21,396
Iowa:														
Undergorund	--	--	1	246	1	172	--	--	--	--	--	--	2	418
Strip	--	--	--	--	1	115	5	308	4	139	1	10	11	571
Total	--	--	1	246	2	287	5	308	4	139	1	10	13	989
Kansas: Strip	1	765	--	--	2	381	--	--	--	--	1	5	4	1,151

Kentucky:														
Underground	27	24,496	33	9,701	39	5,712	68	4,710	317	6,902	383	1,694	867	53,216
Strip	18	28,941	28	9,019	46	6,021	89	6,273	237	5,655	195	857	613	56,766
Auger	--	--	2	404	9	1,728	28	2,167	100	4,209	126	899	265	9,406
Total [1]	45	53,437	63	19,124	94	13,462	185	13,150	654	16,766	704	3,450	1,745	119,389
Maryland:														
Underground	--	--	--	--	--	--	1	68	4	95	5	13	10	176
Strip	--	--	1	202	3	429	5	321	13	332	17	81	39	1,365
Auger	--	--	--	--	--	--	1	57	2	38	3	7	6	102
Total [1]	--	--	1	202	3	429	7	447	19	465	25	100	55	1,644
Missouri: Strip	4	3,185	2	785	--	--	--	--	3	58	1	8	10	4,036
Montana:														
Underground	--	--	--	--	--	--	--	--	--	--	4	20	4	20
Strip	2	6,657	1	325	--	--	1	50	1	11	1	2	6	7,044
Total	2	6,657	1	325	--	--	1	50	1	11	5	22	10	7,064
New Mexico:														
Underground	1	977	--	--	--	--	--	--	--	--	--	--	1	977
Strip	2	7,198	--	--	--	--	--	--	--	--	--	--	2	7,198
Total	3	8,175	--	--	--	--	--	--	--	--	--	--	3	8,175
North Dakota: Strip	5	5,351	1	368	2	312	--	--	1	19	6	24	15	6,075
Ohio:														
Underground	11	10,615	4	1,559	2	228	2	144	9	284	7	31	35	12,862
Strip	18	19,920	26	7,752	28	3,863	51	3,845	72	2,023	42	193	237	37,595
Auger	--	--	--	--	2	212	2	101	20	605	6	57	30	973
Total [1]	29	30,535	30	9,312	32	4,302	55	4,090	101	2,912	55	281	302	51,431
Oklahoma:														
Underground	--	--	--	--	1	158	--	--	2	35	--	--	3	193
Strip	2	1,528	--	--	2	339	2	170	--	--	1	2	7	2,039
Auger	--	--	--	--	--	--	--	--	--	--	1	2	1	2
Total [1]	2	1,528	--	--	3	498	2	170	2	35	2	4	11	2,234

See footnotes at end of table.

Table 10.—Number and production of bituminous coal and lignite mines, 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
Pennsylvania:														
Underground	31	28,957	31	10,396	20	2,777	16	1,165	32	773	51	221	181	44,289
Strip	4	4,239	15	3,999	49	6,752	103	6,866	215	5,425	141	720	527	28,002
Auger	--	--	--	--	--	--	--	--	18	330	39	214	57	544
Total [1]	35	33,196	46	14,395	69	9,529	119	8,031	265	6,528	231	1,156	765	72,835
Tennessee:														
Underground	1	1,050	2	580	3	446	8	574	29	735	35	158	78	3,543
Strip	--	--	2	473	17	2,340	31	2,075	25	436	22	88	97	5,412
Auger	--	--	--	--	--	--	1	96	7	203	3	17	11	316
Total [1]	1	1,050	4	1,053	20	2,786	40	2,745	61	1,375	60	263	186	9,271
Utah:														
Underground	2	1,462	7	2,011	6	1,016	1	65	4	66	1	2	21	4,620
Strip	--	--	--	--	--	--	--	--	--	--	1	6	1	6
Total	2	1,462	7	2,011	6	1,016	1	65	4	66	2	8	22	4,626
Virginia:														
Underground	6	5,848	21	6,915	15	2,025	32	2,165	183	4,180	98	498	355	21,631
Strip	--	--	3	843	6	926	24	1,656	129	3,506	50	236	212	7,168
Auger	--	--	--	--	2	260	5	312	47	1,017	49	240	103	1,829
Total [1]	6	5,848	24	7,758	23	3,211	61	4,134	359	8,704	197	975	670	30,628
Washington:														
Underground	--	--	--	--	--	--	--	--	1	30	1	2	2	32
Strip	1	1,093	--	--	--	--	--	--	--	--	1	9	2	1,102
Total	1	1,093	--	--	--	--	--	--	1	30	2	11	4	1,134
West Virginia:														
Underground	46	45,787	84	26,638	67	9,661	76	5,285	177	4,327	174	740	624	92,437
Strip	4	2,909	19	4,659	43	6,038	62	4,573	129	3,250	56	318	313	21,747
Auger	--	--	--	--	8	1,074	25	1,615	41	1,197	39	188	113	4,074
Total [1]	50	48,695	103	31,297	118	16,773	163	11,473	347	8,774	269	1,245	1,050	118,258
Wyoming:														
Underground	--	--	--	--	--	--	1	88	1	45	2	8	4	141
Strip	5	6,953	2	734	1	191	--	--	1	22	--	--	9	7,899
Auger	--	--	--	--	--	--	--	--	1	12	--	--	1	12
Total	5	6,953	2	734	1	191	1	88	3	79	2	8	14	8,052
United States:														
Underground	152	154,025	197	62,697	162	23,288	210	14,639	773	17,804	774	3,436	2,268	275,888
Strip	104	140,146	116	34,560	225	31,534	399	27,933	876	22,094	570	2,706	2,290	258,972
Auger	--	--	2	404	21	3,274	62	4,348	239	7,678	267	1,630	591	17,332
Total [1]	256	294,171	315	97,661	408	58,096	671	46,920	1,888	47,576	1,611	7,772	5,149	552,192

Table 11.—Underground mine data for bituminous coal and lignite mines, by State

(Thousand short tons)

State	Number of mines	Production	Cut by hand and shot from solid	Cut by machines			Mined by continuous mining machines	Mined by longwall machines	Number of power drills and production								
									Number of mines using power drills	Face or coal drills				Roof or rock drills			
										Handheld and post mounted		Mobile		Roof bolting		Other uses	
				Quantity	Number of coal cutting machines	Average output per machine				Number	Quantity	Number	Quantity	Rotary	Percussion	Rotary	Percussion
Alabama	16	6,751	7	6,153	79	78	591	--	16	35	1,752	55	4,404	45	6	--	9
Arkansas	1	41	--	41	5	8	--	--	1	5	41	--	--	--	--	--	--
Colorado	32	3,329	9	276	34	8	2,789	255	19	20	90	9	275	39	2	--	--
Illinois	28	29,446	--	9,122	44	207	20,324	--	16	--	--	57	10,941	137	15	9	2
Indiana	4	1,765	--	658	12	55	1,107	--	4	--	--	11	1,312	20	2	--	--
Iowa	2	418	--	418	4	105	--	--	2	--	--	2	418	--	--	--	--
Kentucky	867	53,216	3,108	39,034	672	58	11,074	--	628	687	15,896	205	25,514	320	51	34	--
Maryland	10	176	--	66	10	7	111	--	5	9	63	--	--	3	--	--	--
Montana	4	20	--	20	7	3	--	--	1	5	10	2	9	--	--	--	--
New Mexico	1	977	--	--	--	--	977	--	1	--	--	--	--	5	2	--	--
Ohio	35	12,862	--	5,386	63	85	7,476	--	18	24	1,377	40	3,993	105	1	--	--
Oklahoma	3	193	--	--	--	--	193	--	3	--	--	--	--	7	--	1	--
Pennsylvania	181	44,289	18	4,776	135	35	37,570	1,925	126	80	1,543	38	3,250	276	265	38	32
Tennessee	78	3,543	190	2,696	83	32	656	--	76	109	2,535	3	334	35	--	1	--
Utah	21	4,620	2	389	12	32	3,494	735	8	6	201	8	473	15	16	--	2
Virginia	355	21,631	703	10,554	310	34	9,235	1,139	525	346	7,466	62	8,461	132	122	5	5
Washington	2	32	32	--	--	--	--	--	1	6	30	--	--	--	--	--	--
West Virginia	624	92,437	629	32,009	581	55	57,300	2,498	580	462	11,898	238	19,745	744	193	10	15
Wyoming	4	141	--	96	7	14	45	--	5	5	91	1	4	--	9	1	--
Total [1]	2,268	275,888	4,700	111,693	2,058	54	152,943	6,552	2,035	1,799	42,995	731	79,135	1,883	684	99	65

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

Table 12.—Haulage units in use in bituminous coal and lignite underground mines, by State

State	Locomotives			Tractors, rubber-tired	Trailers, rubber-tired	Mine cars		Shuttle cars		Shuttle buggies	Gathering and haulage conveyors	
	Trolly	Battery	All other			Rail	Rubber-tired	Cable reel	Battery		Units	Miles
Alabama	109	--	--	40	31	2,137	--	168	--	1	114	42.5
Arkansas	--	--	--	--	--	10	--	--	--	--	4	.4
Colorado	50	6	--	--	--	1,346	--	106	--	--	37	8.8
Illinois	98	8	--	50	78	216	77	349	10	--	279	142.7
Indiana	1	--	--	--	--	37	--	19	--	--	14	14.1
Iowa	5	--	--	--	--	45	--	5	--	--	--	--
Kentucky	258	141	11	656	339	4,455	924	1,269	143	96	501	176.6
Maryland	--	--	--	3	3	10	--	3	4	3	3	.5
Montana (bituminous)	--	--	--	--	--	53	--	4	--	--	--	--
New Mexico	--	--	--	--	--	--	5	14	--	--	10	4.9
Ohio	122	19	6	57	30	2,497	6	235	22	8	134	61.8
Oklahoma	--	--	--	2	2	--	--	17	--	--	10	3.4
Pennsylvania	1,022	68	98	218	848	12,576	65	1,060	61	6	619	225.2
Tennessee	20	11	1	98	84	129	103	79	13	--	30	14.8
Utah	74	5	--	14	10	1,896	9	93	8	--	61	15.4
Virginia	152	39	49	428	287	1,622	1,178	506	60	11	292	120.6
Washington	2	--	--	--	--	21	--	--	--	--	--	--
West Virginia	1,154	54	14	285	381	25,735	664	2,243	80	129	1,326	562.5
Wyoming	1	--	--	2	2	20	--	5	--	--	3	.4
Total	3,068	351	179	1,853	2,095	52,805	3,031	6,175	401	254	3,437	1,394.6

Table 13.—Method of haulage at bituminous coal and lignite underground mines, by State

(Thousand short tons)

State	Production from mines					
	Reporting rail mine cars	Reporting rubber-tired mine cars	Reporting shuttle buggies	With conveyor haulage only	Not reporting type of haulage	Total
Alabama	3,756	--	3	2,988	4	6,751
Arkansas	41	--	--	--	--	41
Colorado	1,625	--	--	1,242	462	3,329
Illinois	1,248	1,908	--	25,472	818	29,446
Indiana	145	--	--	713	907	1,765
Iowa	418	--	--	--	--	418
Kentucky	14,287	10,818	2,000	19,482	6,629	53,216
Maryland	12	--	18	68	78	176
Montana (bituminous)	20	--	--	--	--	20
New Mexico	--	977	--	--	--	977
Ohio	9,252	437	15	2,868	290	12,862
Oklahoma	--	--	--	193	--	193
Pennsylvania	30,733	458	2	12,311	785	44,289
Tennessee	621	965	40	1,192	725	3,543
Utah	3,393	264	--	827	136	4,620
Virginia	6,687	5,254	18	8,244	1,428	21,631
Washington	30	--	--	--	2	32
West Virginia	61,607	6,175	317	20,580	3,758	92,437
Wyoming	3	--	--	133	5	141
Total	133,878	27,256	2,413	96,313	16,027	[1] 275,888

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

Table 14.—Rail mine cars used and haulage at bituminous coal and lignite underground mines, by State

State	Capacity							Production, by size of mine car reported (thousand short tons)						
	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total
Alabama	6	16	--	752	985	378	2,137	4	24	--	1,203	1,804	721	3,756
Arkansas	--	--	--	10	--	--	10	--	--	--	41	--	--	41
Colorado	63	944	2	237	--	100	1,346	47	527	4	272	--	775	1,625
Illinois	--	36	18	12	150	--	216	--	90	32	33	1,093	--	1,248
Indiana	--	--	16	21	--	--	37	--	--	62	83	--	--	145
Iowa	--	--	45	--	--	--	45	--	--	418	--	--	--	418
Kentucky	39	302	845	1,253	1,038	978	4,455	44	485	1,493	3,263	2,430	6,572	14,287
Maryland	--	10	--	--	--	--	10	--	12	--	--	--	--	12
Montana (bituminous)	--	39	14	--	--	--	53	--	11	9	--	--	--	20
Ohio	--	--	30	551	1,045	871	2,497	--	--	37	1,537	2,482	5,196	9,252
Pennsylvania	165	829	669	57	4,895	5,961	12,576	27	405	2,238	559	9,633	17,871	30,733
Tennessee	6	26	51	46	--	--	129	6	50	273	292	--	--	621
Utah	88	21	82	1,663	42	--	1,896	137	12	196	2,697	351	--	3,393
Virginia	--	32	230	1,048	--	312	1,622	--	228	2,067	1,524	--	2,868	6,687
Washington	--	--	--	21	--	--	21	--	--	--	30	--	--	30
West Virginia	10	446	2,559	7,182	3,773	11,765	25,735	5	485	4,377	10,103	8,560	38,077	61,607
Wyoming	--	20	--	--	--	--	20	--	3	--	--	--	--	3
Total	377	2,721	4,561	12,853	11,928	20,365	52,805	270	2,332	11,206	21,637	26,353	72,080	133,878

Table 15.—Rubber-tired mine cars used and haulage at bituminous coal and lignite underground mines, by State

State	Capacity							Production, by size of mine car reported (thousand short tons)						
	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total
Illinois	--	32	--	--	45	--	77	--	88	--	--	1,820	--	1,980
Kentucky	10	474	262	174	4	--	924	59	3,854	2,931	3,768	206	--	10,818
New Mexico	--	--	--	5	--	--	5	--	--	--	977	--	--	977
Ohio	--	--	--	6	--	--	6	--	--	--	437	--	--	437
Pennsylvania	--	29	36	--	--	--	65	--	79	379	--	--	--	458
Tennessee	1	67	24	4	7	--	103	3	373	575	6	8	--	965
Utah	--	--	--	7	2	--	9	--	--	--	244	20	--	264
Virginia	53	696	238	191	--	--	1,178	187	1,537	2,321	1,209	--	--	5,254
West Virginia	--	242	157	214	13	38	664	--	1,479	1,676	2,128	320	572	6,175
Total	64	1,540	717	601	71	38	3,031	249	7,410	7,882	8,769	2,374	572	27,256

Table 16.—Number and production of underground bituminous coal and lignite 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)	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
Alabama	6	7	4,369	3,706	67	114	1,836	1,968	23.3	42.5
Arkansas	1	1	6	41	2	4	1,500	500	.6	.4
Colorado	11	9	1,908	3,212	31	37	1,172	1,250	6.9	8.8
Illinois	23	24	30,755	29,234	246	279	2,743	2,700	127.8	142.7
Indiana	1	1	1,909	713	9	14	5,400	5,300	9.2	14.1
Kentucky	75	65	33,230	28,653	338	501	1,881	1,861	120.4	176.6
Maryland	4	1	135	68	7	3	928	800	1.2	.5
New Mexico	1	1	938	977	8	10	2,550	2,600	3.9	4.9
Ohio	19	19	17,697	12,083	107	134	2,121	2,434	43.0	61.8
Oklahoma	2	3	219	193	8	10	1,625	1,800	2.5	3.4
Pennsylvania	96	93	35,100	28,618	562	619	1,875	1,921	199.6	225.2
Tennessee	6	10	2,280	2,014	24	30	3,003	2,597	13.7	14.8
Utah	13	14	5,186	4,207	65	61	1,287	1,336	15.8	15.4
Virginia	44	43	18,256	13,665	308	292	2,209	2,181	128.9	120.6
West Virginia	284	247	89,639	106,894	1,226	1,326	2,075	2,240	481.8	562.5
Wyoming	1	2	110	133	4	3	1,500	767	1.1	.4
Total [2]	587	540	241,737	234,411	3,012	3,437	2,068	2,121	1,179.7	1,394.6

[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 17.—Production, shipments, and value at bituminous coal and lignite mines, by State and county

(Thousand short tons)

State and county	Production: Underground: Number of mines	Underground: Quantity	Strip: Number of mines	Strip: Quantity	Auger: Number of mines	Auger: Quantity	Shipments: Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total [3]	Average value per ton [4]
Alabama:												
Bibb	--	--	7	807	--	--	755	52	--	--	807	$5.85
Blount	--	--	4	253	--	--	169	83	--	--	253	10.24
Cullman	--	--	3	248	--	--	--	248	--	--	248	5.85
De Kalb	--	--	2	83	--	--	--	83	--	--	83	W
Etowah	--	--	1	41	--	--	41	--	--	--	41	W
Franklin	--	--	1	21	--	--	--	21	--	--	21	W
Jackson	--	--	2	1,045	--	--	918	127	--	--	1,045	4.99
Jefferson	10	4,856	27	3,498	2	67	7,061	1,361	--	--	8,421	8.92
Marion	1	24	5	349	--	--	253	121	--	--	373	6.06
Shelby	1	338	3	178	--	--	338	178	--	--	516	10.56
Tuscaloosa	--	--	10	2,366	--	--	2,241	125	--	--	2,366	7.08
Walker	4	1,532	27	2,062	2	6	2,060	875	665	--	3,600	8.33
Winston	--	--	3	170	--	--	52	118	--	--	170	10.60
Total [3]	16	6,751	95	11,121	4	73	13,888	3,393	665	--	17,946	8.15
Alaska:	--	--	4	698	--	--	562	16	120	--	698	8.18
Arizona: Navajo:	--	--	1	1,146	--	--	--	--	--	1,146	1,146	NA
Arkansas:												
Franklin	--	--	1	89	--	--	89	--	--	--	89	8.31
Johnson	1	41	3	116	--	--	157	--	--	--	157	11.71
Logan	--	--	1	13	--	--	--	13	--	--	13	10.01
Sebastian	--	--	1	17	--	--	18	--	--	--	18	8.00
Total [3]	1	41	6	235	--	--	264	13	--	--	276	10.30
Colorado:												
Delta	3	388	1	2	--	--	378	12	--	--	391	W
Fremont	8	91	2	152	--	--	2	241	--	--	243	4.39
Garfield	2	3	--	--	--	--	--	3	--	--	3	W
Gunnison	4	683	--	--	--	--	661	21	--	--	683	9.88
Huerfano	2	11	--	--	--	--	--	11	--	--	11	10.04
La Plata	1	10	1	2	--	--	--	12	--	--	12	5.21
Las Animas	1	510	--	--	--	--	510	--	--	--	510	10.35
Mesa	1	14	--	--	--	--	--	--	14	--	14	W
Moffat	3	388	1	60	--	--	414	34	--	--	448	4.64
Montrose	--	--	1	54	--	--	--	54	--	--	54	5.71
Pitkin	3	744	--	--	--	--	744	--	--	--	744	W
Routt	1	13	3	1,738	--	--	1,151	15	585	1	1,751	3.86
Weld	3	474	--	--	--	--	197	277	--	1	474	5.25
Total [3]	32	3,329	9	2,008	--	--	4,056	679	599	2	5,337	6.34

Illinois:												
Christian	1	4,079	--	--	--	--	989	364	2,723	3	4,079	W
Douglas	1	930	--	--	--	--	181	749	--	--	930	W
Franklin	5	7,443	--	--	--	--	7,395	48	--	--	7,443	5.69
Fulton	--	--	5	4,413	--	--	3,955	453	--	5	4,413	5.44
Gallatin	2	1,701	1	433	--	--	2,134	--	--	--	2,134	5.36
Jackson	--	--	2	87	--	--	87	--	--	--	87	4.99
Jefferson	3	6,019	1	1,018	--	--	6,884	132	--	21	7,037	6.10
Johnson	--	--	3	9	--	--	--	4	5	--	9	3.70
Kankakee	--	--	1	706	--	--	358	348	--	--	706	W
Knox	--	--	1	1,432	--	--	1,349	83	--	--	1,432	W
Macoupin	1	1,158	--	--	--	--	1,158	--	--	--	1,158	W
Mercer	1	33	1	17	--	--	16	34	--	--	50	W
Montgomery	2	2,206	--	--	--	--	814	279	1,113	--	2,206	W
Peoria	--	--	3	2,269	--	--	1,662	605	--	2	2,269	5.86
Perry	--	--	4	7,890	--	--	7,866	--	--	24	7,890	4.30
Pope	--	--	1	7	--	--	--	7	--	--	7	W
Randolph	1	739	2	2,462	--	--	3,075	125	--	1	3,201	4.94
St. Clair	2	1,607	2	4,535	--	--	5,030	1,112	--	--	6,142	4.49
Saline	4	1,399	4	1,034	--	--	2,369	57	--	7	2,433	7.05
Stark	--	--	1	659	--	--	659	--	--	--	659	W
Vermilion	1	32	--	--	--	--	8	24	--	--	32	7.38
Williamson	4	2,098	4	1,986	--	--	3,735	340	--	9	4,084	6.37
Total [3]	28	29,446	36	28,956	--	--	49,723	4,764	3,842	73	58,402	5.46
Indiana:												
Clay	--	--	6	1,192	--	--	520	652	--	20	1,192	5.80
Fountain	--	--	1	27	--	--	--	27	--	--	27	6.85
Gibson	1	907	--	--	--	--	907	--	--	--	907	W
Greene	--	--	4	2,462	--	--	2,230	233	--	--	2,462	5.05
Parke	--	--	1	11	--	--	--	11	--	--	11	3.50
Pike	1	62	9	4,466	--	--	3,906	572	50	--	4,528	5.46
Spencer	--	--	2	59	--	--	11	48	--	--	59	W
Sullivan	1	713	2	3,136	--	--	2,408	726	713	1	3,849	5.78
Vermillion	--	--	2	1,318	--	--	1,300	18	--	--	1,318	W
Vigo	1	83	--	--	--	--	--	83	--	--	83	W
Warrick	--	--	7	6,961	--	--	5,174	53	1,734	--	6,961	4.57
Total [3]	4	1,765	34	19,631	--	--	16,456	2,422	2,497	22	21,396	5.18
Iowa:												
Lucas	1	172	--	--	--	--	78	94	--	--	172	5.41
Mahaska	--	--	5	290	--	--	162	127	--	--	290	4.43
Marion	--	--	3	192	--	--	182	10	--	--	192	4.79
Monroe	1	246	1	36	--	--	36	246	--	--	282	W
Van Buren	--	--	1	18	--	--	--	18	--	--	18	W
Wapello	--	--	1	36	--	--	36	--	--	--	36	4.48
Total [3]	2	418	11	571	--	--	494	495	--	--	989	4.66

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, 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]
Kansas:												
Cherokee	--	--	2	771	--	--	764	7	--	--	771	W
Crawford	--	--	2	381	--	--	311	69	--	1	381	W
Total [3]	--	--	4	1,151	--	--	1,075	76	--	1	1,151	$5.72
Kentucky:												
Eastern:												
Bell	20	545	31	2,676	22	457	2,973	705	--	--	3,678	6.28
Boyd	--	--	5	157	2	13	--	169	--	--	169	6.44
Breathitt	2	26	21	2,526	18	1,321	3,832	41	--	--	3,873	6.51
Carter	--	--	11	223	3	34	125	132	--	--	257	4.79
Clay	17	147	20	474	11	185	638	167	--	--	806	6.22
Clinton	1	32	1	257	--	--	--	286	--	3	289	6.50
Elliott	--	--	3	11	--	--	--	11	--	--	11	5.00
Floyd	138	2,478	15	1,582	10	410	3,885	585	--	--	4,470	6.23
Harlan	77	6,861	36	1,079	30	789	7,978	717	--	34	8,729	9.34
Jackson	--	--	4	18	1	1	18	2	--	--	20	6.00
Johnson	21	228	13	2,298	4	230	2,655	101	--	--	2,756	5.28
Knott	59	2,166	28	1,142	14	499	3,665	143	--	--	3,807	6.69
Knox	14	40	50	1,216	6	59	1,126	188	--	--	1,315	6.73
Laurel	--	--	22	470	2	4	405	70	--	--	474	6.56
Lawrence	--	--	10	260	7	74	160	174	--	--	334	5.92
Lee	1	20	2	11	--	--	9	19	--	2	30	7.14
Leslie	15	1,140	17	549	8	166	1,711	143	--	--	1,855	6.85
Letcher	101	3,420	55	1,752	24	918	5,681	388	--	21	6,090	8.83
Magoffin	--	--	9	806	3	53	853	5	--	--	859	5.29
Martin	6	1,118	11	614	5	155	1,885	2	--	--	1,887	6.34
McCreary	7	574	3	133	--	--	704	3	--	--	706	7.55
Morgan	--	--	6	449	--	--	430	19	--	--	449	9.58
Owsley	--	--	1	28	--	--	--	28	--	--	28	6.50
Perry	39	2,851	51	2,732	22	1,576	6,954	205	--	--	7,159	6.75
Pike	309	15,494	64	2,532	50	2,060	19,063	972	48	2	20,087	8.58
Pulaski	2	6	4	347	2	26	220	9	130	20	379	6.93
Rockcastle	--	--	2	6	--	--	--	6	--	--	6	6.00
Wayne	--	--	1	11	--	--	--	11	--	--	11	6.00
Whitley	11	208	30	609	11	201	951	68	--	--	1,018	6.20
Wolfe	--	--	2	13	2	3	--	16	--	--	16	6.00
Total [3]	840	37,353	528	24,981	257	9,236	65,922	5,386	178	82	71,569	7.60
Kentucky:												
Western:												
Butler	2	64	3	161	--	--	122	103	--	--	225	5.58
Christian	--	--	8	166	--	--	128	38	--	--	166	5.75
Daviess	--	--	1	1,094	--	--	506	--	587	--	1,094	5.25

Edmonson	--	--	2	353	--	--	353	--	--	--	353	5.17
Hancock	--	--	1	72	--	--	72	--	--	--	72	6.46
Henderson	2	62	--	--	--	--	4	21	38	--	62	5.50
Hopkins	10	6,250	30	5,650	5	131	11,610	420	--	--	12,030	5.61
McLean	--	--	3	544	--	--	543	1	--	--	544	5.70
Muhlenberg	5	4,058	21	19,223	3	40	15,685	516	7,102	18	23,321	4.35
Ohio	1	1,432	14	4,438	--	--	5,791	74	--	4	5,870	4.40
Union	6	2,947	--	--	--	--	2,947	--	--	--	2,947	5.41
Webster	1	1,050	2	84	--	--	1,133	2	--	--	1,134	5.46
Total [3]	27	15,863	85	31,786	8	171	38,895	1,175	7,727	23	47,819	4.83
Grand total [3]	867	53,216	613	56,766	265	9,406	104,817	6,561	7,906	105	119,389	6.49
Maryland:												
Allegany	2	32	17	393	2	5	124	306	--	--	430	5.42
Garrett	8	144	22	973	4	97	675	539	--	--	1,214	6.55
Total [3]	10	176	39	1,365	6	102	799	845	--	--	1,644	6.25
Missouri:												
Barton	--	--	1	518	--	--	--	--	518	--	518	W
Boone	--	--	1	587	--	--	415	172	--	--	587	W
Callaway	--	--	1	20	--	--	--	20	--	--	20	W
Henry	--	--	2	1,562	--	--	443	3	--	1,117	1,562	W
Macon	--	--	1	963	--	--	963	--	--	--	963	W
Putnam	--	--	1	28	--	--	--	28	--	--	28	W
Randolph	--	--	1	339	--	--	--	339	--	--	339	W
Vernon	--	--	2	18	--	--	5	13	--	--	18	W
Total [3]	--	--	10	4,036	--	--	1,826	575	518	1,117	4,036	487
Montana (bituminous):												
Musselshell	4	20	2	61	--	--	--	80	--	--	80	3.61
Rosebud	--	--	2	6,657	--	--	6,656	1	--	--	6,657	W
Total [3]	4	20	4	6,717	--	--	6,656	81	--	--	6,737	1.79
Montana (lignite):												
Powder River	--	--	1	2	--	--	--	2	--	--	2	5.78
Richland	--	--	1	325	--	--	325	--	--	--	325	W
Total	--	--	2	327	--	--	325	2	--	--	327	2.27
Total Montana	4	20	6	7,044	--	--	6,981	83	--	--	7,064	1.82
New Mexico:												
Colfax	1	977	--	--	--	--	977	--	--	--	977	W
McKinley	--	--	1	533	--	--	533	--	--	--	533	W
San Juan	--	--	1	6,665	--	--	--	--	6,665	--	6,665	W
Total	1	977	2	7,198	--	--	1,510	--	6,665	--	8,175	3.26

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, 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]	
North Dakota (lignite):												
Adams	--	--	1	4	--	--	--	4	--	--	4	$5.28
Bowman	--	--	1	177	--	--	115	--	--	62	177	W
Burke	--	--	2	522	--	--	490	4	28	--	522	1.95
Grant	--	--	2	6	--	--	--	6	--	--	6	3.89
McLean	--	--	1	19	--	--	--	19	--	--	19	4.36
Mercer	--	--	3	3,104	--	--	2,293	11	797	3	3,104	1.78
Oliver	--	--	1	1,730	--	--	--	--	1,728	2	1,730	W
Stark	--	--	2	139	--	--	--	139	--	--	139	4.00
Ward	--	--	1	368	--	--	188	24	156	--	368	W
Williams	--	--	1	7	--	--	--	7	--	--	7	3.00
Total [3]	--	--	15	6,075	--	--	3,086	214	2,709	66	6,075	1.91
Ohio:												
Athens	--	--	2	12	--	--	--	12	--	--	12	3.88
Belmont	10	5,170	27	7,951	2	151	12,108	1,164	--	1	13,272	5.42
Carroll	--	--	5	435	1	16	339	112	--	--	451	4.56
Columbiana	3	122	24	799	8	189	163	946	--	--	1,109	5.06
Coshocton	1	437	7	1,719	4	81	405	737	1,095	--	2,236	5.73
Gallia	1	3	6	370	1	5	12	366	--	--	378	3.23
Guernsey	1	412	4	532	--	--	772	170	--	1	943	5.38
Harrison	5	3,672	11	5,465	--	41	8,245	934	--	--	9,178	5.57
Hocking	--	--	4	170	--	--	--	170	--	--	170	4.34
Holmes	--	--	6	785	--	--	66	719	--	--	785	4.71
Jackson	6	240	9	1,059	--	24	673	649	--	--	1,322	4.49
Jefferson	3	639	31	4,468	8	250	2,414	2,766	175	1	5,356	5.13
Lawrence	--	--	3	200	--	--	110	89	--	--	200	4.54
Mahoning	--	--	9	438	1	18	73	383	--	--	456	4.80
Meigs	--	--	1	1	--	--	--	1	--	--	1	4.62
Monroe	1	47	--	--	--	--	47	--	--	--	47	10.49
Morgan	--	--	1	549	--	--	549	--	--	--	549	5.97
Muskingum	1	37	9	5,674	--	--	963	566	4,182	--	5,711	5.26
Noble	--	--	5	2,165	--	--	810	898	456	--	2,165	4.76
Perry	1	1,853	15	1,150	1	33	1,871	1,143	22	--	3,036	5.07
Scioto	--	--	1	1	--	--	--	1	--	--	1	3.00
Stark	--	--	11	729	--	--	--	729	--	--	729	4.28
Tuscarawas	2	231	32	1,944	4	166	375	1,966	--	1	2,341	4.97
Vinton	--	--	12	723	--	--	87	636	--	--	723	4.66
Washington	--	--	1	228	--	--	--	228	--	--	228	4.25
Wayne	--	--	1	30	--	--	--	30	--	--	30	4.00
Total [3]	35	12,862	237	37,595	30	973	30,080	15,416	5,930	4	51,431	5.24

Oklahoma:												
Craig	--	--	2	918	--	--	918	--	--	--	918	5.12
Haskell	1	22	2	339	1	2	363	--	--	2	363	8.89
Le Flore	2	172	--	--	--	--	172	--	--	--	172	14.50
Muskogee	--	--	1	2	--	--	--	2	--	--	2	9.00
Rogers	--	--	2	780	--	--	773	6	--	--	780	5.88
Total [3]	3	193	7	2,039	1	2	2,224	8	--	2	2,234	6.72
Pennsylvania:												
Allegheny	8	3,280	6	730	--	--	2,692	1,319	--	--	4,011	9.02
Armstrong	19	4,679	57	2,628	17	164	2,141	1,994	3,141	195	7,471	6.80
Beaver	1	163	5	87	2	8	--	258	--	--	258	7.83
Bedford	2	4	--	--	--	--	--	4	--	--	4	10.00
Butler	6	577	27	876	2	36	969	519	--	--	1,489	6.35
Cambria	23	5,581	17	757	--	--	5,668	664	--	6	6,338	12.67
Centre	2	385	16	778	--	--	628	535	--	--	1,163	6.22
Clarion	1	3	42	4,198	--	--	3,455	745	--	--	4,201	7.09
Clearfield	11	1,100	93	5,697	6	62	4,499	2,292	--	67	6,859	6.68
Clinton	--	--	5	406	--	--	359	47	--	--	406	6.28
Elk	1	5	7	344	3	36	200	185	--	--	385	6.86
Fayette	4	657	49	890	2	14	1,009	544	--	9	1,562	8.36
Fulton	--	--	1	3	--	--	--	3	--	--	3	6.57
Greene	15	7,474	16	906	--	--	7,606	362	404	7	8,380	9.55
Indiana	35	6,111	34	1,375	7	78	3,442	658	3,463	--	7,563	9.65
Jefferson	7	161	35	1,198	7	59	1,313	98	--	7	1,418	7.34
Lawrence	--	--	12	744	5	28	--	772	--	--	772	4.91
Lycoming	--	--	2	83	--	--	20	64	--	--	83	4.00
Mercer	--	--	4	407	--	--	203	204	--	--	407	6.42
Somerset	27	1,135	46	2,678	3	27	3,045	783	--	13	3,840	7.51
Tioga	--	--	2	986	--	--	--	986	--	--	986	4.40
Venango	--	--	8	369	--	--	38	331	--	--	369	5.27
Washington	12	11,231	16	1,217	3	33	11,224	608	645	4	12,481	9.15
Westmoreland	7	1,743	27	645	--	--	1,506	867	13	2	2,388	8.73
Total [3]	181	44,289	527	28,002	57	544	50,017	14,841	7,667	311	72,835	8.52
Tennessee:												
Anderson	22	1,109	15	1,037	4	117	522	1,741	--	--	2,262	6.85
Bledsoe	--	--	1	44	--	--	44	--	--	1	44	5.56
Campbell	9	109	25	1,718	3	157	825	1,159	--	--	1,985	7.11
Claiborne	2	1,156	8	962	--	--	1,917	202	--	--	2,119	5.94
Cumberland	1	3	1	5	--	--	--	8	--	--	8	6.37
Fentress	3	34	2	103	--	--	75	63	--	--	137	6.05
Grundy	1	39	2	96	--	--	88	47	--	--	135	6.47
Hamilton	1	11	2	36	1	6	--	54	--	--	54	6.76
Marion	19	636	--	--	--	--	564	72	--	--	636	6.40
Morgan	7	102	13	346	--	--	--	448	--	--	448	6.27
Putnam	1	97	--	--	--	--	--	15	82	--	97	6.00
Roane	1	18	--	--	--	--	--	18	--	--	18	6.92
Scott	2	16	20	587	2	18	563	58	--	--	622	5.37
Sequatchie	8	211	2	186	1	18	363	51	--	2	415	5.69

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, 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						
Tennessee—Continued												
Van Buren	1	2	3	223	--	--	87	138	--	--	225	$4.86
White	--	--	3	66	--	--	8	58	--	--	66	6.25
Total [3]	78	3,543	97	5,412	11	316	5,055	4,131	82	3	9,271	6.40
Utah:												
Carbon	11	3,601	1	6	--	--	3,099	161	330	18	3,608	7.52
Emery	7	836	--	--	--	--	624	210	--	2	836	6.99
Kane	1	12	--	--	--	--	--	--	--	12	12	8.88
Sevier	1	158	--	--	--	--	40	118	--	--	158	6.00
Summit	1	12	--	--	--	--	--	12	--	--	12	5.43
Total [3]	21	4,620	1	6	--	--	3,763	501	330	32	4,626	7.37
Virginia:												
Buchanan	235	9,944	59	1,370	43	960	11,718	557	--	--	12,275	8.61
Dickenson	26	4,134	29	1,276	16	208	5,553	65	--	--	5,618	9.00
Lee	24	476	12	326	7	73	758	117	--	--	875	6.92
Russell	11	1,817	12	636	7	76	2,424	105	--	--	2,529	9.19
Scott	1	15	--	--	--	--	5	--	--	10	15	6.56
Tazewell	10	837	12	501	2	41	1,162	218	--	--	1,380	8.19
Wise	48	4,408	88	3,059	28	470	7,721	214	--	2	7,936	7.29
Total [3]	355	21,631	212	7,168	103	1,829	29,340	1,276	--	12	30,628	8.32
Washington:												
King	2	32	--	--	--	--	--	32	--	--	32	W
Lewis	--	--	2	1,102	--	--	--	9	1,093	--	1,102	W
Total	2	32	2	1,102	--	--	--	41	1,093	--	1,134	6.72
West Virginia:												
Barbour	17	1,395	20	1,952	--	--	3,300	45	--	2	3,347	7.52
Boone	44	7,032	22	1,956	23	785	9,522	239	--	12	9,773	8.80
Braxton	--	--	1	22	--	--	--	22	--	--	22	6.00
Brooke	2	511	8	282	--	--	255	61	477	--	793	6.00
Clay	2	44	1	74	--	--	118	--	--	--	118	7.49
Fayette	31	2,442	18	2,434	3	57	4,851	81	--	1	4,932	9.49
Gilmer	3	25	2	80	--	--	104	--	--	--	104	5.96
Grant	3	1,519	7	467	--	--	1,832	31	122	--	1,986	7.18
Greenbrier	10	208	3	284	--	--	456	36	--	--	492	8.93
Harrison	15	4,529	24	1,171	2	43	5,673	70	--	--	5,744	7.23
Kanawha	46	6,386	17	1,671	26	1,172	9,173	54	--	2	9,229	8.35
Lewis	1	3	10	468	5	87	520	37	--	--	557	6.74

Logan	45	8,353	12	1,206	15	799	10,221	135	--	2	10,358	10.93
McDowell	117	12,474	18	982	5	28	13,186	187	--	111	13,484	14.27
Marion	9	6,905	4	157	--	--	6,896	163	--	3	7,062	7.86
Marshall	4	4,805	--	--	--	--	1,777	--	3,029	--	4,805	6.20
Mason	2	420	--	--	--	--	420	--	--	--	420	8.50
Mercer	4	750	3	81	1	2	830	--	--	3	833	13.27
Mineral	1	111	9	259	--	--	229	142	--	--	371	5.52
Mingo	31	2,050	14	903	9	487	2,809	631	--	--	3,440	8.29
Monongalia	18	10,160	10	418	--	--	10,252	226	97	5	10,578	6.54
Nicholas	47	4,418	14	836	3	88	5,247	94	--	--	5,342	9.96
Ohio	2	1,797	--	--	--	--	1,696	--	99	2	1,797	7.75
Pocahontas	1	7	--	--	--	--	7	--	--	--	7	12.00
Preston	24	656	26	1,366	--	--	1,068	924	30	--	2,022	5.91
Raleigh	39	5,148	15	1,531	11	309	6,712	247	--	29	6,988	11.99
Randolph	15	335	10	525	--	--	808	51	--	1	860	7.62
Taylor	--	--	6	190	--	--	186	5	--	--	190	7.50
Tucker	--	--	3	376	--	--	360	16	--	--	376	6.00
Upshur	4	287	16	889	--	--	1,150	26	--	--	1,176	6.67
Wayne	2	275	1	9	1	1	259	25	--	--	284	10.91
Webster	11	120	3	52	--	--	112	57	--	3	171	9.47
Wyoming	74	9,271	16	1,106	9	215	10,243	329	--	23	10,594	12.51
Total [3]	624	92,437	313	21,747	113	4,074	110,274	3,932	3,854	198	118,258	9.54
Wyoming:												
Campbell	--	--	1	647	--	--	427	11	209	1	647	1.49
Carbon	1	46	2	1,813	--	--	1,856	--	--	3	1,859	5.00
Converse	--	--	1	1,730	--	--	--	--	1,730	--	1,730	3.45
Hot Springs	2	8	--	--	--	--	--	8	--	--	8	9.40
Lincoln	--	--	2	1,504	--	--	191	--	1,313	--	1,504	4.14
Sheridan	--	--	2	1,777	--	--	1,756	22	--	--	1,777	3.32
Sweetwater	1	88	1	429	1	12	501	--	--	27	529	2.77
Total [3]	4	141	9	7,899	1	12	4,729	40	3,251	31	8,052	3.39
Total United States [3]	2,268	275,888	2,290	258,972	591	17,332	441,018	60,323	47,727	3,124	552,192	7.07

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 to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, and used for all other purposes at mine.
[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.

Table 18.—Number and production of bituminous coal and lignite strip mines and units of stripping and loading equipment, by State

State	Number of strip mines	Production (thousand short tons)	Number of power shovels and dragline excavators: By type of power: Electric	Diesel electric	Diesel	Gasoline	By capacity of dipper or bucket, cubic yards: Less than 5	6–15	16–50	More than 50	By type of machine: Power shovels	Dragline excavators	Total	Number of carry-all scrapers	Number of bull-dozers	Front-end loaders	Wheel excavators	Power brooms	Motor graders	Coal drills
Alabama	95	11,121	11	20	128	--	66	60	31	2	106	53	159	5	196	92	--	9	10	1
Alaska	4	698	--	--	4	--	1	3	--	--	4	--	4	6	13	8	--	--	3	--
Arizona	1	1,146	3	1	--	--	--	3	1	--	2	2	4	--	4	2	--	--	1	1
Arkansas	6	236	1	--	7	--	2	6	--	--	2	6	8	--	12	7	--	1	3	--
Colorado	9	2,008	7	--	5	--	5	6	1	--	6	6	12	2	21	10	--	--	4	7
Illinois	36	28,956	70	13	23	--	23	32	30	21	60	46	106	4	171	41	12	4	34	13
Indiana	34	19,631	46	5	42	5	50	23	14	11	57	41	98	1	134	40	--	--	20	2
Iowa	11	571	--	--	23	1	22	2	--	--	10	14	24	2	21	14	--	--	5	10
Kansas	4	1,151	7	--	2	--	4	3	1	1	5	4	9	--	17	7	--	--	3	--
Kentucky:																				
Eastern	528	24,981	--	--	728	51	747	31	1	--	763	16	779	10	476	214	5	5	43	10
Western	85	31,785	56	7	127	2	122	42	18	10	155	37	192	10	214	77	--	--	32	5
Total	613	56,766	56	7	855	53	869	73	19	10	918	53	971	20	690	291	5	5	75	15
Maryland	39	1,365	--	6	53	1	56	4	--	--	43	17	60	--	62	32	--	--	5	5
Missouri	10	4,036	18	1	4	2	10	9	5	1	16	9	25	13	35	14	--	--	8	--
Montana:																				
Bituminous	4	6,717	8	--	--	--	2	4	2	--	5	3	8	1	11	4	--	--	2	2
Lignite	2	327	1	--	1	--	1	1	--	--	1	1	2	1	2	3	--	1	1	2
Total	6	7,044	9	--	1	--	3	5	2	--	6	4	10	2	13	7	--	1	3	4
New Mexico	2	7,198	8	--	1	--	--	4	5	--	5	4	9	--	7	8	--	1	4	1
North Dakota (lignite)	15	6,075	20	1	13	4	23	10	5	--	23	15	38	15	26	16	--	2	13	8
Ohio	237	37,595	41	25	416	21	373	110	15	5	376	127	503	79	561	253	4	16	74	6
Oklahoma	7	2,039	7	2	5	--	6	3	5	--	8	6	14	2	16	13	--	1	4	--
Pennsylvania	527	28,002	13	43	713	24	591	196	6	--	467	326	793	38	849	328	11	5	51	5
Tennessee	97	5,412	1	3	135	1	115	24	1	--	125	15	140	13	174	70	--	2	20	--
Utah	1	6	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--
Virginia	212	7,168	--	--	190	24	204	10	--	--	214	--	214	3	177	96	3	3	14	2
Washington	2	1,102	2	--	2	--	2	1	--	1	3	1	4	6	10	4	1	--	2	--
West Virginia	313	21,747	--	22	435	11	397	70	1	--	433	35	468	13	466	267	14	10	66	25
Wyoming	9	7,899	10	--	7	1	9	8	1	--	11	7	18	29	23	10	--	3	13	7
Total	2,290	258,972	330	149	3,064	148	2,831	665	143	52	2,900	791	3,691	258	3,700	1,630	50	63	435	112

Table 19.—Bituminous coal and lignite strip mines using power drills in bank or overburden, by State

State	Number of mines		Production: Quantity (thousand short tons)		Number of power drills: Horizontal		Vertical		Total	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
Alabama	51	55	7,173	10,138	7	9	50	74	57	83
Alaska	3	4	549	698	1	2	3	4	4	6
Arizona	1	1	132	1,146	--	--	2	2	2	2
Arkansas	4	6	194	236	1	--	4	7	5	7
Colorado	7	7	2,165	2,004	2	7	9	4	11	11
Illinois	26	24	32,750	28,192	21	20	27	32	48	52
Indiana	25	24	18,241	19,562	9	6	36	27	45	33
Iowa	9	10	544	562	8	8	9	12	17	20
Kansas	5	4	1,627	1,152	9	7	1	1	10	8
Kentucky:										
Eastern	65	48	6,182	6,725	30	14	45	53	75	67
Western	30	36	24,099	29,821	12	12	48	61	60	73
Total	95	84	30,281	36,546	42	26	93	114	135	140
Maryland	8	4	500	539	2	2	4	5	6	7
Missouri	9	9	4,447	4,028	9	9	6	5	15	14
Montana:										
Bituminous	2	2	3,096	6,657	--	--	4	3	4	3
Lignite	--	--	--	--	--	--	--	--	--	--
Total	2	2	3,096	6,657	--	--	4	3	4	3
New Mexico	2	2	6,406	7,198	2	2	1	--	3	2
North Dakota (lignite)	2	2	7	2,403	1	--	1	6	2	6
Ohio	101	80	30,589	24,762	43	40	99	97	142	137
Oklahoma	6	6	2,197	2,035	7	6	6	7	13	13
Pennsylvania	225	120	14,467	16,322	40	32	138	116	178	148
Tennessee	44	43	2,160	3,823	22	19	31	40	53	59
Virginia	19	53	2,247	3,816	7	20	24	40	31	60
West Virginia	118	111	11,710	14,105	39	46	95	117	134	163
Wyoming	5	7	4,492	7,231	4	3	6	15	10	18
Total	767	658	175,974	193,155	276	264	649	728	925	992

Table 20.—Equipment used at bituminous coal and lignite auger mines, by number of units

State	Augers	Power shovels	Power drills	Bulldozers	Front-end loaders	Power brooms	Motor graders
Alabama	4	--	--	4	3	--	--
Kentucky	374	12	4	145	38	--	1
Maryland	7	--	--	--	1	--	--
Ohio	38	1	--	23	7	--	2
Oklahoma	1	--	--	--	--	--	--
Pennsylvania	58	1	--	45	7	--	--
Tennessee	12	2	2	15	10	--	1
Virginia	106	--	1	65	34	--	2
West Virginia	122	1	4	82	22	--	5
Wyoming	1	--	--	1	--	--	--
Total	723	17	11	380	122	--	11

Table 21.—Bituminous coal and lignite mechanically loaded underground in the United States, by type of loading equipment

(Thousand short tons)

Type of loading equipment	1970	1971
Mobile loading machines:		
Direct into mine cars or onto conveyors	23,303	10,857
Into shuttle cars	128,073	100,210
Continuous-mining machines:		
Onto conveyors	13,871	10,857
Into shuttle cars or rubber-tired mine cars	128,214	116,079
Onto bottom	27,810	26,007
Longwall machines	7,132	6,552
Duckbills, scraper loaders, hand-loaded conveyors	784	334
Total mechanically loaded	[1] 329,189	270,896

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

Table 22.—Comparative changes in underground mechanical loading of bituminous coal and lignite by principal types of loading devices by State

(Thousand short tons)

State	Mobile loading machines		Continuous-mining machines		Longwall machines		Duckbills, scraper loaders, hand-loaded conveyors		Total mechanically loaded		Total production at mines using mechanical loading devices	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
Alabama	8,257	6,125	674	591	--	--	38	--	8,969	6,716	8,969	6,716
Arkansas	--	--	--	--	--	--	51	--	51	--	51	--
Colorado	724	257	3,086	2,789	--	255	37	14	3,847	3,315	3,847	3,315
Illinois	13,563	9,122	18,510	20,324	20	--	--	--	32,093	29,446	32,093	29,446
Indiana	1,563	658	531	1,107	--	--	--	--	2,094	1,765	2,094	1,765
Iowa	421	418	--	--	--	--	--	--	421	418	421	418
Kentucky	45,913	39,484	11,196	11,074	353	--	72	27	57,534	50,585	57,534	50,610
Maryland	127	46	65	111	--	--	2	--	193	157	193	157
Montana	14	11	--	--	--	--	14	9	28	20	28	20
New Mexico	--	--	938	977	--	--	--	--	938	977	938	977
Ohio	7,474	5,372	10,575	7,475	--	--	--	--	18,050	12,847	18,050	12,847
Oklahoma	--	--	219	193	--	--	--	--	219	193	219	193
Pennsylvania	7,120	4,573	46,114	37,570	1,919	1,925	80	51	55,233	44,119	55,233	44,126
Tennessee	3,237	2,729	866	656	--	--	86	11	4,189	3,396	4,189	3,396
Utah	480	369	3,321	3,494	909	735	10	10	4,720	4,608	4,731	4,608
Virginia	14,326	10,753	10,079	9,235	1,555	1,139	60	40	26,020	21,167	26,020	21,167
Washington	17	26	--	--	--	--	14	4	32	30	32	30
West Virginia	48,027	31,033	63,723	57,299	2,376	2,499	314	165	114,440	90,996	114,611	91,018
Wyoming	112	92	--	45	--	--	5	4	118	141	118	141
Total [1]	151,375	111,068	169,897	152,940	7,132	6,553	[r] 783	334	329,189	270,896	329,371	270,951

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

Table 23.—Number of bituminous coal and lignite underground mines using mechanical loading devices and number of units in use, by State

State	Number of mines									
	Using mobile loading machines		Using continuous-mining machines only		Using duckbills, scraper loaders, and hand-loaded conveyors only		Using more than one type of loading device		Total	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
Alabama	8	8	--	--	4	--	4	3	16	11
Arkansas	--	--	--	--	2	--	--	--	2	--
Colorado	14	8	13	13	5	3	4	4	36	28
Illinois	9	10	8	12	--	--	10	5	27	27
Indiana	5	2	--	1	--	--	1	1	6	4
Iowa	2	2	--	--	--	--	--	--	2	2
Kentucky	474	379	39	50	1	2	7	13	[1] 523	444
Maryland	3	3	2	2	--	--	1	--	6	5
Montana	2	2	--	--	2	2	--	--	4	4
New Mexico	--	--	1	1	--	--	--	--	1	1
Ohio	14	13	12	13	--	--	3	4	29	30
Oklahoma	--	--	2	3	--	--	--	--	2	3
Pennsylvania	31	31	90	95	9	10	19	14	149	150
Tennessee	17	45	--	--	3	2	1	1	21	48
Utah	4	5	11	10	--	--	5	3	20	18
Virginia	299	168	55	46	2	2	11	75	367	291
Washington	--	--	--	--	--	--	1	1	1	1
West Virginia	279	189	r 112	135	7	4	81	104	r 479	432
Wyoming	2	2	--	1	2	1	--	--	4	4
Total	1,163	867	r 345	382	37	26	148	228	r [2]1,695	1,503

State	Number of loading devices							
	Mobile loading machines		Continuous-mining machines		Longwall machines		Duckbills, scraper loaders, and hand-loaded conveyors	
	1970	1971	1970	1971	1970	1971	1970	1971
Alabama	70	77	9	8	--	--	6	--
Arkansas	--	--	--	--	--	--	4	--
Colorado	47	40	37	38	--	1	11	5
Illinois	77	53	97	119	1	--	--	--
Indiana	22	12	5	7	--	--	--	--
Iowa	3	3	--	--	--	--	--	--
Kentucky	690	617	111	129	5	--	7	4
Maryland	7	7	2	2	--	--	2	--
Montana	4	4	--	--	--	--	6	6
New Mexico	5	6	5	6	--	--	--	--
Ohio	66	66	83	100	--	--	--	--
Oklahoma	--	--	6	8	--	--	--	--
Pennsylvania	152	120	464	501	10	9	19	10
Tennessee	32	63	5	5	--	--	5	3
Utah	25	17	31	36	2	3	3	3
Virginia	366	266	116	139	4	7	4	4
Washington	1	1	--	--	--	--	1	1
West Virginia	849	710	595	681	12	14	33	19
Wyoming	4	3	--	2	--	--	5	1
Total	2,420	2,065	1,566	1,781	34	34	106	56

r Revised.
[1] Includes two mines using longwall machines only.
[2] Data may not add to total shown because of independent rounding.

Table 24.—Production at bituminous coal and lignite underground mines, by State and method of loading

(Thousand short tons)

State	Hand-loaded 1970	Hand-loaded 1971	Mechanically loaded 1970	Mechanically loaded 1971	Total underground production 1970	Total underground production 1971
Alabama	109	35	8,969	6,716	9,078	6,751
Arkansas	--	41	51	--	51	41
Colorado	11	14	3,847	3,315	3,858	3,329
Illinois	--	--	32,093	29,446	32,093	29,446
Indiana	--	--	2,094	1,765	2,094	1,765
Iowa	2	--	421	418	423	418
Kentucky	5,076	2,631	57,534	50,585	62,610	53,216
Maryland	45	19	193	157	238	176
Montana	--	--	28	20	28	20
New Mexico	--	--	938	977	938	977
Ohio	61	15	18,050	12,847	18,111	12,862
Oklahoma	--	--	219	193	219	193
Pennsylvania	149	170	55,233	44,119	55,382	44,289
Tennessee	161	147	4,189	3,396	4,350	3,543
Utah	13	12	4,720	4,608	4,733	4,620
Virginia	1,998	464	26,020	21,167	28,018	21,631
Washington	--	2	32	30	32	32
West Virginia	1,974	1,441	114,440	90,996	116,414	92,437
Wyoming	--	--	118	141	118	141
Total	9,599	4,992	329,189	270,896	338,788	[1] 275,888

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

Table 25.—Mechanical cleaning at bituminous coal and lignite mines, by State

(Thousand short tons)

State	Total production	Mechanical cleaning: Number of cleaning plants	Raw coal	Cleaned coal	Refuse
Alabama	17,945	22	15,110	9,142	5,968
Alaska	698	2	225	152	73
Colorado	5,337	3	2,035	1,780	255
Illinois	58,402	40	58,287	45,336	12,949
Indiana	21,396	11	21,589	16,547	5,043
Kansas	1,151	2	1,721	1,146	576
Kentucky	119,389	50	46,589	36,114	10,474
Missouri	4,036	4	2,677	2,004	673
New Mexico	8,175	1	1,131	977	154
Ohio	51,431	20	15,223	10,938	4,285
Oklahoma	2,234	4	790	428	362
Pennsylvania	72,835	68	57,223	42,632	14,592
Tennessee	9,271	2	1,390	1,120	270
Utah	4,626	7	4,784	4,156	628
Virginia	30,628	30	21,207	16,171	5,036
Washington	1,134	2	1,660	1,123	537
West Virginia	118,258	142	109,466	81,576	27,890
Wyoming	8,052	1	63	61	2
Other States [1]	17,194	--	--	--	--
Total [2]	552,192	411	361,168	271,401	89,766

[1] Includes Arkansas, Arizona, Iowa, Maryland, and bituminous coal and lignite from Montana, and North Dakota.

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

Table 26.—Mechanical cleaning of bituminous coal and lignite in the United States, by type of equipment

(Thousand short tons)

Type of equipment	1970	1971
Wet methods:		
Jigs	140,457	115,407
Concentrating tables	44,058	35,656
Classifiers	3,593	2,071
Launders	5,199	4,896
Dense medium processes:		
Magnetite	76,590	70,262
Sand	23,290	17,802
Calcium chloride	1,714	1,702
Total [1]	101,593	89,764
Flotation	10,694	9,098
Total, wet methods	305,594	256,892
Pneumatic methods	17,855	14,506
Grand total [1]	323,452	271,401

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

Table 27.—Mechanical cleaning at bituminous coal and lignite mines, by State and underground, strip, and auger 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	6,751	6,386	11,121	2,756	73	--	17,945	9,142
Alaska	--	--	698	152	--	--	698	152
Colorado	3,329	1,712	2,008	68	--	--	5,337	1,780
Illinois	29,446	19,549	28,956	25,788	--	--	58,402	45,336
Indiana	1,765	796	19,631	15,751	--	--	21,396	16,547
Kansas	--	--	1,151	1,146	--	--	1,151	1,146
Kentucky	53,216	22,360	56,766	13,705	9,406	49	119,389	36,114
Missouri	--	--	4,036	2,004	--	--	4,036	2,004
New Mexico	977	977	7,198	--	--	--	8,175	977
Ohio	12,862	8,482	37,595	2,367	973	89	51,431	10,938
Oklahoma	193	193	2,039	234	2	--	2,234	428
Pennsylvania	44,289	35,535	28,002	7,092	544	5	72,835	42,632
Tennessee	3,543	1,120	5,412	--	316	--	9,271	1,120
Utah	4,620	4,156	6	--	--	--	4,626	4,156
Virginia	21,631	16,171	7,168	--	1,829	--	30,628	16,171
Washington	32	30	1,102	1,093	--	--	1,134	1,123
West Virginia	92,437	76,255	21,747	4,779	4,074	542	118,258	81,576
Wyoming	141	61	7,899	--	12	--	8,052	61
Other States [2]	655	--	16,437	--	102	--	17,194	--
Total [1]	275,888	193,782	258,972	76,934	17,332	685	552,192	271,401

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Arkansas, Arizona, Iowa, Maryland, and bituminous coal and lignite from Montana and North Dakota.

Table 28.—Mechanical crushing of bituminous coal and lignite at mines, by State

State	Number of plants crushing coal		Coal crushed (thousand short tons)	
	1970	1971	1970	1971
Alabama	26	39	7,838	12,801
Alaska	3	2	670	406
Arizona	--	1	--	1,146
Arkansas	4	5	178	237
Colorado	28	25	3,450	3,475
Illinois	50	37	41,035	36,150
Indiana	21	22	13,600	15,361
Iowa	11	9	838	570
Kansas	1	3	250	1,146
Kentucky	145	153	43,070	56,993
Maryland	12	14	754	783
Missouri	8	7	2,896	3,978
Montana:				
Bituminous	6	3	845	6,661
Lignite	2	2	200	325
Total	8	5	1,045	6,986
New Mexico	4	3	4,456	8,175
North Dakota (lignite)	14	11	4,567	5,119
Ohio	98	92	26,106	28,036
Oklahoma	6	7	1,500	2,019
Pennsylvania	154	188	36,950	48,532
Tennessee	43	19	3,935	2,780
Utah	14	15	1,595	5,189
Virginia	65	52	16,056	15,707
Washington	2	2	4	39
West Virginia	225	210	50,967	59,565
Wyoming	11	11	2,422	7,998
Total	953	932	264,182	323,191

Table 29.—Thermal drying of bituminous coal and lignite in the United States, by type of drying equipment

Type of drier	Number of thermal drying units		Thermally dried (thousand short tons)	
	1970	1971	1970	1971
Fluidized-bed	75	77	42,595	32,564
Multilouver	24	20	8,554	6,337
Rotary	4	4	876	835
Screen	16	10	4,806	1,176
Suspension or flash	29	32	5,410	5,432
Vertical tray and cascade	15	16	1,924	1,761
Total	163	159	64,165	48,105

Table 30.—Comparison of thermal drying of bituminous coal and lignite with mechanical cleaning at mines, by State

(Thousand short tons)

State	Number of cleaning plants				Production mechanically cleaned		Thermally dried	
	Total		With thermal drying					
	1970	1971	1970	1971	1970	1971	1970	1971
Colorado	3	3	1	1	2,029	1,780	648	600
Illinois	39	40	16	11	51,151	45,336	10,129	5,254
Indiana	12	11	3	2	17,711	16,547	1,942	426
Kentucky	49	50	9	8	40,094	36,114	3,296	2,532
North Dakota (lignite)	--	--	2	2	--	--	199	155
Ohio	18	20	6	5	14,528	10,938	3,555	1,898
Pennsylvania	74	68	9	9	51,284	42,632	6,143	6,056
Utah	7	7	2	2	3,434	4,156	1,120	838
Virginia	33	30	10	10	20,978	16,171	8,589	6,984
West Virginia	136	142	53	53	102,259	81,576	28,544	23,362
Other States	44	40	--	--	19,984	16,153	--	--
Total	415	411	111	103	323,452	[1] 271,401	64,165	48,105

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

Table 31.—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	
	1970	1971	1970	1971	1970	1971
Colorado	1	1	6,025	5,337	648	600
Illinois	24	18	65,119	58,402	10,129	5,254
Indiana	4	3	22,263	21,396	1,942	426
Kentucky	12	10	125,305	119,389	3,296	2,532
North Dakota (lignite)	2	2	5,639	6,075	199	155
Ohio	13	10	55,351	51,431	3,555	1,898
Pennsylvania	11	11	80,491	72,835	6,143	6,056
Utah	2	2	4,733	4,626	1,120	838
Virginia	23	23	35,016	30,628	8,589	6,984
West Virginia	71	79	144,072	118,258	28,544	23,362
Other States	--	--	58,918	63,814	--	--
Total	163	159	602,932	[1] 552,192	64,165	48,105

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

Table 32.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, as reported by mine operators

(Thousand short tons)

Route	State	By State	Total for route
RAILROAD			
Alaska	Alaska	562	562
Atchison, Topeka & Santa Fe	Illinois	179	1,689
	New Mexico	1,510	
Baltimore & Ohio	Illinois	181	28,113
	Maryland	5	
	Ohio	9,035	
	Pennsylvania	3,624	
	West Virginia	15,268	
Bevier & Southern	Missouri	963	963
Bessemer & Lake Erie	Pennsylvania	1,673	1,673
Burlington Northern	Illinois	8,604	20,579
	Iowa	274	
	Montana (bituminous and lignite)	6,981	
	North Dakota (lignite)	2,538	
	Wyoming	2,182	
Cambria & Indiana	Pennsylvania	2,219	2,219
Carbon County	Utah	593	593
Chesapeake & Ohio	Kentucky	21,763	56,045
	Ohio	5	
	West Virginia	34,277	
Chicago & Eastern Illinois	Illinois	1,840	1,840
Chicago & Illinois Midland	Illinois	989	989
Chicago, Milwaukee, St. Paul & Pacific	Indiana	2,728	2,843
	North Dakota (lignite)	115	
Chicago & North Western	Illinois	4,599	4,599
Chicago, Rock Island & Pacific	Iowa	163	163
Clinchfield	Kentucky	289	5,262
	Virginia	4,973	
Colorado & Wyoming	Colorado	510	510
Denver & Rio Grande Western	Colorado	3,350	5,208
	Utah	1,858	
Erie-Lackawanna	Ohio	316	316
Gulf, Mobile & Ohio	Illinois	5,028	5,028
Illinois Central	Illinois	16,057	26,620
	Kentucky	10,563	
Interstate	Virginia	3,653	3,653
Kansas City Southern	Oklahoma	317	317
Kentucky & Tennessee	Kentucky	567	567
Lake Erie, Franklin & Clarion	Pennsylvania	488	488
Louisville & Nashville	Alabama	3,566	49,784
	Indiana	2,207	
	Kentucky	43,223	
	Tennessee	690	
	Virginia	98	
Mary Lee	Alabama	707	707
Missouri Illinois	Illinois	1,827	1,827
Missouri-Kansas-Texas	Kansas	764	1,296
	Missouri	443	
	Oklahoma	89	

Table 32.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, as reported by mine operators—Continued

(Thousand short tons)

Route	State	By State	Total for route
RAILROAD—Continued			
Missouri Pacific	Arkansas	245	
	Illinois	4,692	5,157
	Missouri	5	
	Oklahoma	215	
Monon	Indiana	632	632
Monongahela	West Virginia	6,339	6,339
Montour	Pennsylvania	2,548	2,548
Norfolk & Western	Iowa	57	
	Kentucky	11,204	
	Missouri	414	
	Ohio	6,628	67,134
	Virginia	18,113	
	West Virginia	30,718	
Penn Central (includes coal shipped over Kanawha & Michigan, Kelley's Creek, Toledo & Ohio Central, and Zanesville and Western).	Illinois	2,067	
	Indiana	7,632	
	Ohio	9,924	45,650
	Pennsylvania	21,656	
	West Virginia	4,371	
Pittsburgh & Shawmut	Pennsylvania	2,503	2,503
St. Louis-San Francisco	Alabama	279	
	Kansas	311	2,193
	Oklahoma	1,603	
Soo Line	North Dakota (lignite)	433	433
Southern	Alabama	2,875	
	Indiana	3,257	
	Kentucky	684	12,544
	Tennessee	3,224	
	Virginia	2,504	
Tennessee	Tennessee	403	403
Tennessee Coal, Iron & Railroad Co	Alabama	1,553	1,553
Toledo, Peoria & Western	Illinois	121	121
Union Pacific	Colorado	196	2,742
	Wyoming	2,546	
Unity	Pennsylvania	360	360
Utah	Utah	1,312	1,312
Western Maryland	Maryland	793	
	Pennsylvania	353	5,403
	West Virginia	4,257	
Woodward Iron Company	Alabama	721	721
Total railroad shipments		382,201	382,201
WATERWAY			
Allegheny River	Pennsylvania	820	820
Arkansas River	Arkansas	18	18
Black Warrior River	Alabama	3,270	3,270
Green River	Kentucky	13,415	13,415
Illinois River	Illinois	1,404	1,404
Kanawha River	West Virginia	3,957	3,957
Monongahela River	Pennsylvania	13,774	21,650
	West Virginia	7,876	
Ohio River	Illinois	2,134	
	Kentucky	3,109	
	Ohio	4,172	12,627
	West Virginia	3,212	
Tennessee River	Alabama	918	1,656
	Tennessee	738	
Total waterway shipments		58,817	58,817
Total loaded at mines for shipment by railroads and waterways.		441,018	441,018
Shipped by truck from mine to final destination		60,323	60,323
Coal transported to electric utility plants adjacent to or near the mine.		47,727	47,727
Used at mine [1]		3,124	3,124
Total production		552,192	552,192

[1] Includes coal used at mine for power and heat, made into beehive coke at mine, by mine employees used for all other purposes at mine.

Table 33.—Bituminous coal and lignite shipped by unit train

(Thousand short tons)

State	1970	1971
Alabama	3,088	3,373
Arkansas	--	89
Colorado	2,427	1,692
Illinois	17,217	17,329
Indiana	2,997	2,351
Kansas	--	762
Kentucky:		
Eastern	9,361	11,164
Western	8,762	7,730
Total	18,123	18,894
Maryland	232	210
Montana (bituminous)	3,022	6,526
New Mexico	1,130	1,034
North Dakota (lignite)	916	923
Ohio	13,308	16,688
Oklahoma	974	910
Pennsylvania	21,325	19,125
Tennessee	398	1,343
Utah	2,055	1,825
Virginia	5,861	2,525
West Virginia	30,110	26,793
Wyoming	107	441
Total [1]	123,289	122,832

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

Table 34.—Consumption of bituminous coal and lignite, by consumer class, with 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 [6]
1967	271,784	467	1,372	90,900	6,330	92,464	17,099	480,416
1968	294,739	417	1,268	89,497	5,657	92,028	15,224	498,830
1969	308,461	313	1,158	91,743	5,560	85,374	14,666	507,275
1970:								
January	r 30,008	--	133	7,659	702	7,707	2,078	r 48,287
February	r 25,993	--	126	7,238	577	6,959	1,481	r 42,374
March	r 26,508	3	123	8,116	582	7,166	1,072	r 43,570
April	r 24,039	28	123	7,853	510	7,079	540	r 40,172
May	r 24,019	40	114	8,099	410	6,657	203	r 39,542
June	r 25,453	39	114	7,786	353	6,240	504	r 40,489
July	r 27,434	40	117	7,841	332	5,913	516	r 42,193
August	r 28,280	37	114	7,822	327	5,984	672	r 43,236
September	r 26,298	37	117	7,809	328	5,997	1,038	r 41,624
October	r 25,080	37	122	8,216	369	7,197	1,339	r 42,360
November	r 26,429	27	113	7,957	385	7,607	1,300	r 43,818
December	r 29,380	10	112	8,185	535	8,403	1,329	r 47,954
Total	r 318,921	298	1,428	94,581	5,410	82,909	12,072	r 515,619
1971:								
January	30,804	2	107	8,169	729	8,427	1,786	50,024
February	27,127	--	120	7,298	680	7,660	1,340	44,225
March	28,040	5	126	8,255	693	7,777	876	45,772
April	25,103	25	110	8,047	555	6,810	490	41,140
May	24,808	26	125	8,182	465	6,011	230	39,847
June	28,154	30	126	7,615	392	5,527	510	42,354
July	28,004	29	110	6,895	330	5,102	517	40,987
August	27,783	26	97	5,067	351	4,564	670	38,558
September	27,052	31	95	5,722	362	4,102	950	38,314
October	25,167	17	90	5,633	288	3,984	1,224	36,403
November	25,944	8	71	4,597	318	4,153	1,315	36,406
December	28,294	8	101	6,051	397	4,538	1,443	40,832
Total	326,280	207	1,278	81,531	5,560	68,655	11,351	494,862

r Revised.

[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. Revised.

[5] Estimates based upon reports collected from a selected list of representative retailers. Includes some coal shipped by truck from mine to final destination. Revised.

[6] The total of classes shown approximates total consumption. The calculation of consumption from production, imports, exports, and changes in stocks is not as accurate as the "Total of classes shown" because certain significant items of stocks are not included in yearend stocks. These items are stocks on Lake and Tidewater docks, stocks at other intermediate storage piles between mine and consumer, and coal in transit.

Table 35.—Stocks of bituminous coal and lignite in the hands of commercial consumers and in the retail dealers' yards in the United States

Date	Total stocks (thousand short tons)	Day's supply at current rate of consumption on date of stocktaking: Electric power utilities	Manufacturing and mining industries: Oven coke plants	Steel and rolling mills	Other manufacturing and mining industries	Retail Dealers	Total
Jan. 31	88,342	69	32	16	39	6	55
Feb. 28	85,818	69	32	14	36	8	54
Mar. 31	89,462	77	34	18	40	9	61
Apr. 30	97,138	93	37	20	41	7	71
May 31	102,936	104	40	28	43	14	80
June 30	107,081	93	43	27	47	10	76
July 31	102,827	94	38	31	52	16	78
Aug. 31	111,427	102	63	36	57	14	90
Sept. 30	117,049	108	62	34	52	8	92
Oct. 31	100,388	106	44	28	43	5	86
Nov. 30	85,638	87	35	17	36	4	71
Dec. 31	89,985	84	37	14	37	5	68

Table 36.—Distribution of bituminous coal and lignite, in 1971, by method of movement and consumer use

(Thousand short tons)

Shipments	Electric utilities	Coke and gas plants	Retail dealers	All others	Railroad fuel	Used at mines and sales to employees
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movements and consumer use, overseas exports	341,694	87,241	11,144	[1] 72,984	542	1,483
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	176,770	46,325	5,683	[1] 42,125	--	--
River and ex-river	73,039	21,341	443	5,790	--	--
Great Lakes[2]	20,238	12,938	2,170	8,918	--	--
Tidewater [3]	3,480	4,685	--	89	--	--
Truck	43,627	1,925	2,848	16,060	--	--
Tramway, conveyor, private railroad	24,540	27	--	2	--	--
Method of movement and/or consumer uses unknown	--	--	--	--	542	1,483
Total	341,694	87,241	11,144	[1] 72,984	542	1,483

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
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movements and consumer use, and overseas exports	91	−263	--	37,810	397	553,123
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] 270,903
River and ex-river	--	--	--	--	--	100,613
Great Lakes [2]	--	--	--	--	--	44,264
Tidewater [3]	--	--	--	--	--	8,254
Truck	--	--	--	--	--	64,460
Tramway, conveyor, private railroad	--	--	--	--	--	24,569
Method of movement and/of consumer uses unknown	91	−263	--	37,810	397	40,060
Total	91	−263	--	37,810	397	553,123

[1] Includes overseas exports from producing districts 13, 14, 17 and 20.
[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, 14, 17 and 20.

Table 37.—Distribution of bituminous coal and lignite, by district of origin and 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	31,340	4,062	450	5,227	95	201
2	8,369	18,748	368	4,872	1	15
3 and 6	34,065	4,003	266	4,058	21	11
4	38,322	1	1,115	10,540	71	37
7	978	14,275	458	1,023	57	817
8	69,785	30,992	5,407	24,123	188	158
9	43,233	122	411	3,523	41	--
10	47,556	4,185	899	8,099	44	44
11	16,226	--	284	4,632	4	3
12	966	--	--	51	--	--
13	11,397	5,663	349	[2] 2,601	--	--
14	--	528	--	[2] 334	--	--
15 [3]	6,629	119	35	332	2	--
16	438	--	18	23	--	2
17	2,225	3,041	251	[2] 313	--	--
18	8,205	--	5	31	--	--
19	6,982	27	103	550	10	5
20	1,184	1,475	582	[2] 1,416	2	40
21	5,439	--	94	696	--	150
22 and 23	8,355	--	49	540	6	--
Total	341,694	87,241	11,144	72,984	542	1,483

District of origin [1]	Canadian Great Lakes commercial docks [4]	U.S. Great Lakes dock storage [4]	U.S. tidewater dock storage [4]	Overseas [5] export	Net change in mine inventory	Total
1	21	--	--	1,898	91	43,385
2	11	−12	--	--	94	32,466
3 and 6	26	−56	--	1,457	79	43,930
4	6	−118	--	--	−112	49,862
7	--	27	--	14,877	−89	32,423
8	27	−40	--	19,578	172	150,390
9	--	−12	--	--	44	47,362
10	--	−52	--	--	−71	60,704
11	--	--	--	--	250	21,399
12	--	--	--	--	--	1,017
13	--	--	--	(6)	−25	19,985
14	--	--	--	(6)	3	865
15	--	--	--	--	−82	7,035
16	--	--	--	--	−1	480
17	--	--	--	(6)	−33	5,797
18	--	--	--	--	44	8,285
19	--	--	--	--	−1	7,676
20	--	--	--	(6)	−51	4,648
21	--	--	--	--	85	6,464
22 and 23	--	--	--	--	--	8,950
Total	91	−263	--	37,810	397	553,123

[1] Producing districts are defined in: Bureau of Mines Bituminous Coal and Lignite Distribution Calendar Year 1971, Mineral Industry Survey, Apr. 10, 1972, 39 pp.
[2] Includes overseas exports.
[3] Excludes Texas.
[4] Consumer use unknown.
[5] Excludes Canada; consumer use unknown.
[6] Included with all others.

Table 38.—Distribution of bituminous coal and lignite, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others [1]
New England:					
Massachusetts	227	122	--	14	91
Connecticut	1,271	1,185	--	--	86
Maine, New Hampshire, Vermont, Rhode Island	947	877	--	7	63
Middle Atlantic:					
New York	15,596	7,373	4,188	54	3,981
New Jersey	2,974	2,862	--	2	110
Pennsylvania	58,982	30,273	21,760	640	6,309
East North Central:					
Ohio	63,116	38,579	10,630	1,299	12,608
Indiana	38,599	21,790	11,164	640	5,005
Illinois	38,289	27,930	3,347	1,871	5,141
Michigan	32,625	19,416	4,861	817	7,531
Wisconsin	15,340	10,449	405	1,299	3,187
West North Central:					
Minnesota	8,313	6,403	509	500	901
Iowa	6,239	4,815	--	113	1,311
Missouri	13,358	11,655	298	73	1,332
North Dakota and South Dakota	5,272	4,718	--	143	411
Nebraska and Kansas	2,225	1,928	--	41	256
South Atlantic:					
Delaware and Maryland	11,599	6,408	4,369	41	781
District of Columbia	598	283	--	29	286
Virginia	9,258	5,821	27	407	3,003
West Virginia	26,606	17,458	4,323	239	4,586
North Carolina	19,779	17,687	--	355	1,737
South Carolina	6,219	4,589	--	219	1,411
Georgia and Florida	16,295	15,763	--	77	455
East South Central:					
Kentucky	25,590	21,611	1,660	341	1,978
Tennessee	18,907	16,637	174	549	1,547
Alabama and Mississippi	27,694	17,761	7,310	101	2,522
West South Central: Arkansas, Louisiana, Oklahoma, Texas	887	--	840	4	43
Mountain:					
Colorado	4,475	3,019	901	212	343
Utah	2,993	472	1,787	228	506
Montana and Idaho	1,348	782	--	299	267
Wyoming	3,728	3,542	--	26	160
New Mexico	6,713	6,701	--	1	11
Arizona and Nevada	2,324	2,184	--	27	113
Pacific:					
Washington and Oregon	1,482	1,083	--	86	313
California	1,847	--	1,830	3	14
Alaska	748	261	--	19	468
Canada [2]	17,417	8,677	6,510	251	1,979
Mexico	291	--	153	--	138
Destinations not revealable	[3] 2,179	580	195	117	[3] 1,287
Destinations and/or consumer uses not available:					
Great Lakes movement:					
Canadian commercial docks	91	--	--	--	--
Vessel fuel	713	--	--	--	--
U.S. dock storage	−263	--	--	--	--
Tidewater movement:					
Overseas exports (except Canada)	[4] 37,810	--	--	--	--
Bunker fuel	--	--	--	--	--
U.S. dock storage	--	--	--	--	--
Railroad fuel:					
U.S. companies	528	--	--	--	--
Canadian companies	14	--	--	--	--
Coal used at mines and sales to employees	1,483	--	--	--	--
Net change in mine inventory	397	--	--	--	--
Total	553,123	--	--	--	--

[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, 14, 17 and 20.
[4] Excludes overseas exports from producing districts 13, 14, 17 and 20.

Table 39.—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				
	1967	1968	1969	1970	1971	1967	1968	1969	1970	1971
Total	552,647	545,319	559,880	597,992	553,123	100.0	100.0	100.0	100.0	100.0
New England	9,741	6,956	5,659	3,568	2,445	1.8	1.3	1.0	.6	.4
Massachusetts	4,022	2,872	2,225	608	227	.7	.5	.4	.1	(1)
Connecticut	4,793	3,013	2,295	1,832	1,271	.9	.6	.4	.3	.2
Maine, New Hampshire, Vermont, Rhode Island	926	1,071	1,139	1,128	947	.2	.2	.2	.2	.2
Middle Atlantic	96,362	91,289	89,485	90,992	77,552	17.4	16.7	16.0	15.2	14.0
New York	27,300	24,562	24,324	23,032	15,596	4.9	4.5	4.3	3.9	2.8
New Jersey	7,865	6,837	5,500	4,951	2,974	1.4	1.2	1.0	.8	.5
Pennsylvania	61,197	59,890	59,661	63,009	58,982	11.1	11.0	10.7	10.5	10.7
East North Central	196,417	195,484	199,349	206,011	187,969	35.5	35.8	35.6	34.5	34.0
Ohio	58,726	59,912	62,160	67,375	63,116	10.6	11.0	11.1	11.3	11.4
Indiana	40,441	40,245	41,299	42,385	38,599	7.3	7.4	7.4	7.1	7.0
Illinois	46,710	43,465	45,244	42,310	38,289	8.5	8.0	8.1	7.1	6.9
Michigan	34,959	36,787	35,674	36,633	32,625	6.3	6.7	6.3	6.1	5.9
Wisconsin	15,581	15,075	14,972	17,308	15,340	2.8	2.7	2.7	2.9	2.8
West North Central	26,761	27,350	30,337	35,098	35,407	4.8	5.0	5.4	5.9	6.4
Minnesota	7,142	7,332	8,100	8,769	8,313	1.3	1.3	1.4	1.5	1.5
Iowa	5,549	5,477	5,673	6,159	6,239	1.0	1.0	1.0	1.0	1.1
Missouri	9,389	9,400	11,098	13,397	13,358	1.7	1.7	2.0	2.3	2.4
North Dakota and South Dakota	3,427	3,781	3,996	4,799	5,272	.6	.7	.7	.8	1.0
Nebraska and Kansas	1,254	1,360	1,470	1,974	2,225	.2	.3	.3	.3	.4
South Atlantic	88,499	88,413	89,574	91,559	90,354	16.0	16.2	16.0	15.3	16.3
Delaware and Maryland	14,954	14,777	15,008	13,928	11,599	2.7	2.7	2.7	2.3	2.1
District of Columbia	[2] 886	[2] 887	1,235	1,113	598	[2] .1	[2] .2	.2	.2	.1
Virginia	14,854	14,526	12,994	11,065	9,258	2.7	2.7	2.3	1.9	1.7
West Virginia	23,244	24,564	24,356	24,395	26,606	4.2	4.5	4.4	4.1	4.8
North Carolina	17,515	16,912	18,711	21,696	19,779	3.2	3.1	3.3	3.6	3.6
South Carolina	5,554	4,695	5,319	6,143	6,219	1.0	.8	1.0	1.0	1.1
Georgia and Florida	11,492	12,052	11,951	13,219	16,295	2.1	2.2	2.1	2.2	2.9
East South Central	61,312	60,487	62,730	69,185	72,191	11.1	11.1	11.2	11.6	13.0
Kentucky	19,046	18,811	20,355	23,672	25,590	3.4	3.4	3.6	4.0	4.6
Tennessee	18,185	16,833	16,793	18,315	18,907	3.3	3.1	3.0	3.1	3.4
Alabama and Mississippi	24,081	24,843	25,582	27,198	27,694	4.4	4.6	4.6	4.5	5.0
West South Central: Arkansas, Louisiana, Oklahoma, Texas	955	976	929	1,144	887	.2	.2	.2	.2	.2
Mountain	14,261	14,868	16,418	20,232	21,581	2.6	2.7	2.9	3.4	3.9
Colorado	4,720	4,967	4,687	5,36	4,475	.9	.9	.8	.9	.8
Utah	2,853	2,836	2,978	3,010	2,993	.5	.5	.5	.5	.5
Montana and Idaho	968	1,042	1,063	1,065	1,348	.2	.2	.2	.2	.3
Wyoming	2,494	2,702	3,324	3,809	3,728	.4	.5	.6	.6	.7
New Mexico	2,526	2,392	3,263	6,032	6,713	.5	.4	.6	1.0	1.2
Arizona and Nevada	700	929	1,103	1,180	2,324	.1	.2	.2	.2	.4
Pacific	2,592	2,546	2,683	2,691	3,329	.5	.5	.5	.5	.6
Washington and Oregon	541	449	452	374	1,482	.1	.1	.1	.1	.3
California	2,051	2,097	2,231	2,317	1,847	.4	.4	.4	.4	.3

See footnotes at end of table.

Table 39.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State of destination—Continued

Geographic division and State of destination	Thousand short tons					Percent of total				
	1967	1968	1969	1970	1971	1967	1968	1969	1970	1971
Alaska	952	804	672	612	748	.2	.1	.1	.1	.1
Canada [3]	15,257	16,746	16,752	18,673	17,522	2.8	3.1	3.0	3.1	3.2
Mexico	62	74	84	163	291	(1)	(1)	(1)	(1)	.1
Destinations not revealable	994	2,138	2,175	[4] 2,969	[5] 2,179	.2	.4	.4	[4] .5	.4
U.S. railroad fuel	1,146	976	827	721	528	.2	.2	.1	.1	.1
U.S. Great Lakes dock storage	−62	−239	−446	−16	−263	(1)	(1)	−.1	(1)	(1)
U.S. tidewater dock storage	--	−5	--	--	--	--	(1)	--	--	--
Vessel fuel	878	879	951	1,072	713	.1	.2	.2	.2	.1
Bunker fuel	5	--	--	--	--	(1)	--	--	--	--
Overseas exports	34,174	33,998	39,361	[6] 51,766	[7] 37,810	6.2	6.2	7.0	[6] 8.6	[7] 6.8
Coal used at mines and sales to employees	1,678	1,496	1,450	1,486	1,483	.3	.3	.3	.2	.3
Net change in mine inventory	663	83	890	66	397	.1	(1)	.2	(1)	.1

[1] Less than 0.1 percent.
[2] A considerable block of tonnage is included under "Destinations not revealable."
[3] Includes shipments to Canadian Great Lakes commercial docks and railroad companies.
[4] Includes overseas exports from producing districts 13 and 17.
[5] Includes overseas exports from producing districts 13, 14, 17, and 20.
[6] Excludes overseas exports from producing districts 13 and 17.
[7] Excludes overseas exports from producing districts 13, 14, 17, and 20.

Table 40.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced, by State

State	1970				1971			
	Under-ground	Strip	Auger	Total	Under-ground	Strip	Auger	Total
Alabama	$11.33	$5.52	$5.75	$8.09	$11.96	$5.85	$4.90	$8.15
Alaska	--	7.39	--	7.39	--	8.18	--	8.18
Arizona	--	NA	--	NA	--	NA	--	NA
Arkansas	9.01	8.13	--	8.30	12.00	10.01	--	10.30
Colorado	7.05	3.71	--	5.85	7.80	3.91	--	6.34
Illinois	5.33	4.53	--	4.92	5.96	4.95	--	5.46
Indiana	5.79	4.47	--	4.60	6.61	5.05	--	5.18
Iowa	4.03	4.17	--	4.11	4.82	4.54	--	4.66
Kansas	--	5.59	--	5.59	--	5.72	--	5.72
Kentucky	6.75	4.46	5.37	5.68	7.88	5.24	6.16	6.49
Maryland	5.25	4.87	5.99	5.01	5.32	6.35	6.50	6.25
Missouri	--	4.39	--	4.39	--	4.87	--	4.87
Montana:								
Bituminous	9.39	1.76	--	1.83	9.33	1.79	--	1.79
Lignite	--	2.13	--	2.13	--	2.27	--	2.27
Total	9.39	1.79	--	1.85	9.33	1.79	--	1.82
New Mexico	5.54	2.50	--	2.89	8.05	2.61	--	3.26
North Dakota (lignite)	--	1.95	--	1.95	--	1.91	--	1.91
Ohio	5.43	4.41	4.18	4.74	6.75	4.75	4.35	5.24
Oklahoma	13.86	5.50	8.43	6.27	14.41	5.98	8.50	6.72
Pennsylvania	8.12	5.38	5.51	7.27	9.88	6.41	6.04	8.52
Tennessee	5.07	4.71	4.69	4.90	6.99	5.99	6.85	6.40
Utah	7.28	--	--	7.28	7.37	8.00	--	7.37
Virginia	7.62	4.66	4.64	7.03	9.45	5.58	5.66	8.32
Washington	13.47	8.50	--	12.81	13.55	6.52	--	6.72
West Virginia	8.07	7.06	8.34	7.93	10.07	7.49	8.53	9.54
Wyoming	6.72	3.33	--	3.38	6.25	3.35	2.20	3.39
Total	7.40	4.69	6.08	6.26	8.87	5.19	6.57	7.07

NA Not available.

Table 41.—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	11,132	6,813	17,945	$6.78	$10.38	$8.15
Alaska	71	627	698	11.02	7.86	8.18
Arizona	1,146	--	1,146	W	--	W
Arkansas	276	--	276	10.30	--	10.30
Colorado	3,792	1,545	5,337	4.70	10.35	6.34
Illinois	54,588	3,814	58,402	5.49	5.00	5.46
Indiana	18,293	3,103	21,396	5.33	4.29	5.18
Iowa	760	229	989	4.52	5.13	4.66
Kansas	1,151	--	1,151	5.72	--	5.72
Kentucky	111,770	7,619	119,389	6.19	10.94	6.49
Maryland	1,644	--	1,644	6.25	--	6.25
Missouri	4,036	--	4,036	4.87	--	4.87
Montana:						
Bituminous	6,737	--	6,737	1.79	--	1.79
Lignite	327	--	327	2.27	--	2.27
Total [1]	7,064	--	7,064	1.82	--	1.82
New Mexico	7,471	704	8,175	2.86	7.48	3.26
North Dakota (lignite)	5,940	135	6,075	1.86	4.00	1.91
Ohio	46,957	4,474	51,431	5.18	5.90	5.24
Oklahoma	2,234	--	2,234	6.72	--	6.72
Pennsylvania	47,681	25,154	72,835	7.47	10.50	8.52
Tennessee	9,271	--	9,271	6.40	--	6.40
Utah	3,055	1,571	4,626	6.59	8.88	7.37
Virginia	30,621	7	30,628	8.32	6.68	8.32
Washington	41	1,093	1,134	12.46	6.50	6.72
West Virginia	105,063	13,194	118,258	9.07	13.30	9.54
Wyoming	5,671	2,381	8,052	3.59	2.92	3.39
Total [1]	479,727	72,464	552,192	6.66	9.77	7.07

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

Table 42.—Shipments of bituminous coal and lignite by average sulfur content 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] [2]	Electric utilities	Coke and gas plants	Other industrial uses and retail dealers	All other uses	Exports (overseas and Canada)	Total
1. Eastern Pennsylvania	18,661	3,434	3,085	592	790	26,562	2.3	0.9	1.9	1.8	2.4	2.1
2. Western Pennsylvania	5,272	10,865	4,862	663	648	22,310	2.3	1.4	1.8	1.7	2.3	1.7
3. Northern West Virginia	10,172	2,102	1,636	357	760	15,027	2.7	1.1	2.5	2.6	.9	2.3
4. Ohio	29,899	108	5,754	1,383	52	37,194	3.4	3.5	3.3	2.8	2.8	3.3
5. Michigan	--	--	--	--	--	--	--	--	--	--	--	--
6. Panhandle	2,155	--	463	159	25	2,802	3.1	--	3.0	3.0	3.0	3.1
7. Southern Numbered 1	504	4,042	387	55	4,498	9,486	.7	.7	.7	.8	.7	.7
8. Southern Numbered 2	16,486	14,111	6,158	2,050	6,660	45,465	1.2	.7	1.0	1.1	.7	.8
9. West Kentucky	33,706	--	2,558	4	--	36,268	4.0	--	3.6	2.7	--	4.0
10. Illinois	33,685	872	7,530	141	--	42,227	3.4	1.5	2.8	2.4	--	3.2
11. Indiana	13,343	--	3,454	10	--	16,807	3.3	--	3.3	3.8	--	3.3
12. Iowa	672	--	9	25	--	706	3.6	--	5.0	4.5	--	3.6
13. Southeastern	7,022	3,686	996	393	1,276	13,372	1.7	1.1	1.6	1.1	1.1	1.5
14. Arkansas-Oklahoma	--	449	156	2	18	625	--	.9	3.1	.9	1.0	1.4
15. Southwestern	7,527	37	559	19	--	8,143	3.8	1.0	3.6	1.8	--	3.7
16. Northern Colorado	431	--	42	2	--	474	.4	--	.4	.3	--	.4
17. Southern Colorado	2,247	2,561	269	52	65	5,195	.6	.6	.6	1.1	.5	.6
18. New Mexico	8,278	--	66	--	--	8,344	.7	--	.5	--	--	.7
19. Wyoming	7,316	27	701	7	--	8,052	.7	.8	.7	.6	--	.7
20. Utah	608	2,800	1,062	270	380	5,120	.5	.7	.5	.6	.8	.6
21. North-South Dakota	3,576	--	241	66	--	3,884	.8	--	.5	1.0	--	.8
22. Montana	6,843	--	147	1	--	6,991	.8	--	.7	.7	--	.8
23. Alaska and Washington	620	--	30	39	--	689	.1	--	.5	.2	--	.1
Total United States	209,023	45,094	40,165	6,290	15,172	315,744	2.7	1.0	2.3	1.8	.9	2.3

[1] Data may not add to totals shown because of independent rounding.
[2] Total shipments by producers reporting sulfur content (57 percent of total U.S. production).

Table 43.—Exports of bituminous coal, by country group

(Thousand short tons and thousand dollars)

Country group	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada (including Newfoundland and Mexico	16,905	$147,312	18,846	$197,934	17,852	$208,795
Overseas (all other countries):						
West Indies and Central America	1	8	1	9	--	--
Bermuda, Greenland, Miquelon, St. Pierre Islands	3	41	2	44	(1)	10
South America	2,869	30,904	2,920	40,929	2,673	49,092
Europe	15,088	163,415	21,503	303,352	16,403	280,943
Asia	21,368	243,765	27,649	r 408,171	19,705	352,644
Africa	--	--	(1)	1	--	--
Oceania	(1)	7	23	349	(1)	(1)
Total	39,329	438,140	52,098	r 752,855	38,781	682,689
Grand total	56,234	585,452	70,944	r 950,789	56,633	891,484

r Revised.
1 Less than ½ unit.

Table 44.—Bituminous coal exported from the United States, by country [1]

(Thousand short tons and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	--	--	23	$346	(2)	(2)
Austria	--	--	65	919	--	--
Argentina	477	$5,017	596	8,222	539	$9,754
Belgium-Luxembourg	943	10,394	1,881	29,977	765	15,005
Brazil	1,843	19,818	2,020	27,691	1,869	34,619
Canada	16,789	145,710	18,673	195,133	17,565	202,922
Chile	519	5,697	275	4,705	207	3,843
Ecuador	20	253	--	--	--	--
France	2,253	24,192	3,346	46,177	3,106	50,623
Germany:						
East	87	1,111	396	5,942	77	1,448
West	3,451	34,942	5,022	65,876	2,911	43,091
Greece	--	--	--	--	65	1,130
Ireland	83	918	69	1,014	17	349
Italy	3,679	40,824	4,205	r 59,811	2,680	50,257
Japan	21,367	243,753	27,637	407,963	19,706	352,629
Mexico	116	1,602	173	2,801	285	5,835
Miquelon and St. Pierre Islands	3	41	2	44	2	38
Netherlands	1,622	17,544	2,112	27,941	1,625	27,386
Norway	248	2,726	192	3,051	83	1,597
Peru	--	--	--	--	26	277
Portugal	15	230	--	--	12	243
Romania	72	891	70	1,380	--	--
Spain	1,825	20,910	3,153	46,971	2,556	48,562
Sweden	668	7,365	764	11,586	618	12,149
Switzerland	--	--	--	--	32	433
United Kingdom	--	--	--	--	1,669	25,897
Uruguay	10	114	26	274	31	597
Yugoslavia	141	1,366	225	2,681	185	2,774
Other	3	34	r 19	r 285	2	26
Total	56,234	585,452	70,944	950,790	56,633	891,484

r Revised.
1 Amounts stated do not include fuel or bunker coal on vessels engaged in foreign trade, which aggregated 59,152 tons ($738,409) in 1969; 67,424 tons ($916,181) in 1970; and 44,010 tons ($676,437) in 1971.
2 Less than ½ unit.

Table 45.—Bituminous coal exported from the United States, by customs district

(Thousand short tons and thousand dollars)

Customs district	1969 Quantity	1969 Value	1970 Quantity	1970 Value	1971 Quantity	1971 Value
Baltimore, Md	2,654	$24,746	4,723	$62,880	3,374	$53,560
Boston, Mass	1	10	--	--	--	--
Buffalo, N.Y	444	3,653	189	1,698	21	280
Chicago, Ill	43	298	9	102	57	639
Cleveland, Ohio	15,656	134,975	r 18,030	r 186,722	17,146	195,975
Detroit, Mich	70	728	69	1,050	93	1,624
Duluth, Minn	5	54	3	69	4	85
El Paso, Tex	45	616	64	831	53	844
Laredo, Tex	70	981	108	1,953	231	4,990
Los Angeles, Calif	93	1,073	r 269	r 3,670	385	4,975
Miami, Fla	--	--	(1)	3	--	--
Mobile, Ala	1	6	379	4,465	745	10,406
New Orleans, La	79	852	460	5,597	656	9,271
New York City	--	--	10	108	(1)	4
Norfolk, Va	37,023	416,918	r 46,239	r 676,625	33,396	603,471
Ogdensburg, N.Y	40	442	30	414	16	262
Pembina, N.D	--	--	3	61	8	166
Philadelphia, Pa	6	53	297	3,625	66	1,035
Port Arthur, Tex	--	--	16	263	380	3,862
Portland, Maine	1	9	--	--	--	--
Portland, Oreg	--	--	r 44	r 617	--	--
St. Albans, Vt	1	14	--	--	--	--
San Diego, Calif	(1)	5	1	17	(1)	(1)
San Francisco, Calif	--	--	(1)	(1)	--	--
Seattle, Wash	2	19	1	19	2	35
Tampa, Fla	(1)	(1)	(1)	1	--	--
Total	56,234	585,452	70,944	950,790	56,633	891,484

r Revised.
1 Less than ½ unit.

Table 46.—Bituminous coal [1] imported for consumption in the United States, by country and customs district

Country and customs district	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Country:						
Canada	108,857	$1,074	36,312	$450	87,447	$1,044
Colombia	--	--	--	--	171	(2)
Germany, West	--	--	--	--	103	1
India	30	3	85	4	37	3
Japan	--	--	15	2	--	--
Netherlands	11	2	--	--	(2)	(2)
Norway	--	--	16	(2)	--	--
South Africa, Republic of	6	2	--	--	11,417	434
Sweden	--	--	--	--	11,861	290
United Kingdom	--	--	13	1	--	--
Total	108,904	1,081	36,441	457	111,036	1,772
Customs district:						
Buffalo, N.Y	2,297	34	1,416	29	977	10
Chicago, Ill	98	2	--	--	73	(2)
Detroit, Mich	18	2	104	3	47,698	525
Duluth, Minn	4,371	65	7,185	103	9,584	142
Great Falls, Mont	35,845	304	17,145	160	11,844	109
Honolulu, Hawaii	--	--	15	1	--	--
Mobile, Ala	--	--	16	(2)	--	--
New Orleans, La	--	--	--	--	23,278	724
New York City	41	6	85	4	37	3
Pembina, N.D	12,796	185	10,460	155	16,902	253
Philadelphia, Pa	6	2	13	1	--	--
Portland, Maine	43,779	401	2	1	--	--
Portland, Oreg	--	--	--	--	171	(2)
St. Louis, Mo	(2)	(2)	--	--	--	--
San Francisco, Calif	--	--	--	--	30	(2)
Seattle, Wash	9,653	80	--	--	442	6
Total	108,904	1,081	36,441	457	111,036	1,772

1 Includes slack, culm, and lignite.
2 Less than ½ unit.

Table 47.—Bituminous coal, and lignite coal: World production by country

(Thousand short tons)

Country [1]	1969	1970	1971 p
North America:			
Canada:			
Bituminous	8,652	12,783	16,053
Lignite	2,021	3,822	3,300
Greenland: Bituminous	23	e 22	e 22
Mexico: Bituminous	2,709	3,262	e 3,696
United States:			
Bituminous	555,493	596,969	545,790
Lignite [2]	5,012	5,963	6,402
South America:			
Argentina: Bituminous	575	678	e 678
Brazil: Bituminous (marketable)	2,685	2,609	2,751
Chile: Bituminous	1,878	1,664	1,789
Colombia: Bituminous [3]	3,656	2,756	e 3,000
Peru: Bituminous	r 170	150	e 110
Venezuela: Bituminous	e 36	44	45
Europe:			
Albania: Lignite [4]	705	736	e 770
Austria: Lignite [5]	4,234	4,045	4,155
Belgium: Bituminous	9,687	8,462	9,222
Bulgaria:			
Bituminous	r 237	260	e 264
Lignite [4]	31,561	31,806	29,323
Czechoslovakia:			
Bituminous	29,837	30,923	31,636
Lignite [4]	87,454	90,150	92,925
Denmark: Lignite	475	149	e 100
France:			
Bituminous	33,619	30,326	e 25,400
Lignite	3,252	3,070	3,029
Germany, East:			
Bituminous	1,468	e 1,430	1,320
Lignite [4]	280,596	287,242	e 292,000
Germany, West:			
Bituminous	r 111,359	111,394	111,196
Lignite	118,415	118,792	115,167
Pech	841	740	75
Greece: Lignite	7,423	8,576	12,098
Hungary:			
Bituminous	4,556	4,576	4,344
Lignite [4]	24,653	26,102	25,886
Ireland: Bituminous	r 60	83	70
Italy:			
Bituminous	334	326	282
Lignite	2,131	1,536	1,461
Netherlands: Bituminous	272	--	--
Poland:			
Bituminous	148,823	154,435	160,376
Lignite [4]	34,022	36,118	38,048
Portugal: Lignite	9	--	NA
Romania:			
Bituminous [6]	8,288	8,914	e 8,900
Lignite [4]	r 12,807	16,257	15,212
Spain:			
Bituminous	r 9,759	8,756	8,467
Lignite	r 3,021	3,120	3,378
Svalbard (Spitzbergen):			
Bituminous:			
Controlled by Norway	r 425	513	484
Controlled by U.S.S.R. (shipments) e	440	440	440
Sweden: Bituminous	24	11	11
U.S.S.R.: [7]			
Bituminous	430,443	e 436,000	e 445,000
Lignite [4]	154,859	159,553	e 170,000
United Kingdom: Bituminous	r 159,128	148,318	157,625
Yugoslavia:			
Bituminous	752	709	779
Lignite [4]	28,456	30,621	33,284
Africa:			
Arab Republic of Egypt:			
Bituminous	4	--	--
Algeria: Bituminous [3]	30	16	e 16
Mozambique: Bituminous	305	387	e 400
Nigeria: Bituminous	17	39	174
Rhodesia, Southern: Bituminous	[10] 3,673	e 3,700	e 3,700
South Africa, Republic of (marketable):			
Bituminous	56,450	58,350	62,638
Swaziland: Bituminous	115	136	163
Tanzania: Bituminous	3	3	3
Zaire: Bituminous	73	112	126
Zambia: Bituminous	438	676	895

See footnotes at end of table.

Table 47.—Bituminous coal, and lignite coal: World production by country—Continued

(Thousand short tons)

Country [1]	1969	1970	1971 p
Asia:			
Afghanistan: Bituminous [8]	150	187	e 200
Burma: Bituminous	r 16	17	22
China, People's Republic of:			
Bituminous and lignite e	r 360,000	400,000	430,000
India:			
Bituminous	83,126	81,233	76,170
Lignite	4,616	3,908	4,076
Indonesia: Bituminous	211	195	219
Iran: Bituminous [8]	276	356	e 400
Japan:			
Bituminous	47,913	42,398	36,304
Lignite	274	217	148
Korea, North: Bituminous and lignite	5,400	6,300	6,800
Mongolia: Bituminous and lignite	1,600	1,930	e 2,200
Pakistan: Bituminous and lignite e	r 1,390	1,400	1,380
Philippines: Bituminous	r 59	47	e 40
Taiwan: Bituminous	5,120	4,931	4,516
Thailand: Lignite	384	441	491
Turkey:			
Bituminous [9]	5,234	4,820	e 4,600
Lignite [9]	6,075	6,272	e 6,400
Oceania:			
Australia:			
Bituminous	50,851	54,246	53,915
Lignite	25,602	26,648	25,776
New Zealand:			
Bituminous	2,606	2,421	e 2,120
Lignite	188	210	e 180
World total:			
Bituminous [10]	r 1,782,899	1,821,823	1,786,446
Lignite	r 838,245	865,354	883,609
Mixed Grades [11]	r 368,390	409,630	440,380
Total, all grades	r 2,989,534	3,096,807	3,110,435

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 material reported in national sources as brown coal.

[5] Available sources give only lignite production; a small quantity of bituminous coal also may be produced.

[6] Official sources report the aggregate of anthracite and bituminous, distribution to these separate grades is estimated from reported total.

[7] Run of mine.

[8] Year beginning March 21 of that stated.

[9] Sales.

[10] Includes pech coal from West Germany.

[11] Anthracite plus bituminous coal for Colombia and bituminous plus lignite for People's Republic of China, Mongolia, North Korea, and Pakistan.

Coal—Pennsylvania Anthracite

By D. R. Federoff [1]

Data in this chapter refer only to anthracite or hard coal, mined in the northeastern part of the Commonwealth of Pennsylvania. This anthracite region is divided geologically into four fields: Northern, Eastern Middle, Western Middle, and Southern. The area is also grouped by trade usage into three regions: Wyoming, Lehigh, and Schuylkill.

The downward trend in the production of anthracite continued in 1971. Reduced industrial activity, a relatively mild heating season, and continued losses to competitive fuels in domestic and foreign markets were some of the factors that contributed to the steady decline in anthracite production.

Total production of anthracite in 1971 was 8.7 million short tons, a decrease of 1 million tons or 10.3 percent from that of 1970. Anthracite was produced at 155 underground mines, 180 strip pits, 81 culm and silt banks, and 8 dredging operations. Of the total output, 51 percent was produced at strip pits, 30 percent at culm and silt banks, 15 percent at underground mines, and 4 percent at dredging operations. Compared with tonnages produced in 1970, underground production declined 26 percent; culm and silt banks, 15 percent; dredging, 5 percent; and strip production, 1 percent.

The average value f.o.b. preparation plants for all sizes of anthracite (excluding dredge coal) was $12.08 per ton compared with $11.03 per ton in 1970. The value of pea and larger sizes showed an increase of $1.33 and averaged $16.39 per ton and the average value per ton for buckwheat No. 1 and smaller sizes increased $0.98 per ton to $9.90. Because of the decline in production, the total value of the anthracite output declined from $105.3 million in 1970 to $103.5 million in 1971.

Apparent consumption of anthracite in the United States during 1971 was estimated at 7.3 million tons, a decrease of 11 percent. Although use data are incomplete for anthracite, declines occurred in all consumer categories, particularly in the iron and steel industry (27 percent) and in the public utilities (13 percent).

Foreign demand for Pennsylvania anthracite declined in 1971, and only 671,024 tons were shipped to destinations outside the United States. This tonnage was 15 percent below the amount exported in 1970. Most of the decline resulted from deceased shipments to Europe where coal stocks have been excessive. The tonnage exported to Canada increased by less than 7 percent over that of 1970. 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 Census. Accordingly, approximately 1,389 million tons were actually exported.

The Pennsylvania anthracite mining industry averaged 239 active days in 1971. A decline in the production and the average number of men working daily at anthracite operations, decreased the productivity rate per man-day from 7.10 tons in 1970 to 6.30 tons in 1971. In 1971, there were 2 fatalities, 2 less than in 1970, and 478 nonfatal injuries, compared with 421 in 1970.

Legislation and Government Programs.—State and Federal Government programs in the environmental area continued throughout 1971 and included underground mine fire control, refuse or culm bank-fire control, surface subsidence, mine-water drainage control, and reclamation of old strip pits.

Hydrologic investigations have been continued over a period of years to provide data for evaluating mine-water problems.

[1] Statistical assistant, Division of Fossil Fuels.

The studies involve determination of the varying heights of underground mine pools, their hydrostatic pressures and possible effect upon barrier pillars and mine dams protecting active mining operation, and discharges from flooded mines into surface streams and the unconsolidated valley fill. Flooding of this valley fill has caused extensive damage to part of the densely populated Wyoming Valley in the northern anthracite field.

The project for the installation of a series of mine pool monitoring stations is proceeding. Most of the work will concentrate on phases involving the Western, Middle, and Southern fields.

A total of 38 mine-water-control projects, including five public health and safety projects were approved. Among these were 17 pump projects involving the installation of 29 large-capacity, deep-well pumps, and 5 projects to backfill abandoned mine voids.

Efforts to understand causes of burning in an anthracite refuse bank will involve more detailed analyses of samples taken from burning and nonburning banks. In addition, a more thorough investigation will be made of the usefulness of aerial infrared imagery in distinguishing the presence and parameters of burning in anthracite refuse banks.

Measurement of the impact on the environment and the development of economical techniques for preventing and extinguishing such fires also are under investigation.

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1967	1968	1969	1970	1971
Production:					
Preparation plants......short tons..	11,481,582	10,799,260	9,920,130	9,304,221	8,323,168
Dredges......do....	631,660	605,920	535,369	409,354	389,609
Used at collieries for power and heat do....	142,821	55,653	17,417	15,823	14,548
Total production......do....	12,256,063	11,460,833	10,472,916	9,729,398	8,727,325
Value......thousands..	$96,160	$97,245	$100,770	$105,341	$103,469
Average sales realization per short ton on preparation plant shipments (excludes dredge coal):					
Pea and larger......	$11.53	$12.40	$13.56	$15.06	$16.39
Buckwheat No. 1 and smaller......	$6.35	$6.87	$7.93	$8.92	$9.90
All sizes......	$8.15	$8.78	$9.91	$11.03	$12.08
Percentage of total preparation plant shipment (excludes dredge coal):					
Pea and larger......	34.8	34.6	35.1	34.4	33.6
Buckwheat No. 1 and smaller......	65.2	65.4	64.9	65.6	66.4
Exports [1]......short tons..	594,797	518,159	627,492	789,499	671,024
Consumption, apparent [2]......do....	10,800,000	10,160,000	8,809,000	8,248,000	7,338,000
Average number of days worked......	219	217	232	r 234	p 239
Average number of men working daily......	7,750	6,932	5,927	r 5,938	p 5,800
Output per man per day......short tons..	7.21	7.62	7.45	r 7.10	p 6.30
Output per man per year......do....	1,579	1,654	1,728	r 1,661	p 1,505
Quantity cut by machines......do....	146,908	61,245	68,300	125,779	6,018
Quantity mined by stripping......do....	4,740,187	4,696,163	4,578,732	4,541,452	4,478,350
Quantity loaded by machines underground do....	1,997,806	1,475,000	1,326,598	1,150,596	669,691
Distribution:					
Exports to Canada [1]......do....	448,744	401,314	472,763	438,008	466,039
Loaded into vessels at Lake Erie [3]..do....	206,975	204,682	209,000	154,002	51,402

p Preliminary. r Revised.

[1] U.S. Department of Commerce, 1967–71 export data does not include shipments to U.S. military forces. See NOTE, tables 4 and 27.

[2] Excludes shipments to U.S. Armed Forces.

[3] Ore and Coal Exchange, Cleveland, Ohio.

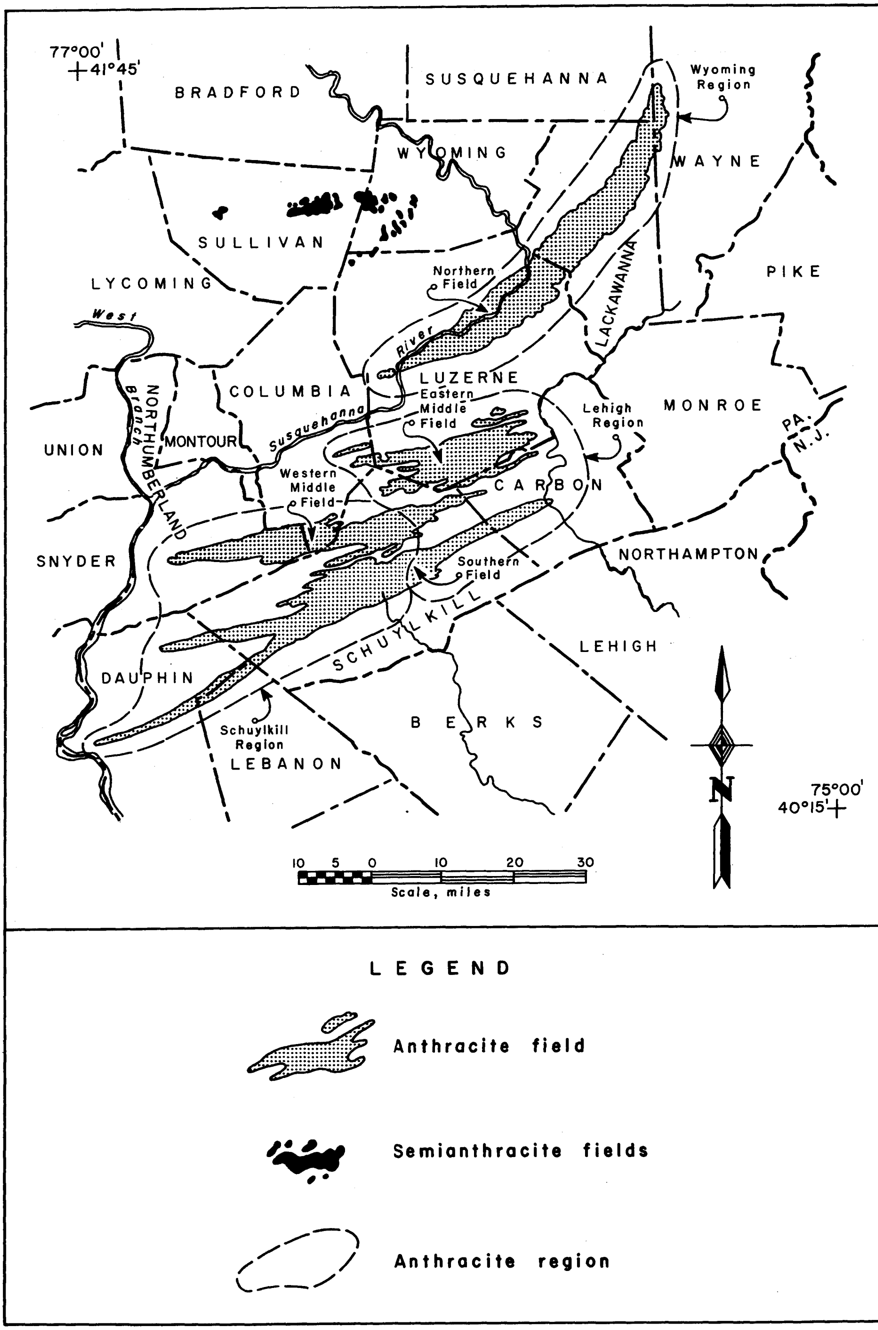

Figure 1.—Coalfields, regions, and counties of the Pennsylvania anthracite area.

Table 2.—Standard anthracite specifications approved and adopted by the Anthracite Committee, effective July 28, 1947

Size	Round test mesh (inches)	Percent					
		Oversize maximum	Undersize Maximum	Undersize Minimum	Maximum impurities [1] Slate	Bone	Ash [2]
Broken	Through 4 3/8	--	--	--	1½	2	11
	Over 3 1/4 to 3	--	15	7½	--	--	--
Egg	Through 3 1/4 to 3	5	--	--	1½	2	11
	Over 2 7/16	--	15	7½	--	3	11
Stove	Through 2 7/16	7½	--	--	2	3	11
	Over 1 5/8	--	15	7½	--	--	--
Chestnut	Through 1 5/8	7½	--	--	3	4	11
	Over 13/16	--	15	7½	--	--	--
Pea	Through 13/16	10	--	--	4	5	12
	Over 9/16	--	15	7½	--	--	--
Buckwheat No. 1	Through 9/16	10	--	--	--	--	13
	Over 5/16	--	15	7½	--	--	--
Buckwheat No. 2 (rice)	Through 5/16	10	--	--	--	--	13
	Over 3/16	--	17	7½	--	--	--
Buckwheat No. 3 (barley)	Through 3/16	10	--	--	--	--	15
	Over 3/32	--	20	10	--	--	--
Buckwheat No. 4	Through 3/32	20	--	--	--	--	15
	Over 3/64	--	30	10	--	--	--
Buckwheat No. 5	Through 3/64	30	No limit		--	--	16

[1] When slate content in sizes from broken to chestnut, inclusive, is less than 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 percent 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 plant.
Slate is defined as any material that has less than 40 percent fixed carbon.
Bone is defined as any material that has 40 percent or more, but less than 75 percent, fixed carbon.
[2] Ash determinations are on a dry basis.

DOMESTIC PRODUCTION

Production of Pennsylvania anthracite totaled 8.7 million tons in 1971, a decrease of 10.3 percent, or approximately 1.0 million tons less than in 1970. Underground production comprised 15 percent of the total output, compared with 18 percent in 1970; culm and silt bank recovery accounted for 30 percent (31 percent in 1970); however, strip mining increased from 47 percent in 1970 to 51 percent of the total in 1971, while production of river coal remained at 4 percent of the total.

The total output by regions remained virtually at the same level as in 1970: Schuylkill region produced 54 percent of the total; Lehigh region, 25 percent; and the Wyoming region, 21 percent.

The two leading counties in the production of anthracite in Pennsylvania were Schuylkill County, which produced 3.6 million tons, and Luzerne County, with a production of 2.6 million tons. Other counties producing anthracite were Northumberland, Lackawanna, Carbon, Columbia, Lancaster, Sullivan, Snyder, Berks, Dauphin, and Susquehanna.

Underground production was the only source of Pennsylvania anthracite to show an accelerated decrease, the year's total falling 26 percent below that of 1970. The decline in production at underground mines continued the trend began several years previously when producers began obtaining a greater proportion of their coal requirements from strip pits and culm banks. Several underground mines closed because of inaccessability due to flooding and a manpower shortage. A large number discontinued operations when the new Federal Coal Mine Health and Safety Act of 1969, which was implemented on March 30, 1970, began to take effect in 1971.

Of the total underground production, the Schuylkill region accounted for 69 percent; Wyoming region, 30 percent; and the Lehigh region, 1 percent. Each of the regions showed losses in 1971. Output in the Lehigh region decreased by 63 percent; the Wyoming region, 30 percent; and the Schuylkill region, 23 percent.

Mechanical loading of underground anthracite in 1971 declined 42 percent from the level of the previous year, with a concurrent decrease of 24 percent in the loading units. Of the total underground output, 52 percent was loaded mechanically, compared with 66 percent in 1970. Two mining machines undercut 6,018 tons of anthracite and were discontinued for the remainder of the year.

Production from strip mines totaled 4.5 million tons, a decrease of approximately 1 percent, and accounted for 51 percent of the total production in 1971, compared with 47 percent in 1970. Output in the Schuylkill region declined about 1 percent; however, production in the Lehigh region remained virtually the same as in 1970, while the Wyoming region showed an increase of 10 percent. Of the total strip mine output, 32 percent was stripped in the Lehigh region, 43 percent in the Schuylkill region, and 25 percent in the Wyoming region.

Culm recovery totaled 2.6 million tons, approximately 463,000 tons less than in 1970, or a decrease of 15 percent. Output by region was as follows: Lehigh region, 28 percent (30 percent in 1970); Schuylkill region, 60 percent (52 percent in 1970); and the Wyoming region, 12 percent (18 percent in 1970).

In 1971, there were 32 fewer power shovels and 22 fewer draglines. However, in addition to the power shovels and draglines in use, 77 front-end loaders were in operation at strip pits and in culm recovery.

Dredging operations produced approximately 390,000 tons in 1971, a decrease of 5 percent. As the preponderant part of river coal is consumed by the producer, it is not nearly as responsive to fluctuations in the general market as are the small sizes produced from other sources. Approximately 4 percent (virtually the same as in 1970) of the total anthracite production was dredged.

Of the total industry work force of 5,800 men in 1971, 51 percent were employed in the Schuylkill region, 28 percent in the Wyoming region, and 21 percent in the Lehigh region. Of that total, 31 percent were employed at strip pits, 26 percent at preparation plants, 25 percent at underground workings, 9 percent at culm and silt banks, 8 percent in surface work at underground mines, and 1 percent on dredges.

DISTRIBUTION

Based on reports submitted to the Bureau of Mines, 8,571,532 short tons of Pennsylvania anthracite were shipped to market during the 1970–71 coal year, a decline of 10.4 percent from the preceding coal year. Of this amount, 82 percent was destined to points within the United States, 5 percent to Canada, and 13 percent overseas. Compared with the 1969–70 coal year, shipments in 1970–71 declined 14 percent in American markets. However, shipments to the Canadian market increased by approximately 24 percent, and exports to all other countries by 9 percent.

Shipments of pea and larger sizes to the markets in the United States during the 1970–71 coal year decreased 10.8 percent, compared with a 11.7 decrease in the 1969–70 coal year. Buckwheat No. 1 declined 15.9 percent; buckwheat No. 2 (rice), 16.0 percent; buckwheat No. 3 (barley), 17.9 percent; while other sizes, not otherwise identified, decreased by 14.3 percent.

Shipments to the New England area declined by 17.3 percent; the Middle Atlantic States, 16.8 percent; South Atlantic States, 18.0 percent; Lake States, 6.9 percent; however, shipments to "Other States" increased 37.5 percent.

Increased shipments to western Europe were due in large part to expanded requirements of the U.S. Armed Forces in West Germany.

CONSUMPTION AND USES

Apparent consumption of Pennsylvania anthracite in the United States in 1971, calculated as production minus exports, including that exported to West Germany for use of U.S. Armed Forces, totaled 7.3 millions tons, a drop of 11.0 percent. A significant portion of the loss was attributable to a general business slump in the iron and steel industry and to the conversion to other fuels by the public utilities.

The approximate domestic consumption of anthracite in 1971 was as follows: 53 percent for residential and commercial heating purposes, 22 percent for public utility plants, 11 percent for the iron and steel industry, and 14 percent for other uses.

A general decline occurred in all consumer categories. In the iron and steel industry, anthracite used for sintering iron ore fines and pelletizing concentrates declined 26.9 percent. Anthracite used for electric power generation decreased 13.2 percent; residential and commercial heating, 4.7 percent; coke making, 4.4 percent; and other uses, 23.5 percent.

The Federal Government continued to supplement the fuel needs of the U.S. Armed Forces in West Germany with purchases of anthracite. Shipments in 1971 were 718,000 tons compared with 692,000 tons in 1970, an increase of approximately 4 percent.

STOCKS

Monthly data on stocks held in retail yards indicated an inventory of 182,000 tons at yearend 1971, a decrease of 9.9 percent from that of yearend 1970.

The electric utilities reported an increase of 2.2 percent in their inventory—1,123,000 tons at yearend 1971, compared with 1,099,000 tons at yearend 1970.

Stocks at coke plants totaled 118,000 tons at yearend, a decrease of 2.5 percent from yearend stocks of 1970.

Stocks at the Upper Lake docks (Lake Superior and Lake Michigan) dropped from 6,000 tons in 1970 to 1,000 tons in 1971, a decrease of 83.3 percent.

PRICES AND SPECIFICATIONS

Based on total production, including colliery fuel and dredge coal, the average value of Pennsylvania anthracite for 1971 was $11.86 per short ton, an increase of 9.5 percent from the $10.83 recorded in 1970. Although the per-ton value increased, the total value of $103,469,207 decreased by approximately 1.8 percent.

The average value per ton of the larger groups of sizes was $16.39 f.o.b. preparation plants, an increase of $1.33. Price increases per ton for these larger sizes—egg, stove, chestnut, pea—were $2.83, $1.24, $1.12, and $1.41, respectively. The per-ton prices for the smaller sizes increased to $9.90 per ton, an increase of $0.98. The individual price increase for smaller sizes was as follows: Buckwheat No. 1, $1.57; buckwheat No. 2 (rice), $1.42; buckwheat No. 3 (barley), $1.50; buckwheat No. 4, $0.67; buckwheat No. 5, $0.43; and other, $0.74. All the above prices exclude dredge coal.

Average wholesale prices as quoted in the Black Diamond magazine were as follows: Egg and stove, $20.75 to $17.25; chestnut, $20.70 to $17.00, pea, $18.20 to $15.50; buckwheat No. 1, $17.80 to $15.00; buckwheat No. 2 (rice), $17.80 to $15.50; buckwheat No. 3 (barley), $15.45 to $14.00.

FOREIGN TRADE

Exports of Pennsylvania anthracite totaled 671,024 tons in 1971, a decline of 15 percent from that exported in 1970. Decreased shipments to European countries and to markets in Asia and Oceania were offset by increased shipments to Canada and Japan.

Shipments to Canada increased from approximately 438,008 tons in 1970 to 466,039 tons in 1971, an increase of 6 percent. Exports to Japan rose sharply from 126 tons in 1970 to 10,543 tons in 1971.

Export data does not fully reflect the total movement of anthracite to Europe, because the Bureau of the Census does not include in its figures coal shipped for the use of our Armed Forces in West Germany. Technically it is not considered an export and therefore is not included in the export total.

WORLD REVIEW

World production of anthracite remained virtually unchanged in 1971, the year's total representing a decrease of less than 1 percent from the revised figure of 198.7 million tons for 1970. Some of the anthracite producing countries include in their data, coals which by U.S. standards, are of no higher quality than semi-anthracite; but despite these inadequacies, information is sufficiently accurate to indicate general trends.

Following the downtrend in Europe's economic activity, Belgium, France, the Netherlands, Portugal, and the United Kingdom, showed declines in output in 1971, while the combined production of the U.S.S.R., Spain and Bulgaria increased by less than 1 percent over that of 1970.

The Republic of South Africa achieved mixed results in the anthracite sector in 1971. Production at 2.0 million short tons was 9.7 percent in excess of 1970. Shipments, however, dropped to 1.7 million tons of which 789,265 tons went to the domestic market and 862,140 tons for export. Comparable 1970 data show total sales of 2.0 million tons comprising domestic sales at 936,872 tons, and 1,076,979 tons to the export market.

Government sponsored measures initiated in 1969 to stimulate anthracite production in the Republic of Korea, were largely responsible for the coal industry's increased output during the past 2 years. Production in 1971 achieved a record level of 1.4 million short tons of anthracite, an increase of approximately 431,000 tons compared with 1970. The Republic of Korea's reserves are large and important to the national economy. Known minable reserves are estimated at 551 million short tons. Approximately 75 percent of anthracite production is for household use, 10 percent for thermal electric power generation, and the balance for industrial use and export.

Of the approximately 200,000 short tons of anthracite produced in Canada in 1971, 182,938 tons was shipped to Japan, a decrease of 26 percent from that shipped in 1970.

Exports of coal from Spain, which reached record levels in 1970 as a result of coal shortages fell sharply in 1971. Anthracite exports were 107,336 short tons as compared with 224,547 tons in 1970, a decline of 52 percent. Imports of anthracite, however, virtually all from the Republic of South Africa, increased from 15,945 short tons in 1970 to 46,157 tons in 1971.

Imports of coal into the Netherlands declined in 1971. While imports were not reported by qualities, it is believed that price differences and lower volumes received from certain countries were the result of reduced demands for household coal, in particular, anthracite. This, of course, reflects the conversion from household solid fuels to indigenous natural gas.

Japan's imports of anthracite in 1971 set a record high of 1.7 million short tons and featured the return of North Vietnam as the principal source with total shipments of 451,947 short tons. The record annual shipment of anthracite from North Vietnam was established in 1962 with imports of 718,706 tons. Other important sources of anthracite in 1971 were the People's Republic of China, up 52 percent; the Republic of Korea, unchanged; the Republic of South Africa, down 16 percent; and Canada, also down from the preceding year's level. Receipts of anthracite from the United States increased to 10,543 tons compared with only 126 tons in 1970.

Anthracite imports into Italy in 1971 amounted to 832,795 short tons with an average value per ton increase of 16 percent over the previous year. The U.S.S.R., the Republic of South Africa, and West Germany were the principal sources of these imports and supplied more anthracite in 1971 than in 1970. Imports from the United Kingdom, France, and the United States declined during 1971.

TECHNOLOGY

Helium has been used to trace the movement of gases in oilfields, but it was used for the first time to trace gases from a burning section of a coal mine in 1967.[2] Since carbon monoxide had been detected in several residences and business establishments, it was desirable to trace the toxic gas to its source.

Accordingly, a geothermal investigation of the enlarged project area was planned. For the purpose of this investigation, boreholes were drilled to a depth of about 10 feet each, and individually calibrated thermistors were inserted. The holes were then backfilled. In those boreholes in which temperatures were too high for insertions of thermistor probes, readings were obtained with thermocouples. A liberal interpretation of the readings, influenced to some extent by the fire in the landfill, indicated an underground temperature pattern that coincides closely with the information obtained from the large number of 6-inch exploratory boreholes that were used in outlining the active fire zone in the Big and New County beds.

Bureau of Mines scientists utilized the buoyant and inert qualities of helium gas to identify the source and trace the flow pattern of the toxic gases that were seeping into the basements of homes. Air samples were first taken from several existing boreholes to determine the percentage of helium in the mine atmosphere. Boreholes were then drilled inside the fire zone down to the bed and large quantities of helium gas were injected under pressure. Subsequently, some helium in excess of amounts normally found in mine air was detected in boreholes located a considerable distance from the outer perimeter of the sand barrier that had been made to contain the fire in the bed.

Bureau scientists concluded that possible fissures in the rock strata overlying the original bed seal permitted noxious gases from the contained fire area to enter and travel through abandoned mine workings subjacent to the adjoining residential area. This assumption was indicated by the detection of helium in all but three sampling points outside of the flushed bed seal.

After completion of the helium tracer study, the conclusion was reached that the previous flushing operation had not provided a gas tight seal between the fire area and the residential area. This established the need to extend the isolation trench.

The Pennsylvania Department of Environmental Resources has awarded a contract to a producer of pollution control equipment. Under the contract the firm will pursue a project to demonstrate the economic advantages of using the company's electrochemical process for the removal of metal pollutants from coal mine drainage waste water.

The demonstration project will be carried out over approximately a 1 year period. The first stage will involve laboratory effort on the electrolytic treatment of acid mine drainage waste of the company's plant. Second-stage work will include design and construction of a prototype unit which will be installed in an existing mine, probably in the Wilkes-Barre area.

Maps of abandoned underground mines continued to be microfilmed as part of a Bureau of Mines program to preserve old mine maps for future studies of subsidence and mine fire control, and for evaluating building sites. The data accumulated by the program also has proved to be an invaluable aid in evaluations made by the Army Corps of Engineers for the maintenance and possible expansion of flood-control projects under its jurisdiction in the northern anthracite field.

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[2] Dierks, H. A., R. H. Whaite, and A. H. Harvey. Three Mine Fire Control Projects in Northeastern Pennsylvania. With appendix, "Helium Tracer Study," by B. J. Moore. BuMines Info. Circ. 8524, 1971, 53 pp.

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.
Carbon County:			
Buck Mountain	Lime neutralization stream treatment	Commonwealth of Pennsylvania.	Work in progress 1971.
Lackawanna, Susquehanna, and Wayne Counties:			
Upper Lackawanna River	Abatement and gravity discharge, design and specification project	do	Do.
Luzerne County:			
Catawissa Creek, Hazle Township	Channel relocations to control acid water	do	Do.
Plymouth Borough	Abatement of mine water and reclamation	do	Work started in 1969.
Sandy Run	Lime neutralization stream treatment plant	do	Work in progress 1971.
Northumberland County:			
Shamokin Creek	Engineering study to determine pollution abatement measure needed.	do	Do.
Do	Design, supervision of construction and operation of treatment plants.	do	Do.
Schuylkill County:			
Catawissa Creek	Plugging of abandoned Audenried Tunnel	do	Do.
Frailey Township	Installation of flumes and drainage ditches, sealing strip pits, and reconditioning of stream beds of Bailey and Gebhard Runs.	do	Do.
Hegins Township	Rehabilitation of surface area of Rausch Creek and Lorberry Creek watershed.	do	Do.
Rausch Creek	Lime neutralization mine discharge treatment plant	do	Do.
Swatara Creek	Survey of Swatara Creek watershed to evaluate abatement measures needed on Panther and Black Creeks.	do	Do.
Do	Survey to evaluate abatement measures needed on Middle and Goodspring Creeks, and Gebhard and Coal Runs.	do	Do.
Do	Survey to determine pollution abatement measures needed on Lower Rausch Creek and Lorberry Creek.	do	Do.
SURFACE SUBSIDENCE			
Lackawanna County:			
Scranton, Central City, East	Appalachia project for hydraulic backfill of mine voids in Pine Brook Co. mine adjacent to previous backfill project.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Project completed 1971.
Scranton, Central City, West	Appalachia project for hydraulic backfill of mine voids in top three coalbeds of abandoned Pine Brook Co. mine.	do	Do.

Table 3.—Project Report—Continued

Project location	Project description	Sponsor	Status of report
	UNDERGROUND MINE FIRES		
Columbia County:			
Centralia Borough	Appalachia mine fire control, which includes Phase I exploratory drilling and Phase II (1) underground barrier pillars formed by injecting fly ash into mine void of west barrier, 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.	Phase I completed 1968; Phase II work in progress 1971.
Lackawanna County:			
Carbondale Township	Appalachia mine fire control at site of former mine in the southwest part of the city of Carbondale, which includes Phase I exploratory drilling, Phase II excavation of isolation trench, and sand seal barrier backfill.	do	Phase I completed 1969; Phase II work in progress 1971.
Cedar Avenue, Scranton	Appalachia mine fire control at site under Cedar Avenue section, which includes Phase I exploratory drilling, Phase II (1) sand seal of top bed, and Phase II (2) isolation trench with backfilled sand seal of lower bed.	do	Phase I completed 1967; Phase II (1) completed 1968; Phase II (2) in progress 1971.
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 1971.
Laurel Run Borough	Appalachia mine fire control, which included Phase I exploratory, Phase II (1) sealing 3 tunnels, Phase II (2) reinforcing East and West barriers with sand seals, Phase II (3) additional sand barrier seals.	do	All Phases completed, except Phase II (3) in progress 1971.
Swoyersville Borough, Kingston Township	Appalachia mine fire control at site of former Forty Fort Mine property, which includes Phase I exploratory drilling and Phase II excavation.	do	Do.
Warrior Run Borough	Appalachia mine fire control at site, Phase I which includes exploratory drilling to determine extent of fire.	do	Work started in 1971.
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 the Commonwealth of Pennsylvania in 1970.	do	Phase I work completed in 1968.

Table 4.—Summary of monthly developments in the Pennsylvania anthracite industry in 1971

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1971	Change from 1970 (percent)	Year 1970
Production (including mine fuel, local sales, and dredge coal)	725	654	780	795	782	740	620	813	767	710	685	656	8,727	−10.3	9,729
Shipments (breakers and washeries only, all sizes):															
By rail [1]	229	202	318	373	329	378	256	333	351	283	239	191	3,482	−11.1	3,915
By truck [2]	432	377	336	362	334	341	330	391	361	392	407	424	4,487	−.9	4,527
Carloadings [3]	4	3	6	7	6	6	5	5	6	5	4	3	60	−11.8	68
Distribution:															
Lake Erie loadings [4]	--	--	--	5	13	8	--	9	3	5	8	--	51	−66.9	154
Upper Lake dock trade: [5]															
Receipts	(6)	(6)	1	--	--	--	(6)	1	(6)	--	--	(6)	2	−93.5	31
Deliveries (reloadings)	4	(6)	(6)	(6)	(6)	(6)	2	(6)	(6)	1	(6)	(6)	7	−85.1	47
Exports [7]	17	16	69	75	92	66	36	76	105	17	36	66	671	−15.0	789
Industrial consumption and stocks by:															
Electric utilities: [8]															
Consumption	150	146	105	141	134	135	138	140	146	126	138	147	1,646	−13.2	1,879
Stocks	1,033	968	992	1,017	1,033	1,083	1,101	1,140	1,136	1,158	1,155	1,123	1,123	+2.2	1,099
Coke plants:															
Used for carbonizing	35	28	36	38	37	66	33	37	37	38	27	39	451	−4.4	472
Stocks	111	97	80	65	55	70	89	102	108	110	130	118	118	−2.5	121
Stocks on Upper Lake docks: [5]															
Lake Superior	1	1	1	1	1	1	--	--	--	--	--	--	--	--	5
Lake Michigan	1	(6)	2	2	2	2	2	2	2	1	1	1	1	--	1

Table 4.—Summary of monthly developments in the Pennsylvania anthracite industry in 1971—Continued

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1971	Change from 1970 (percent)	Year 1970
Stocks in retail dealer yards: [9]															
Chestnut and larger	100	98	80	75	106	134	137	137	134	125	107	100	100	−7.4	108
Pea	10	10	7	7	9	11	13	12	13	12	11	11	11	−15.4	13
Buckwheat No. 1 and rice	60	59	52	68	88	99	100	101	101	100	77	71	71	−12.3	81
Total	170	167	139	150	203	244	250	250	248	237	195	182	182	−9.9	202
Retail dealer deliveries: [9]															
Chestnut and larger	133	132	98	48	39	32	30	37	59	74	89	73	844	−3.8	877
Pea	60	60	56	25	20	31	11	12	17	14	15	13	334	−31.8	490
Buckwheat No. 1 and rice	63	63	38	46	33	19	20	24	31	27	39	40	443	−21.6	565
Total	256	255	192	119	92	82	61	73	107	115	143	126	1,621	−16.1	1,923
Wholesale price indexes (1957–59 = 100): [10]															
F.o.b. car at mines:															
Chestnut	139.6	139.6	139.6	139.6	133.7	128.2	131.9	131.9	132.6	131.9	131.9	131.9	134.4	+15.6	116.3
Buckwheat No. 1	155.3	155.3	155.3	155.3	158.3	156.9	169.9	169.9	162.9	161.9	161.9	161.9	160.4	+26.4	126.9

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, 904,948 short tons of anthracite was exported to Europe during 1971 compared with 976,501 short tons for 1970. Of this total 748,996 short tons was consigned to West Germany and the Netherlands, including exports to the U.S. military forces. This compares with 685,599 short tons for 1970.

Table 5.—Commercial production of Pennsylvania anthracite in 1971, by region and size

Size	From preparation plants						From preparation plants						From river dredging			Total		
	Lehigh region			Schuylkill region			Wyoming region [1]			Total preparation plants								
	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]
Quantity, thousand short tons:																		
Lump and broken	--	--	--	--	1	1	--	--	--	--	1	1	--	--	--	--	1	1
Egg	95	4	99	37	1	38	33	1	34	165	7	172	--	--	--	165	7	172
Stove	194	44	237	274	180	453	141	92	233	608	316	924	--	--	--	608	316	924
Chestnut	109	130	239	164	301	465	88	141	229	361	572	933	--	--	--	361	572	933
Pea	98	118	216	89	234	323	46	181	228	234	533	767	--	--	--	234	533	767
Total pea and larger [2]	496	296	792	563	717	1,280	308	416	724	1,367	1,428	2,796	--	--	--	1,367	1,428	2,796
Buckwheat No. 1	124	107	231	164	280	444	95	212	307	384	599	982	--	--	--	384	599	982
Buckwheat No. 2 (rice)	47	185	232	56	331	387	32	127	159	135	643	778	--	--	--	135	643	778
Buckwheat No. 3 (barley)	82	137	219	174	378	552	73	124	197	329	639	968	--	--	--	329	639	968
Buckwheat No. 4	85	36	121	200	215	415	42	35	78	328	286	614	--	3	3	328	289	617
Buckwheat No. 5	186	78	264	609	278	888	40	21	61	835	377	1,212	19	14	33	854	391	1,245
Other [3]	--	316	316	55	329	384	27	246	272	81	892	973	261	92	354	342	984	1,327
Total buckwheat No. 1 and smaller [2]	524	860	1,383	1,259	1,811	3,070	310	765	1,074	2,092	3,435	5,528	280	110	390	2,372	3,545	5,918
Grand total [2]	1,020	1,155	2,175	1,822	2,528	4,350	618	1,180	1,798	3,460	4,863	8,323	280	110	390	3,740	4,973	8,713
Value, thousands:																		
Lump and broken	--	--	--	--	$2	$2	--	--	--	--	$2	$2	--	--	--	--	$2	$2
Egg	$1,676	$66	$1,742	$619	25	643	$637	$24	$661	$2,932	114	3,046	--	--	--	$2,932	114	3,046
Stove	3,215	731	3,946	4,523	3,022	7,550	2,352	1,533	3,885	10,096	5,286	15,382	--	--	--	10,096	5,286	15,382
Chestnut	1,791	2,147	3,988	2,711	4,997	7,708	1,533	2,484	4,018	6,036	9,628	15,664	--	--	--	6,036	9,628	15,664
Pea	1,418	1,738	3,156	1,338	3,512	4,850	736	2,976	3,711	3,492	8,226	11,718	--	--	--	3,492	8,262	11,718
Total pea and larger [2]	8,101	4,681	12,782	9,197	11,557	20,754	5,259	7,017	12,275	22,556	23,255	45,812	--	--	--	22,556	23,255	45,812
Buckwheat No. 1	1,819	1,543	3,363	2,422	4,137	6,559	1,351	3,300	4,651	5,592	8,981	14,573	--	--	--	5,592	8,981	14,573
Buckwheat No. 2 (rice)	687	2,641	3,328	814	4,777	5,590	472	1,943	2,415	1,972	9,361	11,333	--	--	--	1,972	9,361	11,333
Buckwheat No. 3 (barley)	1,111	1,674	2,785	2,045	4,737	6,782	933	1,657	2,589	4,089	8,068	12,156	--	--	--	4,089	8,068	12,156
Buckwheat No. 4	778	248	1,027	1,801	1,523	3,323	327	278	605	2,905	2,050	4,955	--	13	13	2,905	2,063	4,968
Buckwheat No. 5	1,247	503	1,751	3,567	1,656	5,223	267	136	403	5,081	2,296	7,376	65	72	137	5,146	2,368	7,514
Other [3]	--	1,278	1,278	226	1,117	1,343	131	1,567	1,698	357	3,962	4,319	2,251	331	2,582	2,608	4,293	6,901

Table 5.—Commercial production of Pennsylvania anthracite in 1971, by region and size—Continued

Size	From preparation plants						From preparation plants						From river dredging			Total		
	Lehigh region			Schuylkill region			Wyoming region [1]			Total preparation plants								
	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]
Total buckwheat No. 1 and smaller [2]	5,643	7,887	13,531	10,874	17,947	28,821	3,479	8,882	12,361	19,996	34,716	54,712	2,316	417	2,733	22,312	35,133	57,445
Grand total [2]	13,744	12,569	26,313	20,070	29,504	49,575	8,737	15,899	24,636	42,552	57,972	100,524	2,316	417	2,733	44,868	58,389	103,257
Average value per ton: [4]																		
Lump and broken	--	--	--	--	$6.00	$6.00	--	--	--	--	$6.00	$6.00	--	--	--	--	$6.00	$6.00
Egg	$17.61	$16.94	$17.59	$16.82	17.20	16.83	$19.30	$18.96	$19.29	$17.77	17.38	17.76	--	--	--	$17.77	17.38	17.76
Stove	16.60	16.71	16.62	16.56	16.80	16.65	16.73	16.59	16.67	16.61	16.73	16.65	--	--	--	16.61	16.73	16.65
Chestnut	16.42	16.50	16.47	16.54	16.60	16.58	17.46	17.62	17.56	16.73	16.83	16.79	--	--	--	16.73	16.83	16.79
Pea	14.45	14.74	14.60	15.02	14.99	15.00	15.86	16.42	16.30	14.95	15.42	15 28	--	--	--	14.95	15.42	15.28
Total pea and larger	16.33	15.83	16.14	16.33	16.12	16.21	17.08	16.87	16.96	16.50	16.28	16.39	--	--	--	16.50	16.28	16.39
Buckwheat No. 1	14.66	14.42	14.55	14.72	14.79	14.77	14.22	15.57	15.15	14.58	15.00	14.83	--	--	--	14.58	15.00	14.83
Buckwheat No. 2 (rice)	14.62	14.25	14.33	14.63	14.42	14.45	14.54	15.33	15.17	14.60	14.55	14.56	--	--	--	14.60	14.55	14.56
Buckwheat No. 3 (barley)	13.55	12.20	12.71	11.75	12.55	12.30	12.71	13.37	13.13	12.41	12.63	12.56	--	--	--	12.41	12.63	12.56
Buckwheat No. 4	9.17	6.95	8.51	8.99	7.08	8.00	7.71	7.85	7.78	8.87	7.16	8.07	--	$4.08	$4.08	8.86	7.14	8.05
Buckwheat No. 5	6.72	6.44	6.64	5.85	5.95	5.88	6.63	6.57	6.61	6.08	6.09	6.08	$3.50	5.05	4.17	6.03	6.06	6.04
Other [3]	--	4.04	4.04	4.13	3.39	3.50	4.92	6.38	6.24	4.39	4.44	4.44	8.61	3.60	7.31	7.63	4.36	5.20
Total buckwheat No. 1 and smaller	10.78	9.17	9.78	8.64	9.91	9.39	11.23	11.62	11.50	9.56	10.11	9.90	8.27	3.81	7.01	9.41	9.91	9.71
Grand total	13.48	10.88	12.10	11.02	11.67	11.40	14.15	13.47	13.70	12.30	11.92	12.08	8.27	3.81	7.01	12.00	11.74	11.85

[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	Lehigh region					Schuylkill region				
	1967	1968	1969	1970	1971	1967	1968	1969	1970	1971
Lump [1] and broken	--	--	--	--	--	--	--	--	--	--
Egg	4.6	4.5	4.6	4.0	4.6	1.2	1.2	1.2	1.0	0.9
Stove	11.0	10.3	10.0	9.4	10.9	9.4	9.4	9.8	10.7	10.4
Chestnut	12.1	12.0	13.1	11.1	11.0	10.7	11.1	11.3	12.3	10.7
Pea	9.0	10.9	10.7	9.2	9.9	8.0	7.7	7.4	8.3	7.4
Total pea and larger	36.7	37.7	38.4	33.7	36.4	29.3	29.4	29.7	32.3	29.4
Buckwheat No. 1	10.5	11.0	11.7	10.2	10.6	11.0	11.0	11.2	11.0	10.2
Buckwheat No. 2 (rice)	8.9	9.6	11.2	9.4	10.7	9.2	9.5	9.2	9.8	8.9
Buckwheat No. 3 (barley)	9.1	10.3	10.8	11.9	10.1	11.1	11.8	14.5	13.1	12.7
Buckwheat No. 4	6.0	6.6	8.0	7.2	5.6	6.7	6.5	7.0	6.8	9.6
Buckwheat No. 5	15.9	16.9	16.9	14.7	12.1	12.8	13.0	13.2	13.5	20.4
Other [2]	12.9	7.9	3.0	12.9	14.5	19.9	18.8	15.2	13.5	8.8
Total buckwheat No. 1 and smaller	63.3	62.3	61.6	66.3	63.6	70.7	70.6	70.3	67.7	70.6
	Wyoming region					Total				
Lump [1] and broken	(3)	(3)	--	--	(3)	(3)	(3)	--	--	(3)
Egg	3.0	1.9	3.1	2.4	1.9	2.6	2.2	2.5	2.1	2.1
Stove	12.0	11.7	12.0	10.3	13.0	10.5	10.2	10.4	10.3	11.1
Chestnut	15.8	15.6	15.9	15.5	12.7	12.4	12.5	12.8	12.7	11.2
Pea	12.1	12.2	12.2	11.5	12.7	9.3	9.7	9.4	9.3	9.2
Total pea and larger	42.9	41.4	43.2	39.7	40.3	34.8	34.6	35.1	34.4	33.6
Buckwheat No. 1	13.3	14.4	14.7	15.4	17.1	11.5	11.9	12.2	11.8	11.8
Buckwheat No. 2 (rice)	9.4	9.2	9.4	8.7	8.8	9.2	9.4	9.7	9.4	9.3
Buckwheat No. 3 (barley)	10.6	10.3	9.7	10.7	11.0	10.4	11.1	12.4	12.2	11.6
Buckwheat No. 4	2.6	2.6	3.6	5.3	4.3	5.4	5.5	6.4	6.6	7.4
Buckwheat No. 5	6.0	5.1	2.6	4.5	3.4	11.9	11.8	11.6	11.8	14.6
Other [2]	15.2	17.0	16.8	15.7	15.1	16.8	15.7	12.6	13.8	11.7
Total buckwheat No. 1 and smaller	57.1	58.6	56.8	60.3	59.7	65.2	65.4	64.9	65.6	66.4

[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 percent.

Table 7.—Production of Pennsylvania anthracite in 1971, 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 [2]	Quantity	Value [2]
REGIONS								
Lehigh:								
Preparation plants	1,020	$13,744	1,155	$12,569	6	$91	2,181	$26,404
Schuylkill:								
Preparation plants	1,822	20,070	2,528	29,504	5	65	4,355	49,640
Dredges	280	2,316	110	417	--	--	389	2,733
Total Schuylkill [1]	2,102	22,386	2,637	29,921	5	65	4,744	52,373
Wyoming:								
Preparation plants [3]	618	8,737	1,180	15,899	4	56	1,802	24,692
Total: [1]								
Preparation plants	3,460	42,552	4,863	57,972	15	212	8,338	100,736
Dredges	280	2,316	110	417	--	--	390	2,733
Grand total [1]	3,739	44,868	4,973	58,389	15	212	8,727	103,469
COUNTIES								
Berks, Lancaster, Snyder, and Susquehanna	280	2,316	93	335	--	--	373	2,651
Carbon	265	3,257	47	278	--	--	313	3,535
Columbia	191	2,893	42	358	--	--	233	3,250
Dauphin	4	50	79	784	--	--	83	834
Lackawanna	150	1,733	291	4,151	1	3	441	5,886
Luzerne	1,073	15,635	1,536	18,445	9	139	2,618	34,219
Northumberland	342	3,221	582	7,070	1	4	925	10,295
Schuylkill	1,434	15,764	2,177	25,852	4	67	3,615	41,683
Sullivan	--	--	126	1,116	--	--	126	1,116
Total [1]	3,739	44,868	4,973	58,389	15	212	8,727	103,469

[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.

Table 8.—Pennsylvania anthracite produced, by field
(Thousand short tons)

Field	1967	1968	1969	1970	1971
Eastern Middle: Breakers and washeries	2,039	1,559	1,583	1,511	1,519
Western Middle:					
Breakers and washeries	2,893	2,840	2,806	2,540	2,167
Dredges	27	17	5	W	W
Total	2,920	2,857	2,811	W	W
Southern:					
Breakers and washeries	3,604	3,557	3,183	3,183	2,849
Dredges	605	589	530	W	W
Total	4,209	4,146	3,713	W	W
Northern: Breakers and washeries [1]	3,088	2,899	2,366	2,086	1,802
Total:					
Breakers and washeries	11,624	10,855	9,938	9,320	8,337
Dredges	632	606	535	409	390
Grand total	12,256	11,461	10,473	9,729	8,727

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Sullivan County.

Table 9.—Pennsylvania anthracite produced in 1971, classified as fresh-mined, culm-bank, and river coal, by field and region
(Thousand short tons)

Source	Fresh-mined coal				From culm banks	From river dredging	Total [1]
	Underground mines			Strip pits			
	Mechanically loaded	Hand loaded	Total [1]				
FIELD							
Eastern Middle	1	--	1	1,001	517	--	1,519
Western Middle	33	170	203	958	1,006	W	W
Southern	275	416	691	1,408	750	W	W
Northern [2]	361	30	391	1,111	300	--	1,802
Total [1]	670	617	1,287	4,478	2,573	390	8,727
REGION							
Lehigh	1	13	14	1,438	729	--	2,181
Schuylkill	309	573	882	1,929	1,544	390	4,744
Wyoming [2]	361	30	391	1,111	300	--	1,802
Total [1]	670	617	1,287	4,478	2,573	390	8,727

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
1967	4,740	59.3	1,883	237
1968	4,696	65.7	1,891	239
1969	4,579	68.5	1,787	256
1970	4,541	72.3	1,855	234
1971:				
Lehigh region	1,438	99.1	505	292
Schuylkill region	1,929	68.6	829	249
Wyoming region [1]	1,111	74.0	466	295
Total or average	4,478	77.7	p 1,800	p 271

p Preliminary.
[1] Includes Sullivan County.

Table 11.—Power shovels and draglines used in recovering coal from culm banks and stripping Pennsylvania anthracite, by type of power

Type of power	1969			1970			1971		
	Number of power shovels	Number of drag-lines	Total	Number of power shovels	Number of drag-lines	Total	Number of power shovels	Number of drag-lines	Total
Gasoline	3	3	6	4	2	6	1	2	3
Electric	27	37	64	18	40	58	18	36	54
Diesel	74	124	198	72	104	176	43	85	128
Diesel-electric	--	1	1	--	--	--	--	1	1
Total	104	165	269	94	146	240	62	124	[1] 263

[1] Includes 77 front-end loaders.

Table 12.—Production of Pennsylvania anthracite from culm banks, by region

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total [1]
1967	1,134	1,710	782	3,627
1968	958	1,868	883	3,709
1969	775	1,815	662	3,253
1970	921	1,591	524	3,036
1971	729	1,544	300	2,573

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

Table 13.—Estimated production of Pennsylvania anthracite in 1971, by week [1]

Week ended—	Thousand short tons	Week ended—	Thousand short tons	Week ended—	Thousand short tons
Jan. 2	[2] 12	May 8	211	Sept. 11	135
9	174	15	198	18	228
16	185	22	139	25	172
23	173	29	215	Oct. 2	174
30	181	June 5	138	9	149
Feb. 6	146	12	171	16	152
13	113	19	178	23	158
20	183	26	204	30	195
27	212	July 3	88	Nov. 6	137
Mar. 6	135	10	62	13	139
13	175	17	167	20	202
20	194	24	198	27	146
27	180	31	154	Dec. 4	175
Apr. 3	158	Aug. 7	170	11	171
10	192	14	193	18	140
17	212	21	190	25	117
24	169	28	187	Jan. 1	[2] 115
May 1	178	Sept. 4	187		
				Total	8,727

[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.
[2] Figures represent output of working days in that part of week included in calendar year shown.

Table 14.—Estimated monthly production of Pennsylvania anthracite [1]

(Thousand short tons)

Month	1967	1968	1969	1970	1971
January	1,101	965	973	808	725
February	939	962	911	770	654
March	979	960	898	814	780
April	952	926	916	759	795
May	1,102	986	869	763	782
June	995	824	812	809	740
July	899	853	704	707	620
August	1,132	1,016	877	898	813
September	1,071	953	947	880	767
October	1,073	1,136	985	895	710
November	1,017	994	831	815	685
December	996	886	750	811	656
Total	12,256	11,461	10,473	9,729	8,727

[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.—Pennsylvania anthracite loaded mechanically underground, by field

(Thousand short tons)

Field	Scraper loaders [1]		Pit-car loaders		Hand-loaded face conveyors, all types [2]		Total mechanically loaded [3]	
	1970	1971	1970	1971	1970	1971	1970	1971
Northern	393	304	4	--	159	57	556	361
Eastern Middle	8	--	--	--	8	--	16	(4)
Western Middle	35	21	--	--	58	13	93	33
Southern	238	146	--	28	248	101	485	275
Total [3]	674	470	4	28	472	171	1,151	670

[1] Includes mobile loaders.
[2] Shaker chutes, including those equipped with duckbills.
[3] Data may not add to totals shown because of independent rounding.
[4] Less than ½ unit.

Table 16.—Pennsylvania anthracite loaded mechanically underground

(Thousand short tons)

Year	Scraper loaders		Mobile loaders		Conveyor [1] and pit-car loaders		Total [2] loaded mechanically	
	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded
1967	119	707	21	201	228	1,090	368	1,998
1968	131	710	26	121	184	643	341	1,475
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

[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

(Thousand short tons)

Year	Underground					Strip pits		
	Mechanical loading	Percent of total underground	Hand loading	Percent of total underground	Total [2]	Quantity	Percent of total underground	Total [2]
1967	1,998	61.3	1,260	38.7	3,258	4,740	59.3	7,998
1968	1,475	60.2	975	39.8	2,450	4,696	65.7	7,146
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

[1] Mechanical loading includes coal handled on pit-car loaders and hand-loaded face conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 18.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by region and size

(Per short ton)

Size	Lehigh region					Schuylkill region				
	1967	1968	1969	1970	1971	1967	1968	1969	1970	1971
Lump [1] and broken	--	--	--	--	--	--	--	--	--	$6.00
Egg	$12.68	$12.99	$14.16	$14.90	$17.59	$12.49	$13.26	$13.66	$14.27	16.83
Stove	12.51	12.93	14.05	14.98	16.62	11.80	12.82	13.92	15.35	16.65
Chestnut	12.46	12.93	14.08	15.19	16.47	11.53	12.66	13.84	15.29	16.58
Pea	9.42	10.33	11.75	13.56	14.60	9.15	10.44	11.91	13.46	15.00
Total pea and larger	11.76	12.18	13.43	14.65	16.14	11.00	12.15	13.38	14.81	16.21
Buckwheat No. 1	9.01	9.70	11.18	12.78	14.55	9.02	10.03	11.56	13.26	14.77
Buckwheat No. 2 (rice)	9.62	10.24	11.49	12.94	14.33	8.67	9.80	11.30	12.99	14.45
Buckwheat No. 3 (barley)	7.78	8.29	9.42	11.07	12.71	7.43	8.13	9.54	11.05	12.30
Buckwheat No. 4	5.48	5.72	5.92	7.16	8.51	5.50	5.91	6.67	7.60	8.00
Buckwheat No. 5	5.46	5.54	5.80	6.20	6.64	4.70	4.95	5.34	5.54	5.88
Other [2]	3.13	3.36	3.55	4.14	4.04	3.95	3.56	3.73	3.68	3.50
Total buckwheat No. 1 and smaller	6.49	7.20	8.39	8.51	9.78	6.18	6.65	7.76	8.77	9.39
Total all sizes	8.42	9.08	10.33	10.74	12.10	7.60	8.26	9.43	10.72	11.40
	Wyoming region [3]					Total				
Lump [1] and broken	$14.96	$14.80	--	--	--	$14.96	$14.80	--	--	$6.00
Egg	12.74	13.24	$13.86	$15.62	$19.29	12.65	13.12	$13.95	$14.93	17.76
Stove	12.66	13.40	14.32	16.00	16.67	12.25	13.02	14.06	15.41	16.65
Chestnut	12.31	13.58	14.58	16.75	17.56	12.03	13.02	14.12	15.67	16.79
Pea	10.73	11.61	12.81	14.83	16.30	9.75	10.80	12.14	13.87	15.28
Total pea and larger	11.99	12.93	13.96	15.93	16.96	11.53	12.40	13.56	15.06	16.39
Buckwheat No. 1	9.60	10.56	11.77	13.62	15.15	9.19	10.13	11.53	13.26	14.83
Buckwheat No. 2 (rice)	9.59	10.59	11.79	13.77	15.17	9.16	10.11	11.47	13.14	14.56
Buckwheat No. 3 (barley)	7.44	8.26	9.43	11.07	13.13	7.51	8.20	9.49	11.06	12.56
Buckwheat No. 4	5.65	5.80	7.55	7.16	7.78	5.51	5.84	6.56	7.40	8.07
Buckwheat No. 5	4.55	4.17	4.65	4.41	6.61	4.95	5.06	5.47	5.65	6.08
Other [2]	2.45	2.45	1.98	4.50	6.24	3.43	3.22	3.16	4.00	4.44
Total buckwheat No. 1 and smaller	6.58	7.04	7.88	9.56	11.50	6.35	6.87	7.93	8.92	9.90
Total all sizes	8.91	9.48	10.51	12.09	13.70	8.15	8.78	9.91	11.03	12.08

[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 19.—Average value of Pennsylvania anthracite from all sources, by region [1]

(Per short ton)

Region	1970				1971			
	Shipped by rail	Shipped by truck	Colliery fuel	Total	Shipped by rail	Shipped by truck	Colliery fuel	Total
Lehigh	$10.87	$10.63	$13.30	$10.75	$13.48	$10.88	$15.27	$12.11
Schuylkill	9.61	10.94	11.91	10.36	10.65	11.34	14.16	11.04
Wyoming [2]	13.32	11.66	11.58	12.09	14.15	13.47	14.08	13.70
Total	10.47	11.06	12.34	10.83	12.00	11.74	14.59	11.86

[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 20.—Wholesale prices of Pennsylvania anthracite in 1971, by size [1]

(Per short ton)

Size	Winter	Spring discount	Summer-fall	End of year
Egg and Stove	$18.25–$20.75	$17.25	$17.75–$18.75	$17.75
Chestnut	18.00– 20.70	17.00	17.50– 18.50	17.50
Pea	15.50– 18.20	15.50– 15.60	16.00– 17.10	16.00– 16.10
Buckwheat No. 1	15.00– 17.80	15.50– 15.60	16.00– 17.10	16.00– 16.10
Buckwheat No. 2 (rice)	15.00– 17.80	15.50– 15.60	16.00– 17.10	16.00– 16.10
Buckwheat No. 3 (barley)	14.00– 15.45	14.50	15.00– 15.25	15.00

[1] As quoted in the Black Diamond Magazine. All prices are per short ton f.o.b. at mines.

Table 21.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1971

	Lehigh region	Schuylkill region	Wyoming region [1]	Total 1971 [p]	Total 1970
Average number of men working daily:					
Underground	28	925	487	1,440	1,423
In strip pits	505	829	466	1,800	1,855
At culm banks	194	241	105	540	560
At preparation plants	457	745	298	1,500	1,581
Other surface	20	155	285	460	456
Total excluding dredge operations	1,204	2,895	1,641	5,740	5,875
Dredge operations	--	60	--	60	63
Total	1,204	2,955	1,641	5,800	5,938
Average number of days active:					
All operations except dredges	263	229	236	238	234
Dredge operations	--	300	--	300	292
Average, all operations	263	230	236	239	234
Man-days of labor:					
All operations except dredges	317,000	662,000	388,000	1,367,000	1,373,260
Dredge operations	--	18,000	--	18,000	18,412
Total, all operations	317,000	680,000	388,000	1,385,000	1,391,672
Average tons per man-day:					
All operations except dredges	6.88	6.58	4.64	6.10	6.90
Dredge operations	--	21.64	--	21.64	22.25
Average, all operations	6.88	6.98	4.64	6.30	7.10

[p] Preliminary.
[1] Includes Sullivan County.

Table 22.—Employment at operations producing Pennsylvania anthracite (including strip contractors) by county

County	1970	1971 [p]	County	1970	1971 [p]
Berks, Lancaster, Lebanon, Snyder, and Susquehanna	57	56	Luzerne	1,910	1,866
Carbon	254	248	Northumberland	725	708
Columbia	163	159	Schuylkill	2,381	2,326
Dauphin	73	71	Sullivan	35	34
Lackawanna	340	332	Total	5,938	5,800

[p] Preliminary.

Table 23.—Distribution of Pennsylvania anthracite, April 1, 1970 to March 31, 1971, by State, province, and country of destination

(Short tons)

Destination	Pea and larger: Broken and egg	Pea and larger: Stove	Pea and larger: Chestnut	Pea and larger: Pea	Pea and larger: Total	Buckwheat No. 1 and smaller: Buckwheat No. 1	Buckwheat No. 1 and smaller: Buckwheat No. 2 (rice)	Buckwheat No. 1 and smaller: Buckwheat No. 3 (barley)	Buckwheat No. 1 and smaller: Other	Buckwheat No. 1 and smaller: Total	Total all sizes	Percent of total
United States:												
New England States:												
Connecticut	163	3,930	6,519	163	10,775	1,121	428	72	215	1,836	12,611	0.1
Maine	--	4,896	5,253	69	10,218	444	2,580	5	39	3,068	13,286	.2
Massachusetts	770	17,634	13,818	1,790	34,012	3,870	8,129	1	374	12,374	46,386	.6
New Hampshire	--	2,945	2,364	91	5,400	1,123	1,947	--	178	3,248	8,648	.1
Rhode Island	--	1,136	916	--	2,052	--	105	--	1	106	2,158	(1)
Vermont	--	6,775	4,389	939	12,103	1,812	7,487	--	--	9,299	21,402	.2
Total	933	37,316	33,259	3,052	74,560	8,370	20,676	78	807	29,931	104,491	1.2
Middle Atlantic States:												
New Jersey	1,581	32,783	71,878	22,654	128,896	36,095	21,650	65,953	201,874	325,572	454,468	5.3
New York	6,110	148,868	115,946	257,754	528,678	115,210	51,439	71,624	185,953	424,226	952,904	11.1
Pennsylvania [2]	6,061	251,084	590,774	420,804	1,268,723	630,701	634,737	798,169	1,149,983	3,213,590	4,482,313	52.3
Total	13,752	432,735	778,598	701,212	1,926,297	782,006	707,826	935,746	1,537,810	3,963,388	5,889,685	68.7
South Atlantic States: [3]												
Delaware	716	6,464	6,569	2,040	15,789	364	149	3,724	116	4,353	20,142	.2
District of Columbia	--	2,546	2,486	381	5,413	372	673	2	20	1,067	6,480	.1
Maryland	4,417	19,878	16,564	4,684	45,543	7,249	1,668	10	42,707	51,634	97,177	1.1
Virginia	--	2,390	957	307	3,654	129	150	2	5,660	5,941	9,595	.1
Total	5,133	31,278	26,576	7,412	70,399	8,114	2,640	3,738	48,503	62,995	133,394	1.5

Table 23.—Distribution of Pennsylvania anthracite, April 1, 1970 to March 31, 1971, by State, province, and country of destination—Continued

Destination	Pea and larger					Buckwheat No. 1 and smaller					Total all sizes	Percent of total
	Broken and egg	Stove	Chestnut	Pea	Total	Buckwheat No. 1	Buckwheat No. 2 (rice)	Buckwheat No. 3 (barley)	Other	Total		
Lake States:												
Illinois	--	27	859	1,577	2,463	79,851	8,509	2,147	14,382	104,889	107,352	1.3
Indiana	--	--	8,680	15,393	24,073	2,636	173	429	41,277	44,515	68,588	.8
Michigan	180	21,370	1,944	217	23,711	33	742	14,188	48,716	63,679	87,390	1.0
Minnesota	--	--	4	1	5	2	1	3	28,573	28,579	28,584	.3
Ohio	--	11,871	6,637	11,024	29,532	14,048	13,940	1,714	120,932	150,634	180,166	2.1
Wisconsin	--	2,405	4,590	132	7,127	22	314	43	6,360	6,739	13,866	.2
Total	180	35,673	22,714	28,344	86,911	96,592	23,679	18,524	260,240	399,035	485,946	5.7
Other States	26	34	2,901	28,200	31,161	79,259	4,185	29,125	281,002	393,571	424,732	5.0
Total United States	20,024	537,036	864,048	768,220	2,189,328	974,341	759,006	987,211	2,128,362	4,848,920	7,038,248	82.1
Canada:												
Ontario	4,971	28,482	35,081	21,234	89,768	41,332	6,137	10,526	12,194	70,189	159,957	[4] 1.9
Quebec	--	4,450	3,975	1,792	10,217	35,453	31,512	121,288	83,461	271,714	281,931	[4] 3.3
Other provinces	--	696	640	3	1,339	3	122	3	428	556	1,895	(1)
Total Canada	4,971	33,628	39,696	23,029	101,324	76,788	37,771	131,817	96,083	342,459	443,783	5.2
Other countries	186,641	365,615	169,325	31,107	752,688	13,729	39	32,353	290,692	336,813	1,089,501	12.7
Grand total	211,636	936,279	1,073,069	822,356	3,043,340	1,064,858	796,816	1,151,381	2,515,137	5,528,192	8,571,532	100.0

[1] Less than 0.05 percent.
[2] Includes "Local Sales."
[3] Shipments to other States in the South Atlantic area are included in "Other States."
[4] Data may not add to totals shown because of independent rounding.

Table 24.—Truck shipments of Pennsylvania anthracite in 1971, 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 [2]	Percent of total trucked
Pennsylvania:														
Within region	179	150	149	142	123	126	128	182	158	173	176	194	1,880	41.9
Outside region	183	166	149	177	165	165	168	173	171	177	183	173	2,050	45.7
New York	47	42	28	31	29	32	23	26	23	27	30	35	373	8.3
New Jersey	16	13	7	9	14	14	7	6	5	9	12	14	126	2.8
Delaware	2	2	2	1	1	1	1	1	1	1	2	2	17	.4
Maryland	4	3	1	1	2	2	2	1	2	3	4	4	29	.6
District of Columbia	(3)	(3)	(3)	--	--	--	--	--	--	--	--	--	(3)	--
Other States	1	1	1	1	1	1	(3)	2	1	1	1	1	12	.3
Total: [2]														
1971	432	377	337	362	334	341	330	391	361	392	408	424	4,487	100.0
1970	499	443	432	257	353	326	289	352	363	413	362	437	4,527	100.0

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.

Table 25.—Shipments of Pennsylvania anthracite, by destination [1]

(Thousand short tons)

Destination	1967	1968	1969	1970	1971
TRUCK SHIPMENTS					
Pennsylvania:					
Within region	1,986	2,021	1,918	1,847	1,880
Outside region	2,485	2,269	2,151	1,979	2,050
New York	418	409	369	418	373
New Jersey	286	248	247	198	126
Delaware	23	26	22	18	17
Maryland	89	188	94	50	29
District of Columbia	6	2	2	2	(2)
Other States	20	18	17	15	12
Total [3]	5,312	5,181	4,821	4,527	4,487
RAIL SHIPMENTS					
New England States	174	163	107	102	100
New York	703	606	645	455	532
New Jersey	323	263	291	173	113
Pennsylvania	1,052	846	940	847	819
Delaware	5	1	(2)	1	1
Maryland	83	32	34	19	24
District of Columbia	10	9	4	7	3
Virginia	13	6	6	9	7
Ohio	85	98	215	151	122
Indiana	51	43	70	66	54
Illinois	114	108	102	93	57
Wisconsin	16	14	6	12	8
Minnesota	22	13	25	51	1
Michigan	41	42	33	53	70
Other States	244	233	312	408	455
Total United States [3]	2,936	2,476	2,792	2,447	2,366
Canada	306	308	373	384	411
Other countries	894	697	853	691	572
Grand total [3]	4,136	3,481	4,018	3,522	3,347

[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.

Table 26.—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: Coke making	Iron and steel industry: Sintering and pelletizing [2]	Other uses [e]	Unaccounted for [3]
1967	5,035	143	2,186	239	528	819	1,800	50
1968	4,759	56	2,203	[r] 181	532	748	1,635	46
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	451	339	1,037	--

[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.

[3] Data discontinued after December 1969.

Table 27.—U.S. exports of anthracite by country and customs district

	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY				
Argentina	2,236	$24	4,006	$138
Australia	3,673	207	3,976	237
Brazil	1,032	53	3,947	327
Canada	438,008	5,851	466,039	6,018
Chile	572	17	905	36
Colombia	24	2	358	19
Finland	213	3	320	14
France	228,630	3,226	101,330	1,473
Germany, West	7,880	79	26,248	440
India	372	r 12	278	17
Iran	6	(1)	954	58
Ireland	1,789	43	--	--
Italy	60,968	733	229	3
Japan	126	3	10,543	103
Korea, Republic of	825	35	190	2
Mexico	4,608	115	4,316	115
Netherlands	656	8	1,469	76
Peru	6,196	121	--	--
Philippines	635	25	1,042	45
Singapore	--	--	4,149	120
Surinam	1,424	42	254	19
United Kingdom	1,096	39	22	2
Venezuela	16,098	377	2,967	97
Vietnam, South	10,609	128	2,713	41
Yugoslavia	314	15	33,891	678
Other	1,509	57	878	26
Total	789,499	11,215	671,024	10,104
CUSTOMS DISTRICT				
Baltimore	1,732	50	54,410	602
Buffalo	95,348	1,443	108,612	1,725
Cleveland	10,287	155	--	--
Detroit	4,608	274	1,033	13
Duluth	574	7	--	--
Galveston	--	--	618	8
Houston	5,218	293	11,077	610
Laredo	4,608	115	4,316	115
Los Angeles	--	--	135	2
Miami	43	2	26	1
Mobile	1,170	23	--	--
New Orleans	999	68	3,438	231
New York City	2,603	126	1,006	29
Norfolk	40,688	569	155	2
Ogdensburg	62,304	1,144	45,265	764
Pembina	--	--	30	2
Philadelphia	558,458	6,906	440,619	5,996
Port Arthur	191	10	--	--
Portland, Oregon	131	11	229	3
San Francisco	481	16	55	1
St. Albans	56	3	--	--
Total	789,499	11,215	671,024	10,104

r Revised.
1 Less than ½ unit.

NOTE: According to the Association of American Railroads, 904,948 short tons of anthracite was exported to Europe during 1971, compared with 976,501 tons for 1970. Of this total 748,996 tons was consigned to West Germany and the Netherlands, including exports to the U.S. Military forces. This compares with 685,599 tons for 1970.

Table 28.—Anthracite:[1] World production, by country

(Thousand short tons)

Country[2]	1969	1970	1971 p
Belgium	r 4,683	4,063	3,716
Bulgaria	r 171	177	e 180
China, People's Republic of e	22,000	22,000	22,000
France	11,116	10,850	10,117
Germany, West	11,692	11,261	10,935
Ireland	e 110	87	e 80
Japan	1,350	1,145	549
Korea:			
North	22,200	24,000	26,800
Republic of	11,324	13,662	14,093
Morocco	438	477	524
Netherlands	6,098	5,011	4,183
Peru	8	22	e 22
Portugal	r 460	299	279
Romania e	17	17	17
South Africa, Republic of	1,699	1,850	2,029
Spain	r 3,057	3,095	3,157
U.S.S.R	r 84,559	83,558	e 83,800
United Kingdom	4,002	4,061	e 4,000
United States (Pennsylvania)	10,473	9,729	8,727
Vietnam, North e	3,300	3,300	3,300
Total	r 198,757	198,664	198,508

e Estimate. p Preliminary. r Revised.

[1] An undetermined 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; in Canada, output is of the order of 200,000 tons annually; 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]

In 1971, cobalt demand continued a decline that began in 1970 and reflected a general slowdown in the Nation's economy. Consumption of cobalt in the United States in 1971 was 6.5 percent below that of the previous year, which in turn had fallen 14 percent below the record consumption in 1969. Consumer stocks during 1971 reached their lowest point in over 5 years, and imports decreased 12.1 percent when compared with 1970. Government sales of cobalt from the strategic stockpile continued to decline since only 901,699 pounds had been sold at yearend, compared with 2,484,730 pounds sold during 1970.

Legislation and Government Programs.—The General Services Administration (GSA) continued to offer cobalt metal for sale in various forms at a rate of approximately 2 million pounds per month on a competitive-bid basis. Sales to individual purchasers was limited to 500,000 pounds per month; total sales for the year were 901,699 pounds of cobalt metal.

As of December 31, 1971, total U.S. Government stockpile inventory was 77,443,583 pounds of cobalt. Of this quantity, 71,811,518 pounds was stockpile grade.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1967	1968	1969	1970	1971
United States:					
Consumption	13,976	12,998	15,608	13,367	12,500
Imports for consumption	8,215	9,068	12,911	12,417	10,912
Stocks, Dec. 31: Consumer	2,471	2,139	2,191	1,890	1,411
Price: Metal, per pound	$1.85	$1.85	$1.85–$2.20	$2.20	$2.20–$2.45
World: Production	44,028	41,968	43,556	52,578	51,734

DOMESTIC PRODUCTION

Cobalt continued to be produced in the United States as a byproduct of iron ore mining. The cobalt-bearing concentrate was processed by The Pyrites Co., Inc., of Delaware, through utilization of a solvent extraction process introduced in 1970. The Blackbird cobalt-copper deposit of The Hanna Mining Co. remained inactive during the year; however, some metallurgical test work was done at Blackbird No. 2.

American Metals Climax Inc. (AMAX) announced plans to revive the nickel refinery at Braithwaite, La., which was closed in 1960 following confiscation by the Castro Government of nickel properties in Cuba which supplied the plant. The refinery was designed to produce 50 million pounds of nickel plus cobalt per year. Cobalt will be produced in three forms: metal, oxide powder, and metal briquettes. Company officials also announced a preliminary agreement with Bamangwato Concessions Ltd. (BCL) to toll-refine nickel-copper matte once BCL's nickel-copper mining project in Botswana is brought into production.

CONSUMPTION AND USES

Consumption of cobalt in the United States in 1971 continued a decline that began in 1970. Reduced economic activity around the world, particularly reduced demand for superalloys and aerospace materials was the principal cause of reduced cobalt consumption. Major uses of cobalt in 1971 were as shown in table 4, in magnetic alloys, superalloys, salts and driers, and cutting and wear-resistant materials. Data reported by consumers showed that 72 percent of the cobalt consumed in the U.S. during 1971 was in the form of metal, the remaining percentage was comprised of cobalt oxide, purchased scrap, and salts and driers. Total U.S. cobalt consumption was 12.5 million pounds in 1971.

Commercial production of high-strength cobalt-samarium permanent magnets (Gecor) was announced by the General Electric Co. late in 1971. Laboratory samples of these magnets have shown a maximum energy product of over 25 million gauss-oersteds, making them 2.5 to 5.0 times more powerful than conventional high-strength magnets. Company officials anticipated that Gecor magnets would find use in aircraft and spacecraft motors and instruments, hearing aids, electronic tubes, electric watches, biomedical devices, and commercial motors and generators.

Table 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1967	1968	1969	1970	1971
Alloy and concentrate	1,168	1,184	516	274	356
Metal	1,618	1,831	2,819	2,639	2,899
Hydrate	18	14	25	32	18
Other	2	11	1	9	9

[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)

	1970				1971			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	458	322	434	305	713	489	771	519
Hydrate	585	338	584	330	523	322	483	296
Salts [2]	6,355	1,677	6,184	1,620	6,306	1,681	6,240	1,679
Driers	8,662	662	8,691	666	8,335	728	8,580	769
Total	16,060	2,999	15,893	2,921	15,877	3,220	16,074	3,263

[1] Figures on metal withheld to avoid disclosing individual company confidential 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	1971
Steel:	
Carbon	1
Stainless and heat-resisting	50
Alloy (excludes stainless and tool)	196
Tool	318
Cast irons	W
Superalloys	1,983
Alloys (excludes alloy steels and superalloys):	
Cutting and wear-resistant materials [1]	1,230
Welding and alloy hard-facing rods and materials	246
Magnetic alloys	2,278
Nonferrous alloys	532
Other alloys	470
Mill products made from metal powder	W
Chemical and ceramic uses:	
Pigments	146
Catalysts	474
Ground coat frit	137
Glass decolorizer	60
Other	102
Miscellaneous and unspecified	1,532
Total [2]	9,756
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc.	[e] 2,744
Grand total [2]	12,500

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."
[1] Includes cemented and sintered carbides and cast carbide dies or parts.
[2] Data may not add to totals shown because of independent rounding.

Table 5.—Cobalt consumed in the United States, by form

(Thousand pounds of contained cobalt)

Form	1967	1968	1969	1970	1971
Metal	11,610	10,456	12,057	10,056	9,006
Oxide	654	573	646	626	625
Purchased scrap	120	143	328	69	125
Salts and driers	1,592	1,826	2,577	2,616	2,744
Total	13,976	12,998	15,608	13,367	12,500

PRICES

After remaining at $2.20 per pound, f.o.b. New York or Chicago, for more than 2 years, the price of cobalt metal in the form of granules (shot) or broken cathodes in 551-pound (250-kilogram) drums was increased by African Metals Corp., the principal supplier, to $2.45 per pound, effective December 27. Other suppliers soon followed African Metals' move; on December 29 Sherritt Gordon Mines Ltd. and the Finnish producer, Outokumpu Oy, announced similar price increases. The increase reportedly was related to the 1971 realignment of world currencies.

Sales of cobalt metal by GSA on a "sealed-bid" basis generally brought a price of $2.15 per pound during the year. A few exceptions were noted wherein $2.14 per pound was accepted. All prices were f.o.b. carrier's conveyance at Government storage locations.

FOREIGN TRADE

Exports of unwrought cobalt metal and alloys and of waste and scrap totaled 883,660 pounds, gross weight, having a value of $803,607 and went to 19 countries. Japan and Canada received the greater part, 582,760 pounds ($493,054) and 69,667 pounds ($33,864), respectively. Exports of wrought cobalt metal and alloys, 328,404 pounds, gross weight, having a value of $1,303,806, went to 20 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			
	1970		1971		1970		1971	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Belgium-Luxembourg	2,914	$7,114	2,914	$6,754	710	$1,393	726	$1,425
Canada	463	1,093	909	1,933	--	--	--	--
Finland	452	1,103	1,208	2,696	--	--	--	--
France	33	72	126	180	--	--	--	--
Germany, West	110	325	2	4	--	--	--	--
Netherlands	45	70	42	76	--	--	--	--
Norway	794	1,748	800	1,758	--	--	--	--
United Kingdom	132	187	223	212	(1)	1	(1)	1
Zaire (formerly Congo-Kinshasa)	6,930	14,308	4,157	8,674	--	--	--	--
Total	11,873	26,020	10,381	22,287	710	1,394	726	1,426

1 Less than ½ unit.

Table 7.—U.S. imports for consumption of cobalt, by classes

(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
1969	12,037	$21,725	1,175	$2,023	131	$67	13,343	r 12,911
1970	11,873	26,020	710	1,394	157	92	12,740	r 12,417
1971	10,381	22,287	726	1,426	40	27	11,147	10,912

e Estimated. r Revised.

WORLD REVIEW

The quantity of cobalt produced in the free world in 1971 decreased about 2 percent from the preceding year. The Republic of the Zaire, formerly the Congo (Kinshasa), again led all producing countries. Mine production in Morocco and Canada showed increases in 1971, and production from Zaire and Zambia decreased.

Australia.—Government approval was obtained during 1971 for the construction of the Greenvale nickel project located in Queensland, Australia. By yearend, Freeport Queensland Nickel, Inc., and Metals Exploration N.L. had lined up approximately four-fifths of the necessary capital and obtained commitments for 95 percent of the output. Pilot plant operations were reported as successful and were shutdown after 9 months of operation. The $265 million laterite project will have a total capacity of 46-million pounds per year of contained nickel in the form of 90 percent nickel oxide, plus 7.5-million pounds per year of additional nickel, and 2.75-million pounds per year of cobalt in the form of nickel-cobalt sulfide. Startup of the operation was scheduled for 1974. Proven reserves were reported to be 44 million tons, averaging 1.57 percent nickel and 0.12 percent cobalt.

Table 8.—Cobalt: World production by country

(Short tons)

Country	Mine output, cobalt content [1]			Metal [2]		
	1969	1970	1971 [p]	1969	1970	1971 [p]
Australia	[r] 269	511	[e] 350	--	--	--
Canada [3]	1,628	2,281	2,496	818	1,419	1,538
Cuba [e]	1,700	1,700	1,700	--	--	--
Finland	[e] [r] 1,300	[e] 1,400	[e] 1,400	858	1,111	1,020
France [e] [4]	--	--	--	900	900	900
Germany, West [4]	--	--	--	937	911	662
Morocco	1,554	666	1,078	--	--	--
Norway	NA	NA	NA	[5] 810	[5] 862	[5] 958
U.S.S.R. [e] [6]	1,650	1,700	1,750	1,650	1,700	1,750
United States	W	W	W	227	162	154
Zaire (formerly Congo-Kinshasa)	[7] 11,680	15,386	14,800	11,680	14,742	16,003
Zambia [8]	1,997	2,645	2,293	1,983	2,262	2,079
Total	[r] 21,778	26,289	25,867	19,863	24,069	25,064

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

[1] In addition to the countries listed, Bulgaria, Cyprus, East Germany, New Caledonia, Norway, 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] The United Kingdom recovers cobalt metal from intermediate metallurgical products imported from Canada, but data on output is inseparable from the total reported by Canadian producers. Czechoslovakia presumably recovers cobalt from materials imported from Cuba, but data are inadequate to estimate output. Belgium and Japan, 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 apparently processes cobalt-bearing copper ores, but no data on cobalt recovery are available.

[3] Actual mine output not reported. Data presented for mine output are total cobalt content of all products, including nickel oxide sinter shipped to United Kindom and nickel-copper matte shipped to Norway for further processing. Data presented for metal content 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 reduced to metal as well as total metal actually recovered in both Canada and the United Kingdom.

[4] Domestic mine output, if any, is negligible.

[5] Produced entirely from nickel-copper 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] Mine output not available; data presented are metal production.

[8] Metal figures given are content of matte.

Canada.—Canadian mine production of cobalt in 1971 was reported as 5.0 million pounds valued at $10.1 million, compared with 4.6 million pounds valued at $9.4 million in 1970. International Nickel Co. of Canada, Ltd.'s (Inco), deliveries of cobalt equaled those of 1970 and totaled 1,980,000 pounds. Falconbridge Nickel Mines Ltd.'s production of cobalt in 1971 was less than the 1,984,140 pounds produced in 1970. Falconbridge officials announced good progress on the Becancour, Quebec, refinery complex. Completion of the refinery, originally scheduled for 1974, has been rescheduled for 1975. When completed, the refinery will produce annually over 500,000 pounds of high-purity cobalt salts. Cobalt refined by Sherritt Gordon Mines Ltd. was 561,000 pounds in 1971, compared with 803,000 pounds in 1970. Sales of cobalt for the 2 years were 679,000 and 706,000 pounds, respectively. Decreased cobalt sales could be traced to consumers working off stocks. Although Sherritt Gordon completed extensive tests at their Fort Saskatchewan demonstration plant on Le Nickel's laterite ore from New Caledonia, the latter failed to pick up their option on using the process.

Finland.—Outokumpu Oy produced cobalt by treating pyrite concentrates with a sulfating roast. The cobalt, nickel, and copper values were leached with water and a proprietary Sherritt Gordon process was used to separate solubilized cobalt from nickel and copper. Final cobalt recovery was by hydrogen precipitation. The plant's annual capacity was rated at 3-million pounds of refined cobalt. The new Vuonos nickel-copper project, near the Outokumpu mine, was to start operations during 1971. At yearend, it was not known if the project had been started. Vuonos was expected to become the largest mine in Finland with a planned capacity of 148 million tons of ore per year. Actual metal output from the Vuonos operation was to be 2,000 tons per year nickel, 16,000 tons per year copper, and 72,000 tons per year of cobalt-rich iron pyrites. Cobalt metal production was 1,020 tons in 1971, compared with 1,111 tons in 1970.

India.—The Indian National Government and the Orissa State Government planned to establish a nickel extraction plant in Orissa to exploit the Sukinda nickel deposits. Annual capacity of the plant was projected to be 4,400 tons of nickel powder, 220 tons of cobalt powder, and 18,740 tons of byproduct ammonium sulfate. Construction was to take nearly 4 years with the plant reaching its rated capacity during the third year from commissioning.

Indonesia.—P. T. Pacific Nikkel Indonesia licensed Sherritt Gordon's nickel laterite process for possible use. The Indonesian company had developed an ore reserve of 164 million tons grading 1.48 percent nickel and 0.12 percent cobalt on Gag Island in the Waigeo area of Irian Barat, Indonesia. During 1971, the company conducted studies to determine the feasibility of developing the deposit. As part of the study, 12,000 wet tons of ore were to be shipped from Gag Island to Sherritt Gordon's Fort Saskatchewan plant for testing during 1972.

Japan.—Nippon Mining Co. planned to produce about 1,100 tons per year of cobalt from mixed nickel-cobalt sulfides at its smelting facility in Hitachi, Ibaraki Prefecture; Sumitomo Metal Mining Co. intended to produce about 1,300 tons per year at its plant in Niihama, Ehime Prefecture. Sumitomo signed an agreement with Marinduque Mining and Industrial Corp. of the Philippines to purchase approximately 16,500 tons per year of nickel-cobalt concentrate from Nonoc Island in return for a nickel-reduction plant manufactured by Kobe Steel. Combined production capacity of the two companies will provide approximately 30 percent of Japan's total cobalt requirements.

Morocco.—Ugine Kuhlmann experienced considerable difficulty in April 1970 when the company's cobalt veins became depleted. Through assistance of Soviet mining engineers and geologists, a new vein was discovered early in 1971. The new vein graded 2.5 percent cobalt before treatment. Officials estimated that proven reserves would last 3 to 4 years and probable reserves 10 years at the present production rate of 9,000 to 11,000 tons of concentrate per year. The concentrate also contained 1 to 2 percent nickel and 40 percent arsenic. Production of cobalt concentrate was 10,800 tons in 1971 and contained 10 to 12 percent cobalt, a 62-percent increase over that produced in 1970. Exports in 1971 were 4,800 tons and went to France.

Philippines.—Marinduque's planned nickel development on Nonoc Island in the Philippines continued to progress during 1971. Early in the year the company announced that the Philippine Government had agreed to guarantee repayment by Marinduque of up to $120 million in financing. The financing was being solicited by Marinduque in connection with its proposed nickel mine and refinery. Marinduque also announced that it had concluded an agreement with Philipp Brothers Oceanic Inc. (a subsidiary of Engelhard Minerals and Chemicals Philipp Corp.) covering the sale of 55 million pounds of nickel powder and/or briquet output by the proposed refinery. The agreement covered a period of 10 years, effective with the startup of commercial production. The company announced previously that it had entered into a 7-year agreement with Sumitomo Metal Mining Co., Ltd., of Japan to sell approximately 11.2 million pounds of nickel briquets, 5 million pounds of nickel, and approximately 3 million pounds of cobalt contained in mixed sulfide concentrates to Sumitomo. Sherritt Gordon agreed to assist Marinduque in financing its 75-million-pound-per-year nickel mine on Nonoc Island. The assistance was to be in the form of a $5 million purchase of Marinduque's shares after June 30, 1973, at the then-established price (subject to certain restrictions). Marinduque was to use the Sherritt Gordon lateritic nickel process under license. Some financial difficulties were encountered late in the year when Marinduque had to recall a public offering of its shares. The recall was precipitated by a market decline in the value of Marinduque stock. These financial difficulties appeared to be resolved when the Philippine Government agreed to put up $20 million in equity financing needed by Marinduque to go ahead with its nickel project.

Soriano Co. of the Philippines requested members of the Japanese ferronickel industry to participate in developing a nickel mine on Palawan Island. The nickel deposits were estimated to contain approximately 200 million tons of ore grading 1.39 percent nickel and 1.4 percent cobalt.

Uganda.—The planned takeover of Kilembe Copper Cobalt Ltd. mines by the Ugandan Government appeared to have passed when the military took charge of the Government early in 1971. The new administration tended to look favorably upon foreign investments. The Companies Pact of 1970, which was to give the Government an additional 50-percent share in the Kilembe mines, thereby leaving Kilembe with only a 31-percent holding as of April 30, 1970, was changed by the new Government and resulted in Kilembe mines being exempt from Government takeover.

Cobalt bearing pyrite residues were stockpiled during the year. Projects nearing completion in 1971 included a cobalt extraction plant with an annual capacity of approximately 1,100 tons. The plant will produce a cobalt compound for shipment to a Norwegian refinery.

Zaire.—The Republic of the Zaire again led all nations in producing cobalt. Annual mine production of cobalt in 1971 was 29,600,000 pounds, compared with 30,772,000 pounds in 1970. Générale Congolaise des Mines (GÉCOMINES) announced a detailed schedule for a 5-year expansion program. The program called for an output of 16,000 tons of cobalt annually by 1974. Early in the year the Common Market's European Investment Bank reported granting a $16 million loan to GÉCOMINES. The program's total development cost was estimated at $101.2 million. Recent expansions by GÉCOMINES have involved bringing the new Kamoto underground mine into operation, alterations to the Kambove and Kolwezi concentrators bringing total treatment capacity to 5.9 million tons of ore per year, as well as bringing a fifth section at the Ruwe washing plant into operation. Plans called for the Kamoto concentrator capacity to be doubled to 3.6 million tons of ore per year by 1972.

In 1971, Charter Consolidated, Ltd., obtained mining concessions from the Government. The concessions are in the Tenke-Fungurume area of Katanga. Charter, through Société Congolaise du Tenke-Fungurume (SOCOTEF), investigated known high-grade occurrences of copper-cobalt ores during the year. Six drilling rigs were in operation with an additional six to eight rigs expected before the end of the year. The ore zone was described as complex, both geologically and mineralogically, and consisted of a high-grade oxide about 750 feet thick with underlying sulfides. Tentative plans called for open pit mining of the oxide ore body using a solvent extraction process for beneficiation of the complex ore. Deeper lying portions of the ore bodies were to be mined by underground methods.

Zambia.—The Government-controlled mining company, Roan Consolidated Mines Ltd. (RCM), purchased in 1971 the country's largest remaining foreign-owned copper mining property. The property, Baluba Mines Ltd., formerly owned by Roan Selection Trust International, Inc., and Zambia Copper Investments Ltd., contained an estimated 60 million tons of ore grading 2.7 percent copper and 0.17 percent cobalt. The Baluba project was to be operated as part of RCM's Luanshya Division. Production at Baluba was rated at 24,250 tons of copper per year by the second half of 1973. Combined output of Luanshya and Baluba mines would then be 132,300 tons of copper per year. Future plans called for increasing production at Baluba to 55,000 tons per year, and thereby maintain mine output even though Luanshya's production decreased. Cobalt concentrates will be sent to Chambishi for production of cobalt hydroxide. In the 15-month period ending March 31, 1971, Nchanga Consolidated Copper Mines Ltd. (NCCM) produced 2,880 tons of cobalt.

TECHNOLOGY

Bureau of Mines scientists reported on the thermal oxidation of cobalt-nickel-aluminum alloys between 1,351° to 1,429° K.[2] The objective of the research was to determine the effect of aluminum alloy additions on the oxidation behavior of cobalt-nickel alloys. Alloys tested consisted of cobalt-nickel master alloys (0, 22, 50, 70, 91, and 100 weight-percent nickel), with aluminum additions of 0, 1, 2, 4, and 8 weight-percent. Master alloys containing 8 percent aluminum oxidized far more slowly than any other combination. The lower oxidation rates observed in alloys containing 8 percent aluminum were attributed to the formation of a protective Al_2O_3 layer. When cobalt-nickel-aluminum and cobalt-nickel-vanadium oxidation data were combined for statistical analyses, a very slight change in the correlation coefficient was noted, thus indicating basically very similar effects (kinetically and mechanistically) of vanadium and aluminum on the oxidation of cobalt-nickel alloys.

Bureau metallurgists reported the effect of temperature on the electrolytic preparation and recovery of samarium-cobalt alloy.[3] The report described the effect that the temperature of a samarium fluoride-lithium fluoride electrolyte had on the electrolytic preparation of samarium-cobalt alloys by the consumable cathode technique. In order to obtain a satisfactory samarium-cobalt alloy product, temperatures of the cathode zone, alloy collection zone, and samarium oxide (Sm_2O_3) feed zone had to be controlled carefully. Careful control of these zonal temperatures in a thermal gradient cell resulted in production of gram quantities of samarium-cobalt alloy.

Metco Inc. announced the development of a new tungsten carbide-cobalt coating that officials said reduced the cost of producing extreme wear resistance in machine parts. The coating was accomplished through an improved method of plasma flame spraying. The powder was propelled through a plasma flame spray gun, bombarding the work piece with microscopic particles at such high velocities that they bond metallurgically to the metal surface.[4] Company officials of Deepsea Ventures, Inc., announced a breakthrough in metallurgical processing of manganese nodules. In the process, metals were converted to their chlorides in a hydrogen chloride environment. The metal chlorides were solubilized by water leaching. Copper, nickel, and cobalt were recovered from the resulting solution through specific liquid ion exchange reagents. After stripping the metals from their respective reagents, the metals reportedly were recovered electrolytically to a 99.999 percent purity. The president of Deepsea Ventures reported that his company planned to commercialize the process by the mid-1970's.[5]

Other developments of interest during 1971 included a new process utilizing chlorine and sea water for the improved recovery of cobalt from nickeliferous limonites,[6] and the development of high-energy magnetic tapes for sound and video markets utilizing a cobalt-modified ferric oxide.[7] The new cobalt recovery process accomplished two goals; first it permitted the efficient extraction of nickel and cobalt; and secondly it brought about valorization of the iron and chromium contents of low magnesia, nickeliferous limonites. The basic steps of the process were chlorination of the reduced ore with chlorine and sea water followed by beneficiation of the leached pulp to produce a solution, which was subjected to solvent extraction techniques. The extracted cobalt and nickel chlorides are subjected to oxidation or reduction, respectively, to produce cobalt and nickel. Numerous technical papers were presented on cobalt metal, alloys and alloy systems, magnetic materials, alloy steels, and microstructure analysis of alloys.[8]

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[2] Doerr, Robert M., and James W. Jensen. Oxidation of Cobalt-Nickel-Aluminum Alloys at 1,351° to 1,429° K. BuMines Rept. of Inv. 7496, 1971, 27 pp.

[3] Morrice, E., and M. M. Wong. Effect of Temperature on the Electrolytic Preparation and Recovery of Samarium-Cobalt Alloy. BuMines Rept. of Inv. 7556, 1971, 11 pp.

[4] American Metal Market. Metco Develops Cobalt-Tungsten Carbide Coating. V. 78, No. 48, March 11, 1971, p. 15.

[5] Mining Engineering. Deepsea Ventures-Mn Nodule Breakthrough. V. 23, No. 6, June 1971, p. 14.

[6] Queneau, Paul E. and H. J. Roorda. Cobalt from Nickeliferous Limonites. Mining Engineering, v. 23, No. 8, August 1971, pp. 70–73.

[7] Metals Week. Cobalt a Boom to Magnetic Tape. V. 42, No. 16, April 19, 1971, p. 4.

[8] Cobalt-Quarterly Publication on Cobalt and Its Uses (Cobalt Information Center, Battelle Mem. Inst., Columbus, Ohio). Nos. 50–53, March–December 1971.

Coke and Coal Chemicals

By Eugene T. Sheridan [1]

The total coke production of the United States decreased 14 percent in 1971 when compared with output in 1970, and reported production for the year was recorded at 57.4 million tons. The decline in output was attributed mainly to a short labor strike in the steel industry, which curtailed coke-plant operations, and a 44-day labor strike in the bituminous-coal industry, which restricted shipments of coking coal and forced coke plants to decrease their operating rates.

Production was relatively stable during the first half of the year but there was a significant decline in monthly output from June through December. Although the coal-industry strike was settled on November 14, shortages of coking coals prevailed throughout the year and continued through the first quarter of 1972.

Demand for coke exceeded production during most of the year and producers' month-end stocks of oven coke were 15 percent lower at the end of the year than when the year began. Stocks on hand at oven-coke plants at the end of the year were equivalent to 26 days' production at the December rate of output.

Blast furnaces continued to use the bulk of the Nation's coke production, receiving 92 percent of the coke distributed by producers. The remaining coke was consumed principally in foundries and miscellaneous industrial plants. A small quantity of coke was sold for residential heating, but this market is declining rapidly and will soon be nonexistent.

Breeze production decreased 13 percent, mainly because less coal was carbonized; however, the breeze yield increased slightly in 1971. 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 steam raising, sintering iron ores, and other industrial purposes. However, 46 percent of the 1971 output was sold, mainly for use as a reductant in electric furnaces that smelt phosphate rock to produce elemental phosphorus. Sales of breeze in 1971 were 10 percent less than in 1970.

Coal costs increased substantially in 1971. The average delivered value of coking coals at coke-oven plants increased $1.79 per ton, while the value of coking coals received at beehive plants increased $1.23 per ton. Price increases were reported by plants in all States, but the largest increases were noted for the coals received by coke plants in Minnesota and Wisconsin.

Production of coke-oven gas decreased 13 percent because of the smaller quantity of coal carbonized. Output of ammonia, crude tar, and crude light oil decreased also, for the same reason. Except for light oil, yields of these products per ton of coal carbonized increased, however, during 1971.

Coke prices increased significantly during 1971. The average value of receipts of $37.41 per ton for all grades of oven coke and $21.45 per ton for all grades of beehive coke represented price increases of 25 percent for oven-coke and 8 percent for beehive coke.

Most of the overall oven-coke price increase was attributed to blast-furnace coke, which increased 22 percent in value per ton at the producing plant.

Foreign trade in coke was relatively small; exports amounted to only 3 percent of the production. The bulk of the coke exported was shipped to Canada, Japan, the Netherlands, Venezuela, Peru, West Germany, and Mexico. Exports declined 39 percent from the 1970 level.

The total value of all coals carbonized was $1,158 million, and the total value of all products of carbonization was $2,109 million. The combined value of coke and breeze, the principal products, accounted for 88 percent of the total value of all products.

[1] Mineral specialist, Division of Fossil Fuels.

Table 1.—Salient coke statistics

	1967	1968	1969	1970	1971
United States:					
Production:					
Oven coke thousand short tons	63,775	62,878	64,047	65,654	56,664
Beehive coke do	806	775	710	871	772
Total do	64,580	63,653	64,757	66,525	57,436
Imports do	92	94	173	153	174
Exports do	710	792	1,629	2,478	1,509
Producers' stocks, Dec. 31 do	5,468	5,985	3,120	4,113	3,510
Consumption, apparent do	61,572	62,438	66,166	63,207	56,704
Value of coal-chemical materials used or sold thousands	$292,579	$281,250	$288,963	$293,464	$260,171
Value of coke and breeze used or sold thousands	1,119,288	1,187,402	1,402,716	1,899,116	1,848,781
Total value of all products used or sold [1] thousands	1,411,867	1,468,651	1,691,679	2,192,580	2,108,953
World production:					
Hard coke thousand short tons	334,970	348,112	370,205	386,203	374,098
Gashouse and low-temperature coke thousand short tons	34,273	31,293	30,738	28,090	24,152

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

COKE AND BREEZE

DOMESTIC PRODUCTION

Although varying somewhat from month to month, coke production was stable during the first half of 1971. A short labor strike in the steel industry and a 44-day labor strike in the coal industry curtailed production during the latter part of the year, however, and the overall output for the year was 14 percent less than in 1970. Peak production for the year was recorded in March when the output of oven and beehive coke totaled 5.8 million tons. The average daily output of all plants in December 1971 was about 48,000 tons less than in December 1970. Table 5 compares the monthly and average daily production of oven and beehive plants in 1971 and 1970.

The terms "merchant" and "furnace" denote the ownership or affiliation of oven-coke plants. Furnace plants are owned by, or are financially affiliated with, iron and steel companies and mainly produce blast-furnace coke for use in their own blast furnaces. Merchant plants produce various grades of coke for sale on the open market. A few merchant plants, however, are associated with chemical companies and gas utilities.

There were 48 furnace plants and 14 merchant plants in operation at the end of 1971. Two merchant plants—the Koppers plant at Kearney, N.J., and the General Motors plant at Waukegan, Ill.—discontinued operations during the year. The loss of this production was partially offset by the reactivation of the Interlake Iron Co. plant at Erie, Pa. Ninety percent of the total output of oven coke in 1971 was supplied by furnace plants.

Current monthly output of merchant and furnace plants, as well as annual output for the past 5 years, is shown in tables 6 and 7.

Coke was produced in 20 States in 1971. 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 Eastern and North Central States in the major steel-producing areas, and the bulk of the coke output in 1971 was produced in 14 States east of the Mississippi River. About 4 million tons, 7 percent of the total, was produced in States west of the Mississippi River.

Pennsylvania, the largest producer, accounted for 27 percent of the output and was followed by Indiana, Ohio, Alabama, and Michigan, in the order named. The combined output of these five States was about two-thirds of the national total. Pennsylvania had nearly twice the production of any other State. These data are shown in table 8.

An average of 1,380 pounds of coke was produced for each ton of coal carbonized in the United States in 1971. The 1971 yield of coke from coal, which averaged 69.00 percent, 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 currently consume 63 percent of the breeze produced, principally as a fuel in agglomerating plants. The remainder is sold, mainly for use as a fuel for smelting phosphate rock to produce elemental phosphorus. During the past 5 years the amount of breeze sold has increased significantly. The quantity sold in 1971 was 50 percent greater than the quantity sold in 1967.

The breeze yield varies substantially within and between States according to the coals carbonized. The lowest yield, 3.42 percent, was recorded for Pennsylvania, while the yield for Minnesota and Wisconsin averaged 9.52 percent. The national average yield has not varied significantly during the past decade.

An average of 98.8 pounds of breeze was produced for each ton of coal carbonized at oven-coke plants in 1971. This quantity amounted to 4.94 percent of the coal carbonized. Breeze yields of beehive-coke plants were substantially higher, but beehive breeze production was negligible because only a few plants had recovery facilities.

Production and disposal of breeze, by States, in 1971 are shown in table 9. Table 10 shows the quantities consumed by producers for various uses and the quantities sold during the past 5 years.

CONSUMPTION AND SALES

Apparent consumption of coke in the United States in 1971 totaled 56.7 million tons. This consumption (domestic production plus imports, minus exports and changes in stocks) was about 6.5 million tons less than the quantity consumed in 1970. Although the quantity of coke consumed per ton of pig iron and ferroalloys produced decreased slightly in 1971, most of the decrease in total demand was the result of a lower overall requirement for blast-furnace coke, caused by a 10-million-ton decline in blast-furnace pig iron and ferroalloy production in 1971. Apparent consumption of coke in the United States in 1971, including a breakdown for that used in iron furnaces and for all other purposes, is shown in table 11.

The decline in blast-furnace coke consumption rates between 1967 and 1971 is shown in table 12. Except for slight increases in 1965 and 1970, the coke rate had declined each year during the past decade and the amount of coke required to produce a ton of pig iron and ferroalloys in blast furnaces in 1971 was only 1,261 pounds, compared with 1,395 pounds in 1962. The net effect of this 10-percent reduction in coke rate over the 10-year period can best be emphasized by noting that if the 1971 output of 81.3 million tons of blast-furnace pig iron and ferroalloys had been produced in blast furnaces operating at the 1962 rate, total blast-furnace coke requirements for the year would have been 57.0 million tons, rather than the 51.5 million tons actually consumed.

Tables 13 and 14 show the quantities of coke used and sold in each State in 1971. A total of 58.8 million tons of oven and beehive coke was sold and used for all purposes, of which about 90 percent 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, 25 percent of the total coke sold commercially. Fifty-nine percent of the furnace-plant sales was shipped to other blast-furnace plants.

Merchant plants distributed 5.6 million tons of coke in 1971, 98 percent 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 operate coke ovens to supply their own requirements; about 2 percent of the merchant coke distributed is 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 1971.

Alabama, Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania, which are the major iron- and steel-producing States, received about four-fifths of the total.

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 adjoining States.

About 6 percent 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 1971, the combined consumption of Alabama, Illinois, Indiana, Michigan, New Jersey, New York, Ohio, Pennsylvania, and Wisconsin accounted for about four-fifths of the foundry-coke shipments. Foundry coke also was consumed in 36 other States.

Coke used for miscellaneous applications was widely distributed, with 46 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, 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 now.

STOCKS

Yearend stocks of coke decreased 15 percent as the quantity of coke distributed exceeded production by 1,366,000 tons. Oven-coke plants ended the year with an average of 26.0 days' supply at the December rate of production. Output in December was, however, about 1.5 million tons less than in December of the preceding year because of the previously mentioned labor strike in the coal industry.

The bulk of the stocks was at furnace plants, which had, roughly, 28 days' supply, compared with only 10 days' supply at merchant plants. Only 17,000 tons of beehive coke was on hand at the end of 1971. The total was composed entirely of blast-furnace coke.

Stocks of coke breeze at producers' plants at the end of 1971 were slightly lower than at the end of 1970. Roughly three-fourths of the breeze on hand was at furnace plants.

Data on stocks are shown in tables 16 and 17.

VALUE AND PRICE

Coke prices increased significantly during 1971; the average value of receipts for all grades of oven coke reached $37.41 per ton, and beehive coke averaged $21.45 per ton. The 1971 values represented increases of nearly 25 percent for oven coke, and 8 percent for beehive coke.

All grades of coke increased in price but "other industrial" coke, which rose 31 percent to $29.75 per ton, registered the largest percentage increase. Blast-furnace coke increased 22 percent to $30.49 per ton and foundry coke increased 18 percent to $47.98 per ton.

The large variance in the prices of blast-furnace and foundry oven coke was attributed principally to lower recovery yields for foundry coke and to the superior properties (large size, low moisture, ash, volatile, sulfur and phosphorus content) of foundry coke, 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.

Average receipts, f.o.b. plant, for commercial sales of the different grades of coke, as reported by producers, are shown in table 18.

FOREIGN TRADE

There was a continuing demand for U.S. coke in foreign markets, but exports decreased 39 percent because of shortages of coke at home. Exports totaled 1.5 million tons, however, and were equivalent to nearly 3 percent of the domestic output.

The principal foreign market was Canada which received 492,391 tons, about one-third of the foreign shipments. Exports to Canada were substantially larger than in 1970 but considerably less than the record quantity of 854,637 tons shipped in 1966.

Other countries receiving substantial shipments were Japan, the Netherlands, Venezuela, West Germany, Mexico, and Peru. Although coke was shipped to more than 22 countries in 1971, these countries, with

Canada, received more than three-fourths of the total exports.

About four-fifths of the coke exported was shipped from the Baltimore, Buffalo, Detroit, Mobile, and Philadelphia customs districts. Relatively small shipments were exported from at least 19 other ports.

Table 19 shows exports of coke by country and customs district for 1969, 1970, and 1971. The total quantities shown for each year are substantially larger than those reported shipped by producers, as shown in tables 1 and 15, because there were additional shipments to foreign countries by export companies.

Imports were insignificant, amounting to about 0.3 percent of the apparent consumption. Ninety-eight percent of the imported coke came from Canada, and almost all of the remainder was from West Germany. Import data for 1969, 1970, and 1971 are shown in table 20.

COKING COALS

QUANTITY AND VALUE OF COAL CARBONIZED

A total of 82.8 million tons of bituminous coal was carbonized at high temperatures for the production of coke in 1971. The coke industry consumed about one-sixth of the 1971 bituminous coal output, and coke production was the second largest coal market. Only the electric-utility industry, which presently consumes about 60 percent of the production, ranked higher in usage. In addition to bituminous coal, 421,000 tons of anthracite was used in coking coal blends. Anthracite was used principally in the production of foundry coke because its use enhances the physical properties of coke, giving it greater size and density, properties that are desirable for the smelting of iron in foundry cupolas.

The delivered average value of all coal carbonized by oven-coke plants in 1971 was $14.00 per ton, and the value of that carbonized by beehive-coke plants averaged $8.54 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 about 15 percent greater than in 1970. Coals delivered to some States, however, had increases in average value per ton ranging up to 34 percent. The highest coal prices were recorded for Minnesota and Wisconsin where the delivered value of coals used for coke production by all plants averaged $18.99 per ton.

An overall average of 1.45 tons of coal, valued at $20.30, was required for each ton of oven coke produced in 1971. Beehive ovens required an average of 1.67 tons of coal per ton of coke output, but coal costs averaged only $14.26 per ton of coke production because of the lower unit value of the coals charged.

Tables 22 to 25 present data on coals carbonized at oven- and beehive-coke plants.

BLENDING

The blending of coals at oven-coke plants is standard practice because individual coals do not possess all of the properties required for the production of high-quality coke in slot ovens. 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 the production of metallurgical-grade coke. 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 exclusively 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 in the mix, they 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-content coals 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 coal mixes by the coke industry 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.

Table 26 shows the quantities of coals carbonized at oven-coke plants, by volatile-matter content, for 1967–71. Table 27 shows the volatile-matter content of the coals received by oven-coke plants in various States.

SOURCES

Although 22 States produce bituminous coal, only 12 produced coking coal that was shipped to coke plants. Of this number, only 10 can be considered suppliers of coking coals, as the combined shipments of Arkansas and Tennessee were less than 50,000 tons.

Of the coals received by oven-coke plants, 33 percent was produced in West Virginia and 29 percent in Pennsylvania. West Virginia shipments were principally low-volatile coals from McDowell, Wyoming, and Raleigh Counties, medium-volatile coal from McDowell County, and high-volatile coals from Boone, Fayette, Kanawha, Logan, Marion, and Mingo Counties. Pennsylvania supplied, principally, high-volatile coals from Green and Washington Counties and low-volatile coals from Cambria and Somerset Counties.

Another major supplier of coking coal was Kentucky, which supplied 15 percent of the shipments to coke plants. All was high-volatile coal produced mainly in Floyd, Harlan, Letcher, and Pike Counties.

Illinois produced coking coals that were used mainly in Illinois and Indiana; Alabama, Colorado, and Utah produced coking coals that were used for coke production mainly within each producing State. Most of the coals carbonized in California, Colorado, and Utah were produced in the latter two States.

Data showing the origin of coals received by oven-coke plants, by volatile-matter content, are shown in table 28, while table 29 shows the source of the coals received by oven-coke plants in various States.

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 1971, 60 percent of the coal received by furnace plants was captive. Some merchant plants also own coal mines, but only 42 percent of the coal they received in 1971 was their own production.

The quantities of captive coal received by oven-coke plants in 1971 are shown in table 30.

STOCKS

Month-end stocks of bituminous coal and anthracite at oven-coke plants are shown in tables 31 and 32. Bituminous-coal stocks reached their highest yearly level during September when month-end stocks were 11.8 million tons. The lowest level, 5.4 million tons, was reported at the end of November after a curtailment in bituminous coal production because of a labor strike.

Bituminous-coal stocks at the end of 1971 were about 20 percent less than when the year began. The 7.2 million tons on hand at all plants on December 31, 1971, was equivalent to about 37 days' supply, based upon the December rate of consumption.

Only small quantities of anthracite are stocked. Stocks at the end of 1971 totaled only 118,000 tons, about 2 percent less anthracite than was on hand at the end of 1970.

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 is approximately 16 pounds. Data on production and sales of basic chemical materials and derivatives at oven-coke plants in 1971 are shown in table 33.

Table 34 shows the heating value and coal equivalent of products other than coke produced at oven-coke plants. Although the quantities vary from year to year, most of the changes were due to differences in the amount of coal carbonized, rather than fluctuations in yields. In terms of heating value, the products, not including coke, recovered in 1971 were roughly equivalent to the heating value of about one-fourth of the coal carbonized in slot ovens. Table 35 shows average values for the chemicals and surplus gas used and sold, compared with the unit values of the coke and breeze produced, from each ton of coal carbonized.

COKE-OVEN GAS

Coke-oven gas, the material that remains after tar, ammonia, and light oil have been removed from the volatile matter, 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 1971 was 10,510 cubic feet. This was slightly more than the yield of 10,440 cubic feet recorded for 1970. However, total gas production decreased 13 percent from that of 1970 because 13 million tons less coal was carbonized in 1971.

Table 37 shows coke-oven gas production by State, the quantities of gas used for heating ovens, and the amount of surplus gas used or sold. Nearly 40 percent of the output was used at the plants to heat coke ovens. Gas used otherwise is called surplus gas and is 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.

Table 38 shows the disposal of surplus gas by the two segments of the oven-coke industry. Whereas 89 percent of the surplus gas produced by furnace plants was consumed by producing companies, merchant plants used less than 50 percent of the surplus gas they produced. Of the surplus gas sold, furnace-plant sales went primarily for industrial use; 78 percent of the gas sold by merchant plants went to industrial plants, and the remainder was sold to gas utilities.

Table 39 shows the quantities of various gases used to heat ovens in each State and the total gas consumption in terms of coke-oven gas equivalent. Coke-oven gas was the principal fuel used for heating slot ovens, but some operators used blast-furnace gas, a mixture of coke-oven and blast-furnace gas, or natural gas for underfiring. Nearly 400 billion cubic feet of coke-oven gas equivalent was so consumed, of which 91 percent was coke-oven gas, 9 percent was blast-furnace gas, and the remainder was natural gas.

Surplus coke-oven gas used and sold in 1971 was valued at $134 million, a 9 percent decrease from the 1970 value. No value is reported by producers for coke-oven gas used to heat coke ovens, but applying the average value of $0.265 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 1971 would be $223 million. This value is equivalent to about one-fifth the total value of the coal carbonized.

COKE-OVEN AMMONIA

Coal carbonized at high temperatures releases nitrogen, which oven-coke operators recover either as ammonia liquor, a weak solution of ammonia (about 7 grams per liter of solution), or as a crystallized solid (ammonium sulfate and diammonium phosphate). This ammonia must be removed prior to further processing of the gas because it would otherwise form corrosive salts which would damage equipment or, if released as a waste material, would create steam pollution problems.

Most of the coke-oven ammonia is reacted with sulfuric acid to form ammonium sulfate. In 1971, 91 percent of the ammonia recovered was used to produce 540,000 tons of ammonium sulfate and 38,000 tons of diammonium phosphate, and 14,000 tons of ammonia was collected as an aqueous solution.

Table 40 shows production and sales of ammonia products and yields in 1971 in terms of sulfate equivalent. Compared with 1970 the yield of ammonia increased 3 percent but total output fell 9 percent.

Sales of ammonium sulfate increased 2 percent and ammonia liquor sales were the same as in 1970. The average value per ton, f.o.b. plant, of ammonium sulfate decreased $3.25 per ton to $12.19, and the average plant value of ammonia liquor decreased $0.71 per ton. The total value of all ammonia products sold was $12 million, equivalent to 5 percent of the total value of all coal-chemical materials sold.

COAL TAR AND DERIVATIVES

Crude coal tar is a black, viscous mixture of complex organic compounds that condense from the volatile matter when it is cooled. Most of the tar is recovered in collecting mains at the ovens when the gas has been cooled by spraying with ammonia liquor; the remainder is recovered principally from the primary coolers when the gas undergoes further cooling.

All oven-coke plants produce tar. However, yields of tar vary widely among plants; in 1971, they ranged from about 6.10 to 9.79 gallons per ton of coal carbonized. Generally, from 4 to 5 percent of the weight of the coals carbonized is recovered as tar. High-volatile coals evolve a larger percentage of tar; hence, California, Colorado, Utah, West Virginia, and Pennsylvania, which used the most high-volatile coal in their blends, had the highest tar yields. Conversely, plants using higher percentages of low- and medium-volatile coals and anthracite, such as those mainly producing foundry coke, had the lowest yields.

Production of coal tar at oven-coke plants in 1971 decreased 11 percent from that of 1970. The average yield of tar increased slightly to 8.29 gallons per ton of coal, compared with 8.00 gallons in 1970. Table 41 shows the quantities of tar produced, used by producers, sold, and in stock in the various States at the end of 1971.

Coke-plant operators used 51 percent of the tar produced in 1971. Of this quantity, 67 percent was processed (refined or "topped"), 32 percent underwent no processing and was burned for fuel, and less than 1 percent was used for miscellaneous purposes, such as tarring ingots, road materials, and tar paints. The remaining 49 percent of the production was sold, principally to tar-distilling plants which refined it to produce many tar derivatives

Most of the coke plants that processed tar in 1971 topped their tar. In so doing, the low-boiling distillate fraction, consisting mainly of tar, acids, bases, and naphthalenes, is separated from the crude tar. The residue, or soft pitch, is usually burned as fuel. Furnace plants in particular benefit from this procedure since they can sell the distillate and retain the pitch for use as fuel in open-hearth furnaces. This reduces the amount of other fuels that normally have to be purchased. 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 recovered through topping.

The majority of the plants that processed tar in 1971 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 published 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 pale-colored liquid, composed of a number of aromatic hydrocarbons, that is 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 by 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 recovery, light oil is separated from the absorption oil by direct steam distillation. Approximately 3 gallons of light oil, equal to 1 percent of the weight of the coal, is recovered for each ton of coal carbonized. Yields vary, of course, with the kind of coals carbonized and with operating conditions, but an average of 2.57 gallons of light oil was recovered at the plants that extracted light oil in 1971. Most plants recover light oil, but a few plants, which find it uneconomical to remove the light oil, leave it in the gas to be burned as fuel. Yields per ton of coal decreased at both merchant and furnace plants in 1971.

Producers sold about 45 percent of their crude light oil output in 1971. The large increase in light oil sales in recent years is attributed principally to the inability of some plants to produce derivatives, particularly benzene, 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 and a number of other chemical intermediates. Data on light oil and total derived products produced and sold in the various States are shown in table 42.

In the older light oil refining facilities at coke plants, light oil is refined by fractional distillation at atmospheric pressures, but in plants built in recent years, catalytic-pressure refining is employed to produce benzene, toluene, xylene, and solvent naphtha. As with other coal-chemical materials, yields vary somewhat, but approximately 85 percent of the light oil processed is recovered as salable products. Average yields of the various light oil derivatives recovered through refining for 1971 and prior years are shown in table 43.

Table 44 shows the quantities of the various grades of benzene and toluene produced at coke plants, while table 45 shows the principal light oil derivatives produced and sold and yields of the various products by State. About 95 percent of the benzene is specification grades. In past years large amounts of motor-grade benzene were produced for use in gasolines to increase their antiknock properties, but present petroleum-refining techniques have all but eliminated this use for benzene. Production of all light oil derivatives was lower than in 1970 because a smaller amount of light oil was refined.

TECHNOLOGY

Coke plant technology in 1971 was directed mainly at developing systems for reducing atmospheric pollution. There was also renewed interest in coals prior to conventional carbonization, in pipeline charging, and in the development of practical processes for producing form coke.

A complete system for dry quenching

coke was recently offered for sale to domestic coke producers by the American Waagner-Biro Company, Inc., Pittsburgh, Pa. Developed in Europe, the system, a closed gas circuit which operates as a heat-transfer medium and recovers the latent heat of the coke, is said to completely eliminate the pollution of air and water and provide heat for either steam generation or gas preheating for coal drying. Due to the smooth, shockproof cooling, it is claimed that coke quality is increased and cooled coke comes from the equipment completely moisture-free, with much less breeze content than in wet quenching. It is claimed also that the coke rate of blast furnaces is further reduced due to the higher heat value of the dry quenched coke.

A system (Coaltek) [2] of preheating and charging coal through pipelines to coke ovens, which was installed on a commercial battery of 24 ovens at the Ironton, Ohio, plant of the Allied Chemical Corporation, has operated with complete reliability since October 1970 and completely eliminated gas and particulate emissions during oven charging. With this system, blast-furnace coke is produced in 18-inch-wide ovens in 11 hours and foundry coke in 17 to 18 hours instead of 18 hours and 30 hours, respectively, for conventionally charged ovens. It is claimed that the Coaltek system improves coke quality and results in a fuel gas reduction in the magnitude of 10 percent per ton of coke produced.

Recent Bureau of Mines laboratory research [3] indicates that the use of preheated coal in carbonization operations reduces liquor yields and coking times while improving coke quality. Using three blends of coal, which were preheated with high-pressure steam to 232°C and then carbonized by the Bureau of Mines-American Gas Association (BM-AGA) method at 900° C, it was determined that coking time could be reduced about 20 percent while coke stability was increased. It was found also that the percentage of low-volatile coals in certain coal blends could be reduced substantially with little deleterious effect upon coke stability if the coals were preheated prior to carbonization.

A five-company group, which has developed a coke-manufacturing process based upon pelletizing, [4] presently is constructing a $20 million demonstration plant and plans full-scale tests of the product in blast furnaces. The process encompasses a closed system in which the coal is heated and pelletized using as binding material, in some instances, the pitch recovered from the gas. Details of the processing have not been revealed but it is understood that, unlike conventional coke, which generally is made from a blend of both high- and low-volatile coals, strong pellets suitable for use in smelting iron ore in blast furnaces can be made from high-volatile coals alone.

A new type of coke for use in foundry cupolas has been developed from an oil byproduct. Described as "an entirely new type of carbon fuel for iron foundries," the product is said to have been derived from a granular byproduct of oil refining, as opposed to coal, the traditional raw material for foundry coke. Its higher carbon content, which is approximately 98 percent, is said to increase burning efficiency and thereby improve melting operations. Because of the higher carbon content, it was claimed that the coke charge was reduced by as much as 15 percent.

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[2] Evans, D. A. E. and D. G. Marting. The Coaltek System, Preheating and Pipeline Charging of Coal to Coke Ovens. Paper presented at the 39th Blast Furnace Conf., Scarborough, England, Sept. 30, 1971.

[3] Wolfson, D. E. Use of Preheated Coal in Carbonization, Bu. Mines Rept. of Inv. 7630, 1972, 8 pp.

[4] Chemical and Engineering News. Coke Pellets Process. V. 49, No. 27, July 5, 1971, p. 9.

Table 2.—Statistical summary of the coke industry in the United States in 1971

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants thousand short tons	5,567	(1)	(1)
At furnace plants [2] do	51,097	(1)	(1)
Total do	56,664	772	57,436
Breeze produced do	4,048	16	4,064
Coal carbonized:			
Bituminous:			
Thousand short tons	81,531	1,289	82,820
Value (thousands)	$1,141,045	$11,005	$1,152,051
Average per ton	$14.00	$8.54	$13.91
Anthracite:			
Thousand short tons	421	--	421
Value (thousands)	$5,913	--	$5,913
Average per ton	$14.05	--	$14.05
Total: [3]			
Thousand short tons	81,952	1,289	83,241
Value (thousands)	$1,146,959	$11,005	$1,157,964
Average per ton	$14.00	$8.54	$13.91
Average yield in percent of total coal carbonized:			
Coke	69.14	59.89	69.00
Breeze (at plants actually recovering)	4.94	8.84	4.95
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	50,260	--	50,260
Value (thousands)	$1,494,297	--	$1,494,297
In foundries:			
Thousand short tons	324	--	324
Value (thousands)	$14,030	--	$14,030
For other industrial uses:			
Thousand short tons	277	--	277
Value (thousands)	$7,726	--	$7,726
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	309	--	309
Value (thousands)	$2,221	--	$2,221
In agglomerating plants:			
Thousand short tons	1,582	--	1,582
Value (thousands)	$18,558	--	$18,558
For other industrial uses:			
Thousand short tons	650	--	650
Value (thousands)	$5,862	--	$5,862
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	2,947	757	3,704
Value (thousands)	$89,851	$16,237	$106,088
Average per ton	$30.49	$21.45	$28.64
To foundries:			
Thousand short tons	2,928	--	2,928
Value (thousands)	$140,475	--	$140,475
Average per ton	$47.98	--	$47.98
To other industrial plants:			
Thousand short tons	1,248	(4)	1,248
Value (thousands)	$37,127	(4)	$37,127
Average per ton	$29.75	(4)	$29.75
For residential heating:			
Thousand short tons	61	--	61
Value (thousands)	$1,309	--	$1,309
Average per ton	$21.46	--	$21.46
Breeze sold (commercial sales):			
Thousand short tons	1,863	16	1,879
Value (thousands)	$21,057	31	$21,088
Average per ton	$11.30	$1.94	$11.22
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	679,377	--	679,377
Gallons per ton of coal	8.29	--	8.29
Ammonia: [5]			
Thousand short tons	632	--	632
Pounds per ton of coal	16.21	--	16.21
Crude light oil:			
Thousand gallons	201,626	--	201,626
Gallons per ton of coal	2.57	--	2.57
Gas:			
Million cubic feet	861,691	--	861,691
Thousand cubic feet per ton of coal	10.51	--	10.51
Percent burned in coking process	38.99	--	38.99
Percent surplus used or sold	58.79	--	58.79
Percent wasted	2.22	--	2.22

See footnotes at end of table.

Table 2.—Statistical summary of the coke industry in the United States in 1971—Continued

	Slot ovens	Beehive ovens	Total
Coal-chemical materials produced—Continued			
Value of coal-chemical materials used or sold:			
Crude tar and derivatives:			
Used thousands	$27,785	--	$27,785
Sold do	$58,749	--	$58,749
Ammonia products [6] do	$12,167	--	$12,167
Crude light oil and derivatives [7] do	$27,088	--	$27,088
Surplus gas do	$134,382	--	$134,382

[1] Not separately recorded.
[2] Plants associated with iron-blast furnaces.
[3] Data may not add to totals shown because of independent roundings.
[4] Included with beehive coke sold "to blast furnaces" to avoid disclosing individual company data.
[5] In terms of sulfate equivalent.
[6] Includes ammonium sulfate, ammonia liquor (NH_3 content), and diammonium phosphate.
[7] Includes intermediate light oil.

Table 3.—Summary of oven-coke operations in the United States in 1971, 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	7,520	71.32	5,363
California, Colorado, Utah	3	4,717	63.20	2,981
Maryland, New Jersey, New York	4	8,597	69.62	5,985
Illinois	4	3,371	63.60	2,144
Indiana	6	11,456	68.37	7,832
Kentucky, Missouri, Tennessee, Texas	5	2,809	69.60	1,955
Michigan	3	5,127	73.73	3,780
Minnesota and Wisconsin	3	1,050	74.67	784
Ohio	12	10,853	69.80	7,575
Pennsylvania	12	21,981	69.43	15,261
West Virginia	3	4,471	67.23	3,006
Total in 1971	62	81,952	69.14	[1] 56,664
At merchant plants	14	7,730	72.02	5,567
At furnace plants	48	74,222	68.84	51,097
Total in 1970	63	95,053	69.07	65,654

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

Table 4.—Summary of beehive-coke operations in the United States in 1971, 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	6	1,289	59.89	772
Total:				
1971	6	1,289	59.89	772
1970	6	1,428	60.99	871

Table 5.—Production of oven and beehive coke in the United States, by month

(Thousand short tons)

Month	1970		1971	
	Total [1]	Daily average [2]	Total [1]	Daily average [2]
OVEN COKE				
January	5,332	172	5,647	182
February	5,069	181	5,054	174
March	5,655	182	5,752	186
April	5,468	182	5,621	187
May	5,603	181	5,693	184
June	5,402	180	5,268	176
July	5,442	176	4,816	155
August	5,368	173	3,455	111
September	5,425	181	3,976	133
October	5,680	183	3,961	128
November	5,537	185	3,220	107
December	5,672	183	4,200	135
Total	65,654	180	56,664	155
BEEHIVE COKE				
January	81	3	66	2
February	78	3	76	3
March	74	2	78	3
April	73	2	68	2
May	71	2	77	2
June	73	2	76	3
July	71	2	67	2
August	69	2	55	2
September	70	2	54	2
October	74	2	52	2
November	68	2	46	2
December	68	2	56	2
Total	871	2	772	2
TOTAL				
January	5,413	175	5,713	184
February	5,147	184	5,130	177
March	5,729	185	5,830	188
April	5,541	185	5,689	190
May	5,674	189	5,770	186
June	5,475	183	5,344	178
July	5,511	178	4,883	158
August	5,437	175	3,510	113
September	5,495	183	4,030	134
October	5,754	186	4,013	129
November	5,605	187	3,266	109
December	5,741	185	4,256	137
Total	66,525	182	57,436	157

[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	1970 Merchant plants	1970 Furnace plants	1971 Merchant plants	1971 Furnace plants
PRODUCTION				
January	472	4,860	492	5,155
February	467	4,602	443	4,611
March	492	5,163	505	5,247
April	469	4,999	495	5,126
May	489	5,115	502	5,191
June	494	4,908	486	4,783
July	507	4,935	420	4,393
August	495	4,873	480	2,975
September	502	4,923	478	3,498
October	512	5,169	463	3,498
November	511	5,026	368	2,852
December	505	5,167	434	3,766
Total [1]	5,915	59,739	5,567	51,097
DAILY AVERAGE				
January	15	157	16	166
February	17	164	15	159
March	16	167	16	169
April	16	167	17	171
May	16	165	16	167
June	17	164	16	159
July	16	159	13	142
August	16	157	15	96
September	17	164	16	117
October	17	167	15	113
November	17	168	12	95
December	16	167	14	121
Average for year	16	164	15	140

[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
1967	[3] 16	50	6,220	57,555	9.8	90.2
1968	[3] 16	48	5,879	56,999	9.4	90.6
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

[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	1970	1971
OVEN COKE		
Alabama	6,116	5,363
California, Colorado, Utah	3,235	2,981
Maryland, New Jersey, New York	8,020	5,985
Illinois	2,356	2,144
Indiana	8,929	7,832
Kentucky, Missouri, Tennessee, Texas	2,002	1,955
Michigan	3,754	3,780
Minnesota and Wisconsin	901	784
Ohio	8,900	7,575
Pennsylvania	18,212	15,261
West Virginia	3,230	3,006
Total [1]	65,654	56,664
BEEHIVE COKE		
Pennsylvania	444	772
Virginia	427	(2)
Total	871	772
Grand total	66,525	57,436

[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 1971, by State

(Thousands short tons and thousand dollars)

State	Yield per ton of coal [1] (percent)	Produced	Used by producers				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	5.28	397	(2)	(2)	(2)	(2)	27	$360	221	$3,635	52
California, Colorado, Utah	4.71	222	(2)	(2)	154	$1,581	18	157	(2)	(2)	43
Maryland, New Jersey, New York	5.76	495	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	308
Illinois	5.61	189	(2)	(2)	(2)	(2)	19	185	80	930	55
Indiana	6.51	746	--	--	(2)	(2)	128	1,406	426	4,528	59
Kentucky, Missouri, Tennessee, Texas	5.45	153	(2)	(2)	--	--	(2)	(2)	42	629	54
Michigan	4.56	234	--	--	(2)	(2)	(2)	(2)	(2)	(2)	35
Minnesota and Wisconsin	9.52	100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	64
Ohio	4.85	526	(2)	(2)	(2)	(2)	72	498	346	4,243	113
Pennsylvania	3.42	751	(2)	(2)	522	6,235	97	947	144	1,485	100
West Virginia	5.23	234	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	7
Undistributed	--	--	309	$2,221	906	10,742	289	2,309	604	5,607	--
Total 1971	4.94	[3] 4,048	309	2,221	1,582	18,558	650	5,862	1,863	21,057	[3] 888
At merchant plants	7.85	607	118	966	--	--	181	1,416	190	2,760	247
At furnace plants	4.64	3,442	191	1,255	1,582	18,558	469	4,446	1,673	18,297	642
Total 1970	4.91	4,665	366	2,257	1,948	20,893	704	6,195	2,067	20,611	1,030
BEEHIVE COKE											
Pennsylvania and Virginia, 1971	8.84	16	--	--	--	--	--	--	16	31	--
Total 1970	W	W	--	--	--	--	--	--	W	W	--

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 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
1967	594	1,695	517	1,250	$8.46
1968	508	1,634	589	1,364	7.34
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

[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
1967	64,580	92	710	+2,390	61,572	56,205	91.3	5,367	8.7
1968	63,653	94	792	+517	62,438	56,238	90.1	6,200	9.9
1969	64,757	173	1,629	−2,865	66,166	60,176	90.9	5,990	9.1
1970	66,525	153	r 2,478	+993	r 63,207	58,151	r 92.0	r 5,056	r 8.0
1971	57,436	174	1,509	−603	56,704	51,498	90.8	5,206	9.2

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)
1967	1,287.8	69.6	1,850.2
1968	1,263.4	69.8	1,810.0
1969	1,260.4	69.4	1,816.1
1970	1,266.6	69.1	1,833.0
1971	1,260.8	69.0	1,827.2

[1] American Iron and Steel Institute; consumption of coke per ton of pig iron only, excluding furnaces making ferroalloys, was 1,262 in 1967; 1,248 in 1968; 1,252 in 1969; 1,260 in 1970; and 1,254 in 1971.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1971, 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	5,363	3,843	$102,132	262	$9,557	542	$15,555
California, Colorado, Utah	2,981	2,790	80,625	(2)	(2)	--	--
Maryland, New Jersey, New York	5,985	5,516	182,216	(2)	(2)	(2)	(2)
Illinois	2,144	2,193	73,337	(2)	(2)	(2)	(2)
Indiana	7,832	7,489	166,963	(2)	(2)	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	1,955	(2)	(2)	(2)	(2)	(2)	(2)
Michigan	3,780	(2)	(2)	(2)	(2)	(2)	(2)
Minnesota and Wisconsin	784	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	7,575	6,620	195,606	(2)	(2)	892	27,385
Pennsylvania	15,261	14,885	485,649	22	631	120	3,803
West Virginia	3,006	(2)	(2)	(2)	(2)	(2)	(2)
Undistributed	--	6,924	207,769	317	11,569	1,393	43,108
Total 1971	[3] 56,664	50,260	1,494,297	601	21,757	2,947	89,851
At merchant plants	5,567	--	--	134	4,943	1,889	56,042
At furnace plants	51,097	50,260	1,494,297	467	16,814	1,058	33,809
Total 1970	65,654	56,646	1,554,347	672	21,172	3,709	92,910

State	Commercial sales—Continued							
	To foundries		To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	(2)	(2)	367	$10,638	(2)	(2)	1,528	$53,954
California, Colorado, Utah	(2)	(2)	(2)	(2)	--	--	(2)	(2)
Maryland, New Jersey, New York	(2)	(2)	63	1,679	--	--	(2)	(2)
Illinois	--	--	(2)	(2)	(4)	$2	(2)	(2)
Indiana	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Michigan	(2)	(2)	(2)	(2)	--	--	(2)	(2)
Minnesota and Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	(2)	(2)	107	3,242	(2)	(2)	1,251	41,995
Pennsylvania	408	$19,719	(2)	(2)	(2)	(2)	800	31,260
West Virginia	--	--	(2)	(2)	--	--	(2)	(2)
Undistributed	2,520	120,756	711	21,568	61	1,307	3,605	141,553
Total 1971	2,928	140,475	1,248	37,127	61	1,309	7,184	268,762
At merchant plants	2,710	130,600	761	24,629	36	823	5,397	212,094
At furnace plants	218	9,875	487	12,498	24	486	1,787	56,668
Total 1970	2,953	120,544	1,841	41,862	52	1,050	8,554	256,365

[1] Comprises 324,000 tons valued at $14,030,000 used in foundries; 277,000 tons valued at $7,726,000 for other purposes.
[2] Included with "Undistributed" to avoid disclosing individual company data.
[3] Data may not add to total shown because of independent rounding.
[4] Less than ½ unit.

Table 14.—Production and sales of beehive coke in the United States, in 1971

(Thousand short tons and thousand dollars)

State	Produced	Commercial sales			
		To blast-furnace plants		To foundries	
	Quantity	Quantity	Value	Quantity	Value
Pennsylvania and Virginia	772	757	$16,237	--	--
Total:					
1971	772	757	16,237	--	--
1970	871	829	16,383	(1)	(1)

State	Commercial sales—Continued					
	To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania and Virginia	(2)	(2)	--	--	757	$16,237
Total:						
1971	(2)	(2)	--	--	757	16,237
1970	40	$892	--	--	[3] 868	17,275

[1] Included with beehive-coke sold "to other industrial plants" to avoid disclosing individual company data.
[2] Included with beehive-coke sold "to blast-furnace plants" to avoid disclosing individual company data.
[3] Data may not add to total shown because of independent rounding.

Table 15.—Distribution of oven and beehive coke and breeze in 1971 [1]

(Thousand short tons)

Consuming State	Coke					Breeze
	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total [2]	
Alabama	3,222	320	137	5	3,684	265
Arizona	--	1	2	--	3	(3)
Arkansas	--	3	2	--	5	(3)
California	1,130	51	57	--	1,237	45
Colorado	660	8	26	--	694	78
Connecticut	--	10	(3)	--	10	(3)
Delaware	--	(3)	(3)	--	(3)	(3)
Florida	--	2	24	(3)	26	33
Georgia	--	11	3	(3)	14	1
Idaho	--	(3)	136	--	136	--
Illinois	3,298	178	26	3	3,505	367
Indiana	7,446	157	44	26	7,672	703
Iowa	--	85	1	(3)	87	--
Kansas	--	12	1	(3)	12	1
Kentucky	1,072	27	8	2	1,109	91
Louisiana	--	2	63	--	64	1
Maine	--	1	(3)	--	1	--
Maryland	2,947	20	1	--	2,969	252
Massachusetts	--	28	1	--	29	--
Michigan	4,212	788	64	(3)	5,064	241
Minnesota	235	19	26	--	280	31
Mississippi	--	1	(3)	--	1	1
Missouri	--	22	76	--	98	12
Montana	--	(3)	23	--	24	26
Nebraska	--	2	8	--	10	(3)
Nevada	--	--	--	--	--	(3)
New Hampshire	--	(3)	(3)	--	(3)	--
New Jersey	--	90	56	--	146	34
New Mexico	--	--	(3)	(3)	(3)	(3)
New York	2,748	221	52	--	3,021	357
North Carolina	--	13	4	(3)	17	16
North Dakota	--	(3)	4	--	4	--
Ohio	7,785	449	140	--	8,375	451
Oklahoma	--	5	1	--	6	5
Oregon	--	2	17	--	19	5
Pennsylvania	14,613	201	181	22	15,016	798
Rhode Island	--	2	14	--	16	--
South Carolina	--	7	41	(3)	48	4
South Dakota	--	(3)	--	--	(3)	--
Tennessee	10	79	43	1	133	83
Texas	719	90	66	(3)	875	50
Utah	1,001	20	19	--	1,041	57
Vermont	--	2	(3)	--	3	--
Virginia	--	80	17	--	98	13
Washington	--	2	7	--	9	1
West Virginia	2,697	5	19	--	2,722	216
Wisconsin	--	138	4	1	144	82
Wyoming	--	--	8	--	8	1
Total	53,795	3,154	1,429	61	58,439	4,324
Exported	157	98	109	--	363	95
Grand total	53,952	3,252	1,537	61	58,802	4,419

[1] Based upon reports from producers showing destination and principal end use of coke used and sold. Does not include imported coke which totaled 174,000 tons in 1971.

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

[3] Less than ½ unit.

Table 16.—Producers' stocks of coke and breeze in the United States on Dec. 31, 1971, by State

(Thousand short tons)

State	Coke				Breeze
	Blast furnace	Foundry	Residential heating and other	Total [1]	
OVEN COKE					
Alabama	521	2	3	526	52
California, Colorado, Utah	210	--	--	210	43
Maryland, New Jersey, New York	272	2	6	280	308
Illinois	107	--	--	107	55
Indiana	262	4	1	267	59
Kentucky, Missouri, Tennessee, Texas	98	3	14	115	54
Michigan	252	6	2	260	35
Minnesota and Wisconsin	82	3	7	92	64
Ohio	314	6	2	322	113
Pennsylvania	1,231	29	19	1,280	100
West Virginia	52	--	--	52	7
Total 1971 [1]	3,399	55	55	3,510	888
At merchant plants	68	35	30	134	247
At furnace plants	3,331	20	25	3,376	642
Total 1970	3,995	83	35	4,113	1,030
BEEHIVE COKE					
Pennsylvania	17	--	--	17	--
Virginia	--	--	--	--	--
Total:					
1971	17	--	--	17	--
1970	2	--	--	2	--

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

Table 17.—Producers' month-end stocks of oven coke in the United States

(Thousand short tons)

Month	At merchant plants		At furnace plants		Total	
	1970	1971	1970	1971	1970 [1]	1971
January	86	92	2,946	4,149	3,032	4,241
February	65	60	2,969	3,994	3,034	4,054
March	63	40	3,025	3,802	3,088	3,842
April	55	40	3,043	3,559	3,100	3,599
May	58	50	3,040	3,293	3,098	3,343
June	47	60	2,907	3,093	2,954	3,153
July	54	98	2,952	3,303	3,006	3,401
August	49	116	2,914	3,702	2,963	3,818
September	37	151	3,019	3,919	3,057	4,070
October	46	166	3,388	3,977	3,433	4,143
November	86	127	3,691	3,469	3,777	3,596
December	95	134	4,018	3,376	4,113	3,510

[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					
1967	$16.29	$32.40	$17.16	$17.35	$22.67
1968	16.40	32.43	15.97	17.96	22.00
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
BEEHIVE COKE					
1967	$14.97	$12.34	$15.41	$15.41	$15.03
1968	15.14	6.84	14.80	18.60	15.00
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

W Withheld to avoid disclosing individual company confidential data.

Table 19.—Coke exported from the United States, by country and by customs district

	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Algeria	--	--	--	--	40,678	$692
Angola	--	--	13,632	$714	--	--
Argentina	12,233	$535	7,390	453	6,680	300
Belgium-Luxembourg	6,212	132	45,453	1,694	27,983	320
Brazil	29,285	1,027	76,978	3,564	37,801	1,630
Bulgaria	--	--	141,147	7,719	29,126	1,774
Canada	292,223	8,189	347,122	10,698	492,391	16,289
Chile	3,517	37	23,063	1,228	--	--
Dominican Republic	195	5	373	12	210	5
Finland	--	--	16,609	276	--	--
France	--	--	5,621	275	--	--
Germany, West	14,882	631	42,636	1,348	85,411	1,402
India	655	19	745	29	271	12
Iran	--	--	--	--	688	51
Italy	--	--	134,790	1,938	34,524	414
Japan	55,640	648	r 275,147	r 3,675	138,496	2,210
Liberia	--	--	--	--	11,810	187
Mexico	629,816	15,253	375,996	9,827	80,248	2,831
Netherlands	234,460	4,929	102,217	1,242	151,081	1,628
Norway	--	--	6,017	219	19,397	366
Peru	64,394	1,595	38,985	1,731	90,714	3,888
Portugal	--	--	80,367	3,079	52,028	2,090
Romania	129,035	3,192	388,983	14,002	28,043	1,357
Spain	13,552	164	78,180	1,303	--	--
Tunisia	--	--	19,522	1,077	--	--
United Kingdom	447	10	371	7	23,244	263
Venezuela	141,920	2,098	244,588	11,616	119,014	6,039
Yugoslavia	--	--	8,075	391	37,579	998
Zaire (formerly Congo-Kinshasa)	--	--	3,049	162	--	--
Other	1,022	46	r 1,282	r 48	1,222	73
Total	1,629,488	38,510	r 2,478,338	r 78,327	1,508,639	44,819
CUSTOMS DISTRICT						
Baltimore	278,311	6,334	501,485	16,438	199,103	5,333
Buffalo	106,831	2,873	153,427	5,012	295,761	9,191
Cleveland	--	--	18,769	160	67,714	565
Chicago	--	--	13,965	183	7,569	65
Detroit	152,431	4,316	242,292	5,296	243,407	6,287
Duluth	4,690	166	1,322	54	2,028	91
El Paso	29,361	762	1,532	41	30	1
Great Falls	--	--	1,340	36	859	18
Houston	1,276	37	1,235	49	1,191	27
Laredo	598,579	14,438	372,724	9,728	79,084	2,781
Los Angeles	55,565	646	37,707	475	50	3
Miami	--	--	164	4	394	13
Mobile	230,044	4,455	r 401,020	r 10,539	291,529	7,970
New Orleans	13,869	179	30,080	721	1,517	70
New York City	667	21	223	9	214	7
Nogales	845	25	223	11	401	22
Norfolk	9,729	169	181,936	8,059	121,618	4,347
Ogdensburg	11,915	337	20,546	586	17,455	518
Pembina	15,815	550	22,692	874	17,164	815
Philadelphia	90,117	2,374	465,180	19,687	154,556	6,388
Portland, Maine	16,359	376	--	--	241	4
St. Albans	--	--	1,370	22	160	6
San Diego	1,072	29	1,517	47	733	28
Seattle	11,741	408	7,589	296	5,818	255
Other	271	15	--	--	43	14
Total	1,629,488	38,510	r 2,478,338	r 78,327	1,508,639	44,819

r Revised.

Table 20.—U.S. imports for consumption of coke by country and customs district

	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Canada	169,341	$2,989	146,275	$2,784	170,784	$4,593
France	858	102	2,498	255	--	--
Germany, West	2,758	248	3,888	456	3,036	444
Japan	13	(1)	--	--	--	--
Netherlands	82	15	218	36	--	--
United Kingdom	--	--	--	--	94	1
Total	173,052	3,354	152,879	3,531	173,914	5,038
CUSTOMS DISTRICT						
Buffalo	2,703	38	9,339	171	967	25
Chicago	19,085	124	--	--	11,498	339
Detroit	43,475	882	22,102	408	88,835	2,471
Duluth	--	--	8,156	53	330	3
Great Falls	92,795	1,776	93,504	1,964	69,022	1,749
Honolulu	345	15	274	14	110	7
Miami	74	9	--	--	--	--
Mobile	777	93	1,810	176	--	--
New Orleans	2,428	246	3,870	484	3,031	439
Ogdensburg	5,440	43	214	10	--	--
Pembina	--	--	7,204	63	58	1
Portland, Maine	55	1	14	(1)	33	1
St. Albans	34	1	21	(1)	15	(1)
San Juan	105	4	--	--	15	3
Savannah	--	--	650	74	--	--
Seattle	5,736	122	5,721	114	--	--
Total	173,052	3,354	152,879	3,531	173,914	5,038

[1] Less than ½ unit.

Table 21.—Coke: World production by type and country

(Thousand short tons)

Kind of coke and country [1]	1969	1970	1971 p
METALLURGICAL COKE [2]			
North America:			
Canada [3] [4]	5,002	5,669	5,105
Mexico	1,258	1,433	3,696
United States	64,757	66,525	57,436
South America:			
Argentina [3]	398	e 397	e 397
Brazil	1,661	1,797	1,483
Chile	349	e 350	e 350
Colombia	513	513	513
Peru	53	32	e 32
Europe:			
Austria [3]	1,906	1,949	1,806
Belgium	r 7,991	7,847	7,477
Bulgaria	876	923	e 935
Czechoslovakia	11,037	11,316	11,543
Finland [4]	157	132	121
France [3]	r 15,006	15,610	13,790
Germany, East	2,636	2,835	e 2,835
Germany, West	43,002	43,997	41,379
Hungary	r 475	855	862
Italy	7,314	7,766	7,664
Netherlands [3]	r 2,206	2,201	2,094
Norway	358	343	363
Poland	16,336	16,764	17,768
Romania	r 1,247	1,179	e 1,179
Spain [5]	4,063	4,441	4,450
Sweden	588	584	906
U.S.S.R. [3]	81,020	83,114	85,429
United Kingdom	r 22,498	22,358	19,449
Yugoslavia	r 1,351	1,441	1,432
Africa:			
Arab Republic of Egypt	344	e 350	e 350
Rhodesia, Southern	268	e 270	e 270
Southern Africa, Republic of	r 3,519	3,511	e 3,530
Asia:			
China, People's Republic of e	19,000	20,000	20,000
India [6]	9,854	e 9,600	e 9,200
Iran [7]	r 56	60	63
Japan	34,186	40,095	40,654
Korea, North e	2,200	2,400	2,400
Taiwan	217	297	274
Turkey	1,591	1,757	e 2,000
Oceania:			
Australia	4,906	5,485	4,856
New Zealand	6	7	e 7
Subtotal—Metallurgical coke	r 370,205	386,203	374,098
GASHOUSE COKE [8]			
South America:			
Brazil	192	e 200	90
Uruguay	18	17	17
Europe:			
Austria	94	--	--
Czechoslovakia	32	29	e 29
Denmark	177	202	e 202
France	9	11	4
Greece	15	17	--
Germany, West	2,652	2,827	2,220
Hungary	475	440	e 385
Ireland [3]	40	40	e 40
Italy	212	138	125
Poland	1,488	1,475	1,433
Spain	r 18	10	8
Sweden	443	405	e 370
Switzerland	308	182	114
United Kingdom	r 4,215	2,589	848
Africa:			
South Africa, Republic of	e 110	e 110	111
Asia:			
India	71	e 82	e 82
Japan	5,521	5,267	4,913
Taiwan	62	10	9
Turkey e	200	200	200
Oceania:			
Australia	772	e 772	e 772
New Zealand [9]	53	39	e 40
Subtotal—Gashouse coke	r 17,177	15,062	12,012

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]	1969	1970	1971 [p]
ALL OTHER TYPES [10]			
Europe:			
Czechoslovakia	1,540	[e] 1,540	[e] 1,540
Germany, East [11]	7,092	6,918	[e] 6,600
Hungary	301	[e] 90	NA
Asia:			
India	4,548	[e] 4,400	[e] 3,920
Turkey [e]	80	80	80
Subtotal—All other types	13,561	13,028	12,140
Grand total—All types	[r] 400,943	414,293	398,250

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Algeria, Arab Republic of Egypt, Ceylon, Malaysia, People's Republic of China, Mexico, Norway, Romania, and U.S.S.R. have produced gashouse coke in previous years and may have continued production into the time period covered by this table, but no statistics are available and information is inadequate to make reliable estimates of output levels. Japan also produces low temperature coke but data are not available. 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 colleries and coke plants (including those at steel works).

[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 but output is not reported separately from metallurgical coke and the output has been included in that section of this table.

[9] Data are for years beginning March 31 of that stated.

[10] Includes coke produced at low and medium temperatures, as well as coke produced in unconventional equipment (chain-grate cokers).

[11] Includes coke produced from lignite at high temperatures.

Table 22.—Quantity and value at ovens of coal carbonized in the United States in 1971, by State

State	Coal carbonized			Coal per ton of coke	
	Thousand short tons	Value: Total (thousands)	Value: Average	Short tons	Value
OVEN COKE					
Alabama	7,520	$93,716	$12.46	1.40	$17.44
California, Colorado, Utah	4,717	58,941	12.50	1.58	19.75
Maryland, New Jersey, New York	8,597	162,821	18.94	1.44	27.27
Illinois	3,371	45,207	13.41	1.57	21.05
Indiana	11,456	168,024	14.67	1.46	21.42
Kentucky, Missouri, Tennessee, Texas	2,809	32,944	11.73	1.44	16.89
Michigan	5,127	90,797	17.71	1.36	24.09
Minnesota and Wisconsin	1,050	19,944	18.99	1.34	25.45
Ohio	10,853	146,772	13.52	1.43	19.33
Pennsylvania	21,981	271,813	12.37	1.44	17.81
West Virginia	4,471	55,980	12.52	1.49	18.65
Total 1971	81,952	1,146,959	14.00	1.45	20.30
At merchant plants	7,730	117,984	15.26	1.39	21.21
At furnace plants	74,222	1,028,975	13.86	1.45	20.10
Total 1970	95,053	1,160,367	12.21	1.45	17.70
BEEHIVE COKE					
Pennsylvania and Virginia	1,289	11,005	8.54	1.67	14.26
Total:					
1971	1,289	11,005	8.54	1.67	14.26
1970	1,428	10,438	7.31	1.64	11.99

Table 23.—Bituminous coal carbonized in coke ovens in the United States, by month

(Thousand short tons)

Month	1970			1971		
	Slot	Beehive	Total	Slot	Beehive	Total
January	7,659	133	7,792	8,169	107	8,276
February	7,238	126	7,364	7,298	120	7,418
March	8,116	123	8,239	8,255	125	8,380
April	7,853	123	7,976	8,047	110	8,157
May	8,099	114	8,213	8,182	125	8,307
June	7,786	114	7,900	7,615	126	7,741
July	7,841	117	7,958	6,896	110	7,006
August	7,822	114	7,936	5,067	97	5,164
September	7,808	117	7,925	5,722	95	5,817
October	8,216	122	8,338	5,633	90	5,723
November	7,957	113	8,070	4,597	82	4,679
December	8,185	113	8,298	6,051	101	6,152
Total [1]	94,581	1,428	96,009	81,531	1,289	82,820

[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	1970	1971
January	47	35
February	45	28
March	43	36
April	39	38
May	44	37
June	38	36
July	38	33
August	33	37
September	36	37
October	35	38
November	38	27
December	35	39
Total	[1] 472	421

[1] Data may 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	1970	1971
Alabama	$11.38	$12.46
California, Colorado, Utah	11.61	12.50
Maryland, New Jersey, New York	15.63	18.94
Illinois	11.16	13.41
Indiana	11.84	14.67
Kentucky, Missouri, Tennessee, Texas	10.22	11.73
Michigan	14.68	17.71
Minnesota and Wisconsin	14.15	18.99
Ohio	11.35	13.52
Pennsylvania	11.76	12.37
West Virginia	10.76	12.52
Average	12.21	14.00
Value of coal per ton of coke	17.70	20.30

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)
1967	59,787	35.1	12,470	26.4	18,644	18.2	[1] 90,900	30.4
1968	55,853	35.0	12,906	27.3	20,074	18.7	88,833	30.2
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

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

Table 27.—Coal received by oven-coke plants in the United States in 1971, by consuming State and volatile content [1]

(Thousand short tons)

Consuming state	High-volatile Quantity	High-volatile Percent of total	Medium-volatile Quantity	Medium-volatile Percent of total	Low-volatile Quantity	Low-volatile Percent of total	Total coal receipts [2]
Alabama	1,663	22.9	4,946	68.0	669	9.1	7,278
California, Colorado, Utah	3,894	82.9	731	15.6	70	1.5	4,696
Maryland, New Jersey, New York	5,902	71.8	296	3.6	2,018	24.6	8,216
Illinois	2,635	79.4	209	6.3	475	14.3	3,319
Indiana	6,872	61.9	1,558	14.0	2,669	24.1	11,100
Kentucky, Missouri, Tennessee, Texas	1,072	57.3	394	21.1	405	21.6	1,871
Michigan	3,236	68.3	165	3.5	1,339	28.2	4,740
Minnesota and Wisconsin	443	48.2	117	12.7	359	39.1	919
Ohio	7,735	77.0	510	5.0	1,808	18.0	10,053
Pennsylvania	15,271	67.2	3,677	16.2	3,772	16.6	22,721
West Virginia	3,622	80.8	8	.2	853	19.0	4,483
Total 1971 [2]	52,345	65.9	12,611	15.9	14,440	18.2	79,397
At merchant plants	2,456	36.4	2,396	35.5	1,894	28.1	6,746
At furnace plants	49,889	68.7	10,215	14.1	12,546	17.2	72,650
Total 1970	63,073	66.6	11,819	12.5	19,843	20.9	94,735

[1] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.
[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 1971, by producing county and volatile content [1]

(Thousand short tons)

State and county where coal was produced	Volatile content High	Volatile content Medium	Volatile content Low	Total [2]
Alabama:				
Bibb	277	--	--	277
Jefferson	652	4,439	--	5,091
Tuscaloosa	--	234	--	234
Walker	30	4	--	34
Arkansas:				
Johnson	--	--	22	22
Sebastian	--	--	4	4
Colorado:				
Gunnison	743	--	--	743
Las Animas	1,062	--	--	1,062
Moffat	(3)	--	--	(3)
Pitkin	--	731	--	731
Illinois:				
Franklin	2,691	--	--	2,691
Jefferson	761	--	--	761
Saline	373	--	--	373
Williamson	14	--	--	14
Kentucky:				
Bell	17	--	--	17
Boyd	561	--	--	561
Floyd	1,392	--	--	1,392
Harlan	3,680	--	--	3,680
Johnson	4	--	--	4
Knott	338	--	--	338
Knox	220	--	--	220
Letcher	2,560	--	--	2,560
Martin	3	--	--	3
Perry	8	--	--	8
Pike	2,720	--	--	2,720
Whitley	19	--	--	19
New Mexico:				
Colfax	621	--	--	621
Oklahoma:				
Haskell	--	213	15	228
Le Flore	--	--	100	100
Rogers	158	--	--	158
Pennsylvania:				
Anthracite	--	--	369	369
Bituminous:				
Allegheny	1,956	5	(3)	1,961
Blair	--	1	1	2

See footnotes at end of table.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1971, by producing county and volatile content [1]—Continued

(Thousand short tons)

State and county where coal was produced	Volatile content			Total [2]
	High	Medium	Low	
Pennsylvania—Continued				
Cambria	--	207	2,788	2,995
Clearfield	--	--	3	3
Greene	4,608	--	--	4,608
Somerset	--	--	1,842	1,842
Washington	9,914	--	--	9,914
Westmoreland	1,259	(3)	--	1,260
Tennessee: Claiborne	10	--	--	10
Utah: Carbon	1,468	--	--	1,468
Virginia:				
Buchanan	554	369	584	1,508
Dickenson	417	7	--	424
Russell	--	538	--	538
Tazewell	--	1,338	--	1,338
Wise	634	--	--	634
West Virginia:				
Barbour	174	--	--	174
Boone	1,605	--	--	1,605
Fayette	1,355	108	775	2,239
Greenbrier	--	33	--	33
Kanawha	1,321	--	--	1,321
Logan	3,905	319	--	4,225
McDowell	11	2,350	4,390	6,752
Marion	1,395	--	--	1,395
Mercer	--	15	682	696
Mingo	1,246	281	--	1,527
Monongalia	973	--	--	973
Nicholas	213	790	--	1,003
Preston	21	--	--	21
Raleigh	--	219	1,188	1,407
Upshur	--	34	--	34
Wayne	18	--	--	18
Webster	--	49	--	49
Wyoming	384	327	1,676	2,387
Total [2]	52,345	12,611	14,440	79,397

[1] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.
[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 1971, by State

(Thousand short tons)

Consuming state	Producing State						
	Alabama	Arkansas	Colorado	Illinois	Kentucky	New Mexico	Oklahoma
Alabama	5,610	--	--	--	259	--	--
California, Colorado, Utah	--	--	2,536	--	--	621	--
Maryland, New Jersey, New York	--	--	--	--	2,585	--	--
Illinois	--	--	--	1,436	1,137	--	--
Indiana	26	--	--	2,366	2,496	--	--
Kentucky, Missouri, Tennessee, Texas	--	--	--	--	561	--	480
Michigan	--	26	--	27	1,583	--	--
Minnesota and Wisconsin	--	--	--	--	201	--	--
Ohio	--	--	--	11	1,371	--	6
Pennsylvania	--	--	--	--	1,262	--	--
West Virginia	--	--	--	--	66	--	--
Total 1971 [1]	5,636	26	2,536	3,839	11,521	621	486
At merchant plants	707	--	--	--	697	--	15
At furnace plants	4,929	26	2,536	3,839	10,825	621	471
Total 1970 [1]	6,758	--	2,691	4,675	13,227	763	550

See footnotes at end of table.

Table 29.—Origin of coal received by oven-coke plants in the United States in 1971, by State—Continued

Consuming state	Producing State—Continued					
	Pennsylvania	Utah	Virginia	Tennessee	West Virginia	Total [1]
Alabama	48	--	713	--	648	7,278
California, Colorado, Utah	--	1,468	--	--	70	4,696
Maryland, New Jersey, New York	3,465	--	290	--	1,876	8,216
Illinois	22	--	20	--	705	3,319
Indiana	756	--	1,605	--	3,850	11,100
Kentucky, Missouri, Tennessee, Texas	69	--	260	--	501	1,871
Michigan	124	--	154	--	2,826	4,740
Minnesota and Wisconsin	26	--	173	--	520	919
Ohio	3,688	--	617	10	4,351	10,053
Pennsylvania	12,081	--	600	--	8,778	22,721
West Virginia	2,677	--	8	--	1,733	4,483
Total 1971 [1]	22,955	1,468	4,440	10	25,858	79,397
At merchant plants	319	--	728	--	2,820	5,284
At furnace plants	22,639	1,468	3,712	10	23,036	74,113
Total 1970 [1] [2]	27,826	1,704	4,237	89	32,203	94,735

[1] Data may not add to totals shown because of independent rounding.
[2] Total 1970 figure includes 8,000 tons produced in Indiana.

Table 30.—Quantity and percentage of captive coal received by oven-coke plants in the United States

(Thousand short tons)

Year	At merchant plants			At furnace plants			Total [1]		
	Total coal received	Captive coal		Total coal received	Captive coal		Total coal received	Captive coal	
		Quantity	Percent		Quantity	Percent		Quantity	Percent
1967	8,545	3,109	36.4	85,495	52,928	61.9	94,040	56,038	59.6
1968	7,735	2,659	34.4	81,213	48,999	60.3	88,948	51,658	58.1
1969	8,232	2,895	35.2	83,416	52,447	62.9	91,648	55,342	60.4
1970	7,866	2,320	r 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

r Revised.
[1] Data may not add to totals 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	1970	1971
January	7,712	8,389
February	7,796	8,327
March	8,390	8,966
April	8,678	9,804
May	9,093	10,642
June	9,235	10,849
July	6,591	8,517
August	6,719	10,369
September	7,112	11,818
October	8,180	7,988
November	8,674	5,381
December	8,924	7,199

Table 32.—Month-end stocks of anthracite at oven-coke plants in the United States

(Thousand short tons)

Month	1970	1971
January	101	111
February	81	97
March	71	80
April	65	65
May	77	55
June	82	70
July	78	89
August	88	102
September	96	108
October	113	110
November	112	130
December	121	118

Table 33.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1971 [1]

Product	Produced	Sold: Quantity	Sold: Value: Total (thousands)	Sold: Value: Average per unit	On hand Dec. 31
Tar, crude____thousand gallons__	679,377	334,076	$35,960	$0.108	40,634
Tar derivatives:					
Sodium phenolate or carbolate____do____	3,123	3,047	203	.067	221
Crude chemical oil (tar acid oil)____do____	7,279	7,815	1,092	.140	119
Pitch-of-tar: [2]					
Soft____thousand short tons__	262	115	3,970	34.522	13
Hard____do____	211	112	4,575	40.848	6
Other tar derivatives [3]____	--	--	12,979	--	--
Ammonia products:					
Sulfate____thousand short tons__	540	621	7,572	12.193	27
Liquor (NH_3 content)____do____	14	16	806	50.375	2
Diammonium phosphate____do____	38	42	3,789	90.214	1
Total____do____	--	--	12,167	--	--
Sulfate equivalent of all forms____do____	632	723	--	--	35
NH_3 equivalent of all forms____do____	163	187	--	--	9
Gas:					
Used under boilers, etc.____million cubic feet___	--	100,816	26,016	.258	--
Used in steel or allied plants____do____	--	339,299	93,630	.276	--
Distributed through city mains____do____	[4] 861,691	10,795	3,554	.329	--
Sold for industrial use____do____	--	55,653	11,182	.201	--
Total____do____	[4] 861,691	506,563	134,382	.265	--
Crude light oil____thousand gallons__	[5] 201,626	91,423	8,654	.095	8,472
Light oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90 percent) do____	68,756	69,767	13,992	.201	2,795
Other industrial grades____do____	3,391	3,378	501	.148	54
Toluene (all grades)____do____	13,345	13,265	2,300	.173	688
Xylene (all grades)____do____	2,906	2,724	513	.188	557
Solvent naphtha (all grades)____do____	2,875	2,472	359	.145	206
Other light oil derivatives____do____	3,352	2,471	673	.272	378
Total____do____	94,625	[6] 94,076	18,338	.195	4,678
Intermediate light oil____do____	3,879	909	96	.106	94
Grand total____	--	--	[6] 232,418	--	--

[1] Includes products of tar distillation conducted by oven-coke operators under the same corporate name.
[2] Soft-water-softening point less than 110° F; medium—110° to 160° F; hard—over 160° F. Figures on hard pitch include small amount of medium pitch.
[3] Creosote oil, cresols, cresylic acid, naphthalene, phenol, pyridine, refined tar, tar paint.
[4] Includes gas used for heating ovens and gas wasted.
[5] 110,301,000 gallons refined by coke-oven operators to make derived products shown.
[6] Data may not add to total shown because of independent rounding.

Table 34.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced: Coke breeze (thousand short tons)	Materials produced: Surplus gas (billion cubic feet)	Materials produced: Tar (thousand gallons)	Materials produced: Light oil (thousand gallons)	Estimated equivalent in heating value [1] (billion Btu): Coke breeze	Surplus gas	Tar	Light oil	Total	Coal equivalent (thousand short tons)
1967____	4,025	606	780,334	252,138	80,500	333,300	117,050	32,778	563,628	21,513
1968____	4,074	575	760,812	238,887	81,480	316,250	114,114	31,055	542,899	20,721
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	r 21,409
1971____	4,048	507	679,377	201,626	80,960	278,850	101,907	26,211	487,928	18,623

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

	1967	1968	1969	1970	1971
Ammonia products	$0.254	$0.194	$0.173	$0.151	$0.136
Light oil and its derivatives	.441	.427	.435	.405	.365
Surplus gas used or sold	1.512	1.483	1.502	1.561	1.640
Tar and its derivatives (including naphthalene):					
Tar burned by producers [1]	.318	.311	.317	.398	.341
Sold	.675	.727	.685	.623	.721
Total	3.200	3.142	3.112	3.138	3.203
Coke produced	12.152	12.246	[2] 12.560	[2] 19.208	[2] 21.135
Breeze produced	.318	.314	.388	.481	.534
Grand total	15.670	15.702	16.060	22.827	24.872

[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

	1967	1968	1969	1970	1971
Product:					
Ammonia products	2.5	1.9	1.8	1.3	1.1
Light oil and its derivatives	4.4	4.3	4.4	4.3	3.8
Surplus gas used or sold	15.1	15.1	14.4	12.8	11.7
Tar and its derivatives used or sold (including naphthalene)	11.4	10.4	10.5	9.0	8.0
Total	33.4	31.7	31.1	27.4	24.6
Value of coal per short ton	$10.02	$10.01	$10.42	$12.21	$14.00

Table 37.—Production and disposal of coke-oven gas in the United States in 1971, by State

(Million cubic feet)

State	Produced: Total	Produced: Thousand cubic feet per ton of coal	Used in heating ovens	Surplus used or sold: Quantity	Surplus used or sold: Value: Thousands	Surplus used or sold: Value: Average per thousand cubic feet	Wasted
Alabama	72,336	9.62	34,238	35,979	$6,350	$0.176	2,120
California, Colorado, Utah	59,545	12.62	17,737	41,615	8,081	.194	194
Maryland, New Jersey, New York	94,922	11.04	32,828	59,204	24,876	.420	2,890
Illinois	33,285	9.87	14,411	14,870	3,351	.225	4,004
Indiana	122,590	10.70	47,891	74,063	18,374	.248	636
Kentucky, Missouri, Tennessee, Texas	26,693	9.50	13,840	11,228	1,998	.178	1,625
Michigan	51,966	10.14	12,620	36,748	9,894	.269	2,598
Minnesota and Wisconsin	9,062	8.63	4,674	4,372	837	.191	16
Ohio	108,997	10.04	44,816	61,141	18,934	.310	3,041
Pennsylvania	234,417	10.66	98,397	134,002	33,433	.249	2,017
West Virginia	47,878	10.71	14,526	33,340	8,254	.248	12
Total 1971	861,691	10.51	335,978	[1] 506,563	134,382	.265	[1] 19,150
At merchant plants	67,710	8.76	32,256	30,378	7,657	.252	5,076
At furnace plants	793,981	10.70	303,721	476,185	126,725	.266	14,074
Total 1970	992,790	10.44	380,171	584,684	148,381	.254	27,935

[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 1971, by State

(Million cubic feet)

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
		Value			Value	
	Quantity	Thousands	Average per thousand cubic feet	Quantity	Thousands	Average per thousand cubic feet
Alabama	15,427	$2,787	$0.181	17,284	$3,107	$0.180
California, Colorado, Utah	(1)	(1)	(1)	(1)	(1)	(1)
Maryland, New Jersey, New York	1,752	327	.187	50,545	21,465	.425
Illinois	3,858	676	.175	10,258	2,555	.249
Indiana	14,137	4,822	.341	59,224	13,332	.225
Kentucky, Missouri, Tennessee, Texas	6,460	1,076	.167	(1)	(1)	(1)
Michigan	(1)	(1)	(1)	(1)	(1)	(1)
Minnesota and Wisconsin	2,770	576	.208	(1)	(1)	(1)
Ohio	9,660	5,441	.563	45,942	12,043	.262
Pennsylvania	13,933	3,249	.233	77,715	22,178	.285
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	32,820	7,062	.215	78,332	18,950	.242
Total 1971	[2] 100,816	26,016	.258	[2] 339,299	93,630	.276
At merchant plants	11,427	2,238	.196	3,354	1,347	.402
At furnace plants	89,389	23,778	.266	335,945	92,284	.275
Total 1970	111,979	26,367	.235	390,686	104,480	.267

State	Sold					
	Distributed through city mains			For industrial use		
		Value			Value	
	Quantity	Thousands	Average per thousand cubic feet	Quantity	Thousands	Average per thousand cubic feet
Alabama	--	--	--	(1)	(1)	(1)
California, Colorado, Utah	--	--	--	--	--	--
Maryland, New Jersey, New York	(1)	(1)	(1)	(1)	(1)	(1)
Illinois	--	--	--	(1)	(1)	(1)
Indiana	(1)	(1)	(1)	--	--	--
Kentucky, Missouri, Tennessee, Texas	--	--	--	(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)	(1)	(1)	(1)
Undistributed	10,795	$3,554	$0.329	55,653	$11,182	$0.201
Total 1971	10,795	3,554	.329	55,653	11,182	.201
At merchant plants	3,372	1,113	.330	12,224	2,959	.242
At furnace plants	7,423	2,440	.329	43,428	8,223	.189
Total 1970	10,996	4,056	.369	71,023	13,478	.190

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Data may not add to totals shown because of independent rounding.

Table 39.—Coke-oven gas and other gases used in heating coke ovens in the United States in 1971, by State [1]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Total coke-oven gas equivalent
Alabama	34,238	--	60	34,298
California, Colorado, Utah	17,737	--	43	17,780
Maryland, New Jersey, New York	32,828	8,651	285	41,764
Illinois	14,411	1,386	--	15,797
Indiana	47,891	--	2,545	50,436
Kentucky, Missouri, Tennessee, Texas	13,840	--	--	13,840
Michigan	12,620	10,834	--	23,454
Minnesota and Wisconsin	4,674	--	32	4,706
Ohio	44,816	2,997	--	47,813
Pennsylvania	98,397	1,861	20	100,278
West Virginia	14,526	6,219	--	20,745
Total 1971	335,978	[2] 31,947	2,985	370,910
At merchant plants	32,256	--	32	32,288
At furnace plants	303,721	31,947	2,954	338,622
Total 1970	380,171	r 41,945	r 3,826	r 425,941

r Revised.
[1] Adjusted to an equivalent of 550 Btu per cubic foot.
[2] Data may not add to total shown because of independent rounding.

Table 40.—Coke-oven ammonia produced in the United States and sold in 1971, by State

(Thousand short tons and thousand dollars)

State	Active plants [1]	Produced: Sulfate equivalent	Produced: Pounds per ton of coal coked	Produced: As sulfate [2]	Produced: As liquor (NH_3 content)
Alabama	7	67	17.74	67	--
California, Colorado, Utah	3	67	28.62	44	(3)
Maryland, New York	4	85	19.78	81	(3)
Illinois	4	26	15.27	26	--
Indiana and Michigan	7	136	17.60	127	(3)
Kentucky, Tennessee, Texas, Minnesota	4	19	13.99	9	(3)
Ohio	11	83	15.81	75	(3)
Pennsylvania	9	110	10.65	110	--
West Virginia	3	40	17.87	40	--
Undistributed	--	--	--	--	14
Total 1971 [4]	52	632	16.21	[5] 578	14
At merchant plants	7	36	14.78	15	6
At furnace plants	45	596	16.30	563	8
Total 1970	51	691	15.77	636	15

State	Sold: As sulfate [2]: Quantity	Sold: As sulfate [2]: Value	Sold: As liquor (NH_3 content): Quantity	Sold: As liquor (NH_3 content): Value	On hand Dec. 31: As sulfate [2]	On hand Dec. 31: As liquor (NH_3 content)
Alabama	66	$1,039	--	--	2	--
California, Colorado, Utah	43	2,294	(3)	(3)	9	(6)
Maryland and New York	117	1,408	(3)	(3)	3	(6)
Illinois	34	394	--	--	1	--
Indiana, Michigan	105	2,854	(3)	(3)	4	(6)
Kentucky and Tennessee, Texas, Minnesota	9	241	(3)	(3)	(6)	1
Ohio	87	955	(3)	(3)	3	1
Pennsylvania	160	1,879	--	--	6	--
West Virginia	42	298	--	--	1	--
Undistributed	--	--	16	$806	--	--
Total 1971 [4]	[7] 663	11,361	16	806	28	2
At merchant plants	15	183	7	309	(6)	2
At furnace plants	648	11,178	9	497	28	(6)
Total 1970	647	12,416	16	813	163	2

[1] Number of plants that recovered ammonia.
[2] Includes diammonium phosphate.
[3] Included with "Undistributed" to avoid disclosing individual company data.
[4] Data may not add to totals shown because of independent rounding.
[5] Comprises 540,000 tons of ammonium sulfate and 38,000 tons of diammonium phosphate.
[6] Less than ½ unit.
[7] Comprises 621,000 tons of ammonium sulfate valued at $7,572,000 and 42,000 tons of diammonium phosphate valued at $3,789,000.

Table 41.—Coke-oven tar produced in the United States, used by producers, and sold in 1971, by State

(Thousand gallons)

State	Produced: Total	Produced: Gallons per ton of coal coked	Used by producers: For refining or topping	Used by producers: As fuel	Used by producers: Otherwise
Alabama	52,614	7.00	(1)	(1)	(1)
California, Colorado, Utah	46,169	9.79	(1)	(1)	(1)
Maryland, New Jersey, New York	70,638	8.22	(1)	(1)	(1)
Illinois	22,715	6.74	(1)	(1)	(1)
Indiana	105,427	9.20	(1)	(1)	(1)
Kentucky, Missouri, Tennessee, Texas	17,561	6.25	(1)	(1)	(1)
Michigan	34,781	6.78	(1)	(1)	(1)
Minnesota and Wisconsin	6,402	6.10	(1)	(1)	(1)
Ohio	92,098	8.49	(1)	36,758	(1)
Pennsylvania	193,148	8.79	(1)	40,317	(1)
West Virginia	37,825	8.46	(1)	(1)	(1)
Undistributed	--	--	230,959	34,802	1,647
Total 1971 [2]	679,377	8.29	230,959	111,877	1,647
At merchant plants	43,660	5.65	647	--	--
At furnace plants	635,717	8.57	230,313	111,877	1,647
Total 1970	760,926	8.00	280,892	107,967	1,601

State	Sold for refining into tar products: Quantity	Value: Thousands	Value: Average per gallon	On hand Dec. 31
Alabama	30,311	3,339	$0.110	1,964
California, Colorado, Utah	29,375	3,971	.135	3,245
Maryland, New Jersey, New York	36,568	3,830	.105	5,584
Illinois	22,532	2,311	.103	1,471
Indiana	26,710	2,854	.107	4,186
Kentucky, Missouri, Tennessee, Texas	17,739	1,804	.102	268
Michigan	36,159	2,934	.081	2,165
Minnesota and Wisconsin	5,548	784	.141	798
Ohio	44,589	4,792	.108	5,469
Pennsylvania	70,490	7,624	.108	13,891
West Virginia	14,054	1,716	.122	1,594
Undistributed	--	--	--	--
Total 1971 [2]	334,076	35,960	.108	40,634
At merchant plants	40,608	4,256	.105	1,662
At furnace plants	293,468	31,703	.108	38,972
Total 1970	371,203	35,804	.097	47,174

[1] Included with "Undistributed" to avoid disclosing individual company data.
[2] Data may not add to totals shown because of independent rounding.

Table 42.—Coke-oven crude light oil produced in the United States and derived products produced and sold in 1971, by State

(Thousand gallons)

State	Active plants [1]	Crude light oil: Produced	Crude light oil: Gallons per ton of coal	Crude light oil: Refined on premises [2]	Crude light oil: On hand Dec. 31	Derived products: Produced	Derived products: Sold [3] Quantity	Derived products: Sold [3] Value
Alabama	7	14,758	1.96	6,502	2,031	4,858	5,813	$1,030
California, Colorado, Utah	3	17,122	3.63	11,137	260	8,594	7,840	1,614
Maryland, New Jersey, New York	5	23,472	2.73	10,213	1,774	9,648	9,437	1,967
Illinois, Indiana, Michigan	10	40,926	2.33	1,300	773	(4)	(4)	(4)
Kentucky, Missouri, Tennessee, Texas, West Virginia	8	19,087	2.61	2,307	669	2,111	2,173	316
Ohio	11	27,128	2.54	18,051	826	15,345	15,304	2,567
Pennsylvania	12	59,134	2.69	60,792	2,139	54,068	53,510	10,844
Total 1971 [5]	56	201,626	2.57	110,301	8,472	94,625	94,076	18,338
At merchant plants	10	10,440	1.79	1,205	731	390	654	123
At furnace plants	46	191,186	2.63	109,096	7,742	94,235	93,423	18,215
Total 1970	55	244,107	2.68	142,016	9,027	123,433	119,942	25,065

[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 91,423,000 gallons of crude light oil valued at $8,654,000 sold as such.
[4] Included with Maryland, New Jersey, and New York to avoid disclosing individual company confidential data.
[5] Data may not add to totals shown because of independent rounding.

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
1967	58.9	12.6	3.6	2.4	5.4
1968	63.9	13.6	3.8	2.6	4.6
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

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 percent)	Benzene: Other industrial grades	Toluene (all grades)
1967	86,683	3,959	19,358
1968	88,449	4,136	19,645
1969	97,503	4,192	19,603
1970	89,517	3,975	17,401
1971	68,756	3,391	13,345

Table 45.—Light oil derivatives produced at oven-coke plants in the United States and sold in 1971, by State

(Thousand gallons and thousand dollars)

State	Benzene (all grades)				Toluene (all grades)			
	Produced	Yield from crude light oil refined (percent)	Sold		Produced	Yield from crude light oil refined (percent)	Sold	
			Quantity	Value			Quantity	Value
Alabama	3,510	58.5	4,188	$780	700	13.1	932	$157
Colorado, Illinois, Utah	6,734	56.7	6,938	1,442	1,471	12.1	776	140
Indiana and Ohio	11,971	65.1	11,906	1,989	2,472	13.4	2,539	443
Maryland, Tennessee, Texas	9,768	79.1	9,727	1,971	570	4.7	611	105
Pennsylvania	40,164	66.2	40,386	8,311	8,132	13.6	8,408	1,455
Total 1971 [1]	72,147	65.6	73,145	14,493	13,345	12.4	13,265	2,300
At merchant plants	252	48.6	462	85	67	11.3	105	22
At furnace plants	71,895	66.1	72,683	14,408	13,278	12.4	13,160	2,278
Total 1970	93,492	63.0	92,117	19,793	17,041	12.1	16,765	3,093

State	Xylene (all grades)				Solvent naphtha (crude and refined)			
	Produced	Yield from crude light oil refined (percent)	Sold		Produced	Yield from crude light oil refined (percent)	Sold	
			Quantity	Value			Quantity	Value
Alabama	143	2.6	205	$46	323	4.3	314	$37
Colorado, Illinois, Utah	308	2.6	236	44	298	2.5	171	26
Indiana and Ohio	573	3.1	546	106	736	4.4	504	65
Maryland, Tennessee, Texas	100	1.0	103	17	(2)	(2)	(2)	(2)
Pennsylvania	1,783	3.0	1,633	301	1,518	2.8	1,482	230
Total 1971 [1] [3]	2,906	2.8	2,724	513	2,875	3.2	2,472	359
Total 1970	4,501	3.2	4,752	944	3,707	3.3	3,288	536

[1] Data may not add to totals shown because of independent rounding.
[2] Included with Alabama to avoid disclosing individual company confidential data.
[3] Data not broken down into merchant and furnace plants to avoid disclosing individual company confidential data.

Columbium and Tantalum

By Joseph A. Sutton[1]

The extremely high inventories of columbium ores and concentrates built up by industry during 1969 and 1970 were reduced to more reasonable levels in 1971. These high levels were responsible for the depressed market that occurred during 1971. Consumption of columbium and tantalum raw materials was 33 percent below that of 1970, while consumption of ferrocolumbium (FeCb), ferrotantalum-columbium (FeTa-Cb), and other columbium and tantalum materials increased 11 percent. The primary use of FeCb, FeTa-Cb, and other columbium and tantalum materials remained in the production of alloy steels. Tantalum continued to be primarily used in capacitors and other electronic devices for military applications and the aerospace program. A newly discovered group of organometallic superconductors, containing tantalum and columbium as base materials, hold promise for use in magnets and other electrical devices.

Legislation and Government Programs.—Public Law 92–109, signed on August 11, 1971, gave the Administrator of GSA authority to dispose of 5,010,716 pounds (Cb content) of columbium from the national and supplemental stockpile inventories. Constituent makeup of this material includes approximately 4,376,758 pounds, concentrates; 1,614 pounds, columbium carbide powder; 95,383 pounds, columbium oxide powder; and 536,916 pounds, ferrocolumbium. At yearend none of the material authorized for sale had been sold.

The quantities of columbium and tantalum materials reported in government inventories as of December 31, 1971, are listed on Table 3.

During 1971 the Office of Minerals Exploration (OME), U.S. Geological Survey, continued to offer financial assistance of 50 percent (columbium) and 75 percent (tantalum) of costs for exploration of approved columbium and tantalum resources.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1967	1968	1969	1970	1971
United States:					
Mine production of columbite-tantalite concentrates	W	W	W	W	W
Releases from Government stocks (Cb content)[1 2]	779	1,191	1,573	617	--
Consumption of concentrate: Columbium metal contained in all raw materials consumed (Cb content)[1]	4,519	3,997	2,918	3,289	1,991
Production of primary products:					
Columbium metal (Cb content)	W	W	W	W	W
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	1,960	2,380	2,554	1,430	1,020
Consumption of primary products:					
Columbium metal (Cb content)	111	92	179	261	459
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	3,192	3,094	3,328	2,591	2,880
Exports:					
Columbium ore and concentrate (gross weight)	NA	NA	NA	NA	NA
Columbium metal, compounds, and alloys (gross weight)	6	7	41	46	21
Imports for consumption:					
Columbium mineral concentrate (gross weight)	7,431	3,657	4,161	5,719	3,054
Columbium metal and columbium-bearing alloys (Cb content)	(3)	1	5	2	1
Ferrocolumbium (gross weight) e	629	1,171	NA	NA	NA
World: Production of columbium-tantalum concentrates (gross weight)	20,551	23,857	31,451	44,934	23,261

e Estimate. NA Not available. 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] Less than ½ unit.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1967	1968	1969	1970	1971
United States:					
Mine production of columbium-tantalum concentrates	W	W	W	W	W
Releases from Government stocks (Ta content) [1] [2]	307	163	171	100	--
Consumption of concentrate: Tantalum metal contained in all raw materials consumed (Ta content) [1]	1,730	1,060	928	1,733	1,359
Production of primary products:					
Tantalum metal (Ta content)	1,021	692	1,046	916	892
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	1,960	2,380	2,554	1,430	1,020
Consumption of primary products: Tantalum metal (Ta content)	443	423	751	417	649
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	3,192	3,094	3,328	2,591	2,880
Exports:					
Tantalum ore and concentrate (gross weight)	75	65	85	122	48
Tantalum metal, compounds, and alloys (gross weight)	59	106	124	640	194
Tantalum and tantalum alloy powder (Ta content)	51	84	100	139	85
Imports for consumption:					
Tantalum mineral concentrates (gross weight)	1,675	1,230	975	1,046	1,180
Tantalum metal and tantalum-bearing alloys (Ta content)	55	18	11	51	40
World: Production of columbium-tantalum concentrates (gross weight)	20,551	23,857	31,451	44,934	23,261

W Withheld to avoid disclosing individual company confidential data.
[1] Includes tantalum content in raw materials from which tantalum is not recovered.
[2] Includes material released as payment-in-kind for upgrading.

Table 3.—Columbium and tantalum materials in Government inventories as of Dec. 31, 1971

(Thousand pounds, columbium and tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
COLUMBIUM					
Concentrates	--	5,799	1,600	358	7,757
Carbide powder: Stockpile grade	20	21	--	--	21
Ferrocolumbium:					
Stockpile grade	930	556	--	--	556
Nonstockpile grade	--	738	--	--	738
Metal: Stockpile grade	45	45	--	--	45
Oxide powder: Stockpile	--	86	--	--	86
TANTALUM					
Tantalum minerals: Stockpile grade	2,947	3,151	756	6	3,913
Carbide powder: Stockpile grade	27	29	--	--	29
Metal: Stockpile grade	360	201	--	--	201

DOMESTIC PRODUCTION

Domestic mining activity was again insignificant. Small quantities of columbium and tantalum were produced by one company during exploration and development work in Larimer County, Colo., but none of the material was marketed.

Production of columbium metal powder increased 53 percent in 1971 while production of tantalum metal (including capacitor-grade powder) decreased 3 percent; however, data continued to be withheld to avoid disclosing individual company confidential data. There was a 66-percent increase in production of columbium metal ingots and a 19-percent decrease in production of tantalum metal ingots during the year, but production figures also cannot be revealed.

Ferrocolumbium and columbium base master alloys were produced by the thermite process by the Reading Alloys Co., Inc., and Shieldalloy Corp. Foote Mineral Co., Kawecki Division of Kawecki Berylco Industries, Inc., Molybdenum Corp. of America (Molycorp), and Union Carbide Corp. produced these alloys in electric furnaces. During 1970 and 1971 there was no production of ferrotantalum-columbium.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1971

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium
Allegheny-Ludlum Industries, Inc.	Brackenbridge, Pa.; Watervliet, N.Y.	X	--	--	--
Arnold Engineering	Marengo, Ill.	X	--	--	--
Fansteel Inc.	Muskogee, Okla.	X	X	--	--
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 Division, Union Carbide Corp.	Niagara Falls, N.Y.; Marietta, Ohio; Greenville, S.C.	X	X	--	X
Molybdenum Corp. of America	Washington, Pa.	--	--	--	X
Metals Division, Norton Co.	Newton, Mass.	--	X	--	--
Newcomer Products, Inc.	Latrobe, Pa.	X	--	X	--
Reading Alloys, Co., Inc.	Robesonia, Pa.	--	--	--	X
Shieldalloy Corp.	Newfield, N.J.	X	--	--	X
Metallurgical Products Division, Foote Mineral Co.	Cambridge, Ohio	--	--	--	X
Wah Chang Albany (A Teledyne Company)	Albany, Oreg.	X	X	X	--

CONSUMPTION AND USES

Columbium consumed in the form of high-purity metal totaled 458,986 pounds, an increase of 76 percent over the total for 1970. Tantalum metal (including capacitor-grade powder) consumed during the year increased from the 416,620 pounds reported in 1970 to 648,656 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.

Consumption of ferrocolumbium (FeCb), ferrotantalum-columbium (FeTa–Cb), and other columbium and tantalum materials increased in all end-use categories except alloys steels (excluding stainless and heat-resisting steels). The greatest single volume increase occurred in carbon steels. Total consumption of columbium plus tantalum in these forms increased 11 percent to nearly 2.9 million pounds in 1971. Domestic consumption of FeCb, FeTa-Cb, and other columbium and tantalum materials, by major end-use categories was as follows: Carbon steel (29 percent), alloy steel other than stainless and heat-resisting steel (27 percent), superalloys (21 percent), stainless and heat-resisting steel (20 percent), miscellaneous and unspecified (2 percent), and alloy other than alloy steels and superalloys (1 percent).

Use of columbium and tantalum in ferroalloys for additions to steels to control grain size accounted for approximately 76 percent of the FeCb, FeTa-Cb, and other columbium and tantalum materials consumed. Total quantity of ferrocolumbium consumed in alloy steelmaking was over 2.2 million pounds, an increase of 7 percent over the total for 1970.

Consumption of ferrotantalum-columbium continued to be small and amounted to about 1 percent of the FeCb, FeTa-Cb, and other columbium and tantalum materials consumed. Carbon and stainless and heat-resisting steels continued to be the major end-use categories for FeTa-Cb. Consumption of FeTa-Cb in making carbon steel was 11 percent below that recorded for 1970 and consumption of FeTa-Cb in making stainless and heat-resisting steel declined 73 percent.

Consumption of other tantalum and columbium materials was equal to about 4 percent of the total FeCb, FeTa-Cb, and other columbium and tantalum materials consumed. Superalloys remained as the major end-use category and consumption was increased by 20 percent in 1971.

The metals division of the Norton Co. introduced a new capacitor-grade tantalum wire (SGSR), used in the manufacturing of capacitors. The tantalum wire was to be used as the contact between the sintered powder electrode and the outside circuitry.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1970	1971	Percent change
Columbium products:			
Compounds including alloys	1,098,600	689,550	−37.2
Metal including worked products	203,600	270,500	+32.9
All other	15,600	6,800	−56.4
Total Cb	1,317,800	966,850	−26.6
Tantalum products:			
Oxides and salts	90,200	60,900	−32.5
Alloy additive	28,200	48,800	+73.0
Carbide	145,600	135,000	−7.3
Powder and anodes	498,700	398,700	−20.1
Ingot (unworked consolidated metal)	54,400	42,400	−22.1
Mill products	213,300	223,300	+4.7
Scrap	78,600	52,400	−33.3
Other	9,200	--	--
Total Ta	1,118,200	961,500	−14.0

Table 6.—Consumption of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials in the United States in 1971, by end use

End use	Pounds of contained columbium plus tantalum
Steel:	
Carbon	821,668
Stainless and heat-resisting	588,411
Alloy (excludes stainless and heat-resisting)	789,507
Superalloys	591,063
Alloys (excludes alloy steels and superalloys)	37,665
Miscellaneous and unspecified [1]	51,523
Total	2,879,837

[1] Includes tool steel.

STOCKS

The following yearend columbium and tantalum materials (given in pounds) were reported in inventories:

Material	Dec. 31, 1970	Dec. 31, 1971
COLUMBIUM		
Primary metal	71,200	60,303
Ingot	34,581	45,324
Scrap	r 74,711	67,503
Oxide	r 1,228,522	1,051,357
Other compounds	r 222,063	353,776
TANTALUM		
Primary metal	r 250,122	269,249
Capacitor-grade powder	r 216,702	163,320
Ingot	114,279	86,452
Scrap	r 257,704	271,663
Oxide	168,895	114,713
Potassium tantalum fluoride (K_2TaF_7)	r 114,927	211,248
Other compounds	r 44,652	--

r Revised.

Stocks of columbium and tantalum raw materials, as reported by consumers and dealers at yearend 1971, were as follows (in short tons—1970 figures in parentheses): Columbite, 521 (714); tantalite, 1,322 (1,461); pyrochlore, 595 (767); tin slag, 35,787 (31,055); and other, none (172).

Consumers inventories of ferrocolumbium and ferro-tantalum-columbium as of December 31, 1971, were as follows (with 1970 yearend stocks in parentheses): Ferrocolumbium, 758,828 pounds contained columbium plus tantalum (820,458); ferro-tantalum-columbium, 34,737 pounds contained columbium plus tantalum (17,108); and other Cb and Ta materials, 31,818 pounds contained columbium plus tantalum (41,230). Producer stocks of ferrocolumbium at yearend 1971 were 534,000 pounds contained Cb (852,000).

PRICES

Spot prices for columbite ore, c.i.f. U.S. ports, as reported by Metals Week decreased from $1.00–$1.05 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 1971 to $0.75–$0.80 per pound at yearend. Under long-term contracts columbite reportedly sold at discounts from the spot quotations, but prices were subject to negotiation and no quotations were published. The quoted prices for Brazilian and Canadian pyrochlore concentrates remained constant during the year. Brazilian concentrate, f.o.b. shipping point, was quoted at $1.15 per pound of Cb_2O_5; and Canadian pyrochlore concentrate, f.o.b. mine or mill, was quoted at $1.15–$1.20 per pound of Cb_2O_5. The yearend price for tantalite ore and concentrate, 60-percent basis, was $6.25–$6.75 per pound Ta_2O_5, c.i.f. U.S. ports, as compared to $6.75–$7.50 at the beginning of the year.

The quoted prices for various grades of ferrocolumbium per pound of columbium content, ton lots, f.o.b. shipping points, at the beginning of the year were as follows: Low alloy, standard grades, $2.65 to $4.12; and high-purity grades, $5.38 to $6.81. From late in May until yearend, quotations fell to $2.45–$2.65 for the low-alloy grades and to $4.12–$6.81 for the high-purity grades.

The quoted price of tantalum metal remained constant during 1971 and was $28.50 to $38.50 per pound of powder, $36 to $60 per pound for sheet, and $36 to $50 for rod.

The price of columbium metal remained unchanged during the year. Columbium-powder roundels, 99.5 to 99.8 percent purity, were quoted at $11 to $22 per pound for metallurgical-grade material, and $17.50 to $28 per pound for reactor-grade material.

Table 7.—Average grade of concentrate received by U.S. consumers and dealers in 1971, by country of origin

(Percent of contained pentoxides)

	Columbite		Tantalite	
	Cb_2O_5	Ta_2O_5	Ta_2O_5	Cb_2O_5
Argentina	--	--	28	32
Australia	41	21	44	25
Belgium	--	--	43	38
Brazil [1] [2]	57	--	40	27
Canada [2]	51	--	50	4
French Guiana	--	--	54	28
Germany, West	31	32	--	--
Kenya	69	41	7	34
Malaysia [1]	69	19	17	55
Mozambique	--	--	39	21
Nigeria [1]	42	5	28	39
Portugal	--	--	33	35
Rwanda	--	--	26	41
South Africa, Republic of	--	--	33	44
Spain	--	--	31	36
Thailand [1]	--	--	30	32
Uganda	56	18	--	--

[1] Excludes tin slag.
[2] Material reported from Brazil or Canada as columbite represents primarily pyrochlore.

FOREIGN TRADE

West Germany, Japan, France, Canada and the United Kingdom received the majority of the columbium and tantalum exports during the year. Unwrought tantalum alloys in crude form and scrap, the largest export item by volume, were shipped to West Germany (64 percent), the United Kingdom (12 percent), Canada (8 percent), Japan (8 percent), and other Western Europe countries (8 percent). Tantalum and tantalum alloy powder, the largest value item, were destined for West

Table 8.—U.S. exports of columbium and tantalum, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1970		1971	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys, unwrought, and waste and scrap	38	$153	3	$63
Columbium and columbium alloys, wrought	8	409	18	525
Tantalum ores and concentrates	122	422	48	146
Tantalum and tantalum alloys, wrought	31	1,461	26	1,175
Tantalum metals and alloys in crude form and scrap	609	2,001	168	1,290
Tantalum and tantalum alloy powder	139	4,367	85	2,519

Germany (29 percent), Japan (21 percent), the United Kingdom (18 percent), France (13 percent), the Netherlands (6 percent), Italy (6 percent), and Canada (4 percent). The remainder of the tantalum powder exported (3 percent of the total) was destined for Switzerland, Austria, India, and Brazil. Wrought tantalum and tantalum alloys, the smallest tantalum item by volume, were exported to West Germany (19 percent), Belgium-Luxembourg (18 percent), Japan (16 percent), France (12 percent), the United Kingdom (10 percent), the Netherlands (10 percent), and Canada (6 percent). The remainder of the tantalum material (9 percent of the total) was exported to Italy, India, Austria, Switzerland, Argentina, Australia, Chile, Mexico, and Ireland. Tantalum ore and concentrate, believed not to be of domestic origin, was shipped to Japan. Wrought columbium and columbium alloys were mostly exported to France (37 percent), Canada (28 percent), Japan (14 percent), West Germany (12 percent), and the United Kingdom (8 percent). Unwrought columbium alloys in crude form and scrap were shipped to Japan (78 percent), West Germany (18 percent), and Canada (4 percent).

Imports for consumption of unwrought columbium metal and waste and scrap decreased sharply in terms of volume received, while value remained close to that reported in 1970. West Germany supplied 450 pounds of unwrought columbium metal, waste, and scrap valued at $7,227. Imports of wrought columbium metal alloys shipped entirely from West Germany were reported to total 30 pounds valued at $1,493. A small quantity of wrought columbium, totaling 76 pounds and valued at $16,526, was received from France (95 percent) and the United Kingdom (5 percent). Imports for consumption of unwrought tantalum metal, including waste and scrap, decreased approximately 28 percent during the year to 40,091 pounds tantalum content, valued at $278,799. The material was imported from Mexico (56 percent), United Kingdom (40 percent), and Japan, Canada, and West Germany (4 percent). Imports of wrought tantalum, primarily from West Germany, increased by a factor of little more than 5 during the year to 111 pounds tantalum content, valued at $5,214. A small quantity of unwrought tantalum alloy, totaling 7 pounds and valued at $279, was received from West Germany.

In 1971 imports of columbium-mineral concentrates were 47 percent below those of 1970, while tantalum-mineral concentrates imported in 1971 remained about equal to those of 1970.

Receipts of tin slags came primarily from Malaysia and Thailand.

Table 9.—Receipts of tin slags reported by consumers

(Thousand pounds)

Year	Gross weight	Cb_2O_5 content	Ta_2O_5 content
1968	8,709	541	510
1969	8,327	649	453
1970	10,275	713	573
1971	9,064	753	596

Table 10.—U.S. imports for consumption of columbium-mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	22	$42	19	$47	22	$52
Argentina	--	--	8	14	--	--
Belgium-Luxembourg [1]	41	72	37	68	32	60
Brazil	2,462	1,440	3,312	2,430	1,927	1,222
Burundi-Rwanda	48	62	21	38	[2] 18	[2] 24
Canada	920	473	1,271	669	341	267
Congo (Brazzaville)	--	--	--	--	11	23
Germany, West	--	--	7	23	11	3
Malaysia	59	49	104	103	60	44
Mozambique	4	7	10	19	12	18
Netherlands [1]	69	48	--	--	--	--
Nigeria	423	267	682	478	483	307
Portugal	--	--	32	75	14	26
Singapore	--	--	19	21	31	31
Spain	20	37	--	--	11	21
Uganda	3	2	4	3	--	--
United Kingdom	--	--	50	75	--	--
Zaire (formerly Congo Kinshasa)	90	182	143	282	81	124
Total	4,161	2,681	5,719	4,345	3,054	2,222

[1] Presumably country of transshipment rather than original source.
[2] Rwanda separately classified Jan. 1, 1971.

Table 11. U.S. imports for consumption of tantalum-mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	2	$10	2	$8
Australia	75	$170	13	31	62	174
Belgium-Luxembourg [1]	30	97	17	42	14	35
Brazil	253	767	178	624	159	549
Burundi-Rwanda	31	47	31	58	[2] 31	[2] 55
Cameroon	--	--	4	12	--	--
Canada	220	1,195	477	1,724	522	1,818
French Guiana	--	--	2	6	2	8
Germany, West	--	--	--	--	31	62
Japan	--	--	5	8	--	--
Malaysia	25	15	--	--	16	10
Mozambique	77	350	--	--	47	108
Nigeria	8	23	4	10	50	33
Portugal	--	--	10	22	7	11
South Africa, Republic of	19	36	--	--	20	29
Spain	27	40	52	105	35	69
Tanzania	9	22	--	--	--	--
Thailand	22	40	--	--	26	52
Uganda	--	--	--	--	4	4
United Kingdom	--	--	22	45	--	--
Western Africa, n.e.c	--	--	7	13	--	--
Zaire (formerly Congo Kinshasa)	179	394	222	521	152	307
Total	975	3,196	1,046	3,231	1,180	3,332

[1] Presumably country of transhipment rather than country of origin.
[2] Rwanda separately classified Jan. 1, 1971.

Table 12.—U.S. import duties

Tariff classification number	Article	Rate of duty per pound [1]	
		Effective Jan. 1, 1971	Effective Jan. 1, 1972
601.21	Columbium concentrate	Free	Free.
601.42	Tantalum concentrate	do	Do.
607.80	Ferrocolumbium and ferro-tantalum-columbium.	6 percent ad valorem	5 percent ad valorem.
	Columbium:		
628.15	Unwrought, waste, scrap	do	Do.
628.20	Wrought	10.5 percent ad valorem	9 percent ad valorem.
628.17	Unwrought Cb alloys	9 percent ad valorem	7.5 percent ad valorem.
	Tantalum:		
629.05	Unwrought, waste, scrap	6 percent ad valorem	5 percent ad valorem.
629.10	Wrought	10.5 percent ad valorem	9 percent ad valorem.
629.07	Unwrought Ta alloys	9 percent ad valorem	7.5 percent ad valorem.
423.00	Columbium and tantalum chemicals.	6 percent ad valorem	5 percent ad valorem.

[1] Not applicable to Communist countries.

WORLD REVIEW

Arab Republic of Egypt.—Tantalum and columbium deposits in an area 25 miles west of Marsa Alam on the Red Sea coast was discovered by the Egyptian Geological Survey and Mining Authority.[2] The deposits were reported to be located at Abu Dabbad and Nuweibi. Preliminary surveys by Russian and Egyptian experts indicate that there were 10 million tons of tantalum bearing material in the Abu Dabbad deposit and approximately 45 million tons in the Nuweibi deposit.

Australia.—Exploration on the Wodgina, Strelley, and Tabba properties of Goldrim Australia, continued during the year. Samples taken from the Strelley property were reported to average 3 pounds Ta_2O_5 per ton representing a zone approximately 1,030 feet in length and 100 feet in width.[3]

Brazil.—As a result of the decreased demand for columbium, Brazilian columbium production in 1971 was about half of that produced in 1970. Companhia Brasileira de Metalúrgia e Mineração (CBMM), the country's leading producer, continued to recover columbium concentrate from rich pyrochlore ores at the Araxa company mine and mill operations and to produce ferrocolumbium (FeCb) at its pyrometallurgical plant by a thermite-type batch process. In 1970, approximately 4.2 million pounds of FeCb were produced from 6.6 million pounds of pyrochlore concentrate. With the exception of approximately 0.8 million pounds sold domestically, all of the FeCb was exported to the United States, Japan, and European countries. In 1971, FeCb production was approximately 26 percent below that reported in 1970.

During 1970 CBMM's flotation plant was expanded by the addition of a new 8- by 14-foot Marcy mill and complementary magnetic separators, pulp distributors, and flotation cells, which brought production capacity to the present level of 25 million pounds of Cb_2O_5 per year.

During the year CBMM built a new plant for producing high-purity columbium oxide from a process developed by the Molybdenum Corp. of America. The new plant has an annual capacity of 1 million pounds, but no columbium oxide was produced in 1971.

Canada.—Production of pyrochlore concentrate by St. Lawrence Columbium and Metals Corp., Canada's only producer, decreased during 1971 from the peak reached in 1970. The milling operation in fiscal 1971 (ended September 30, 1971) produced 408,500 tons of ore, a decrease of 44 percent from the 724,345 tons produced in fiscal 1970. The general slowdown in the steel industry, a major outlet for the company's product, caused the company to shutdown its mining and milling operations for a 6-week period in 1971.[4]

The development of a second major columbium mine in Canada was continued as a joint undertaking by the Keevil Mining Group of Toronto and the Quebec Government exploration company, SOQUEM. The deposit located at St. Honore, near

[2] Mining Journal (London). Phosphates and Tantalum. V. 277, No. 7102, Oct. 1, 1971, p. 295.
[3] Tron, A. R. Columbium (Niobium) and Tantalum. Min. Ann. Rev., June 1971, p. 74.
[4] The Northern Miner. Production Resumed by St. Lawrence at Columbium Mine. V. 57, No. 24, Sept. 2, 1971, p. 19.

Chicoutimi, Quebec, was discovered in 1967 by SOQUEM. The Copperfields Mining Corp. Ltd. secured participation rights in 1968, after submitting a successful bid in response to SOQUEM's tender.[5] Development work was first proved up by SOQUEM, after which a joint development arrangement was made with Keevil interests through Copperfields Mining Corp.

Results of metallurgical work conducted at the SOQUEM research laboratories indicate that a salable pyrochlore concentrate can be produced with acceptable recoveries according to N. B. Keevil, President of the Keevil group.[6]

Present ore reserves of the columbium deposit were estimated to be approximately 60 million tons averaging 0.65 percent Cb_2O_5 to a vertical depth of about 850 feet, proven by over 70,000 feet of diamond drilling in an area 1,800 feet long and 2,400 feet wide. According to the Copperfields Mining Corp. either an underground or an open pit mine facility will probably become operational at St. Honore in 1973.

Chemalloy Minerals Ltd., Toronto, Ontario, which now has 100-percent control of Tantalum Mining Corporation of Canada Ltd. (TANCC), was planning a $3.5 million expansion at its Bernic Lake, Manitoba, tantalum mine. The expansion project includes the provision of a lithium mill and concentrator, but construction will not begin until the company completes financing arrangements and negotiations for the sale of lithium. In 1970 TANCC produced about 315,000 pounds of Ta_2O_5 at Bernic Lake.[7]

A new tantalum deposit was discovered beneath the existing one at Bernic Lake, and TANCC started a new drilling and development program to determine the extent and grade of the new discovery.[8]

Nord Interex Ltd. and Armco Steel Corp. discovered deposits of columbium and uranium at the Nova Meaucage property at North Bay, Ontario.[9] Extensive drilling indicated that the deposits contain approximately 3.6 million tons of mineralization averaging 0.63 percent columbium and 0.032 percent uranium oxide per ton. Further exploratory drilling was planned.

Canada's first ferroalloy plant in the western provinces was opened in the Roberts Bank area at Surrey, British Columbia in October by Fundy Chemical Corp.[10] The new facility has an overall annual capacity of approximately 6.4 million pounds to produce such alloys as ferrocolumbium, ferrotantalum, ferromolybdenum, and ferrotungsten by the thermite process.

Japan.—A new tantalum refining company was formed in Japan.[11] The new company, Showa-KBI, was founded with capital supplied by the Japanese company Showa Denko K. K. and the American company Kawecki Berylco Industries, Inc. The new company was to produce high-quality tantalum powder, wire, sheet, and other tantalum mill products.

Nigeria.—Nigeria continued to rank third (behind Brazil and Canada) in production of columbium raw material. The largest suppliers of columbite concentrates, a coproduct of the tin industry, were Amalgamated Tin Mines of Nigeria, Ltd. (ATMM), Bisichi Tin Co. Ltd., Jantor Ltd., and Tin and Associated Minerals Ltd.

Nigeria's National Development Plan, covering the years 1970–74, was launched by General Gowon, Nigerian Head of State.[12] The aim of the plan was to make Nigeria a united, strong, and self-reliant nation. It was proposed that the country be divided into seven zones and that the mineral resources be investigated in detail in collaboration with selected overseas organizations, under arrangements which will ensure that the results of such investigations remain the property of the appropriate agency of the Federal Government. It was noted that foreign interests will be encouraged by the offering of incentives in the way of concessions or financial reward. The seven zones were outlined as: Area I —North-Western and Kwara States; Area

[5] Mining Magazine. St. Honore Columbium Development. V. 125, No. 6, December 1971, p. 521.
[6] The Northern Miner. Copperfields, SOQUEM Plan Production of Columbium. V. 56, No. 43, Jan. 14, 1971, pp. 1 and 13.
[7] World Minerals and Metals. Chemalloy to Expand Tantalum Mine. No. 3, September–October 1971, p. 22.
[8] Wall Street Journal. Chemalloy Minerals Reports Possible New Tantalite Zone. V. 181, No. 46, Mar. 7, 1972, p. 16.
[9] Metal Bulletin. Nord Venture Mineral Find. No. 5652, Nov. 23, 1971, p. 7.
[10] Metals Week. Canada's New Ferroalloy Production. V. 42, No. 50, Dec. 13, 1971, p. 5.
[11] American Metal Market. Japanese Report Kawecki Berylco Ready to Establish Joint Tantalum Venture. V. 78, No. 247, Dec. 28, 1971, p. 16.
[12] Mining Journal (London). National Plan Launched. V. 275, No. 7057, Nov. 20, 1970, pp. 452–453.

II—Kano and North-Central States; Area III—Benae-Plateau State; Area IV—North-Eastern States; Area V—Western and Lagos States; Area VI—East-Central, Rivers and South-Eastern States; Area VII—Mid-West States. Of these seven zones, Area III accounts for more than 90 percent of Nigeria's production of columbite.

Zaire (formerly Congo Kinshasa).—Congo-Etain, a Congolese company owned 50 percent by the Congolese Government and 50 percent by the Belgian company Compagnie Géologique et Minière des Ingénieurs et Industriels Belges (GÉOMINES), produced approximately 178,000 pounds of columbite-tantalite concentrate in 1970, which was equal to a little more than half of Zaire's 1970 columbite-tantalite production.

Somikubi-Union Carbide (SOMUCAR), owned 53 percent by Union Carbide Corp., holds a 741,300-acre concession on which it plans to begin pyrochlore production. Production was originally to have started in 1970, but was delayed in 1970 and 1971 owing to technical difficulties.

The Congolese company KIVUMINES, owned by the Belgian company SOBAKI (75 percent) and the American group Engelhard Minerals and Chemicals Corp. Philipp Brothers (25 percent), continued to produce mixed cassiterite/columbite-tantalite ore from deposits at Kabili, 262 kilometers from Bukavu.

Table 13.—Columbium and Tantalum: World production of mineral concentrates by country [1]

(Pounds, gross weight)

Country [2]	1969	1970	1971 p
Argentina: Columbite-tantalite	r 3,560	9,899	e 9,900
Australia: Columbite-tantalite	340,631	121,543	107,000
Brazil:			
Columbite-tantalite:			
Columbite concentrate [3]	152,119	90,000	e 90,000
Tantalite concentrate [3]	r 447,538	461,000	e 463,000
Pyrochlore	19,098,623	29,288,000	13,435,000
Canada:			
Pyrochlore e	6,829,000	9,838,000	4,560,000
Tantalite e	245,850	594,300	845,000
Ivory Coast: Columbite-tantalite	465	--	--
Malaysia: Columbite-tantalite	141,120	134,400	53,760
Mozambique:			
Columbite-tantalite	141,120	214,256	e 141,000
Microlite (tantalum concentrate)	181,440	140,161	e 120,000
Nigeria: Columbite-tantalite:			
Columbite concentrate	r 3,339,840	3,562,666	3,039,680
Tantalite concentrate	r 13,440	9,700	9,296
Portugal: Tantalite	13,440	8,818	24,251
Rwanda: Columbite-tantalite	48,502	NA	73
South Africa, Republic of: Tantalite	8,818	6,614	2,205
Thailand: Columbite-tantalite	57,320	125,663	92,594
Uganda: Columbite-tantalite	4,189	6,614	17,416
Zaire (formerly Congo Kinshasa)	r 383,604	321,875	251,324
Total	r 31,450,619	44,933,509	23,261,499

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

[1] Data generally has been presented as reported in sources, divided into columbite concentrates and tantalite concentrates where information is available to do so, and reported as columbite-tantalite where it is not. Data in table excludes columbium and tantalum-bearing tin concentrates and slags.

[2] In addition to the countries listed, Spain, South-West Africa, Southern Rhodesia, and the U.S.S.R. also produce columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[3] Exports.

TECHNOLOGY

Kawecki Berylco Industries developed a four-step process for upgrading low-grade tin slags to a 40- to 50-percent combined tantalum plus columbium oxides concentrate.[13] The tin slags were smelted with coke to produce a carbidic hearth concentrate of 20 to 25 percent $(Ta,Cb)_2O_5$; the concentrate was then exothermically fused with sodium nitrate and finely divided carbon to form a fusion

[13] American Metal Market. Tin Slag Called Good Source For Tantalum, Columbium. V. 78, No. 44, Mar. 5, 1971, pp. 1 and 10.
Gustison, R. A., J. A. Generazzo. Exothermic Fusion of Eastern Tin Slag Carbides to a Tantalum-Columbium Concentrate. J. Metals, v. 23. No. 8, August 1971, pp. 45–48.

mass which was then water-leached and acid-leached to remove silica, titanium, alumina, tungsten, iron and caustic.

A new cladding process was developed by Fansteel Inc., North Chicago, Ill., for lining process equipment with a thin film of tantalum about 10 mils thick which could make tantalum competitive with glass as a lining for processing equipment.[14] The Eco Pump Corp., South Plainfield, N.J., signed an agreement with Fansteel Inc., to use the Fanclad process to produce small, corrosion-resistant, heavy-duty pumps, and Fansteel Inc. was in the process of installing new facilities at its Torrance, Calif., plant for coating large pieces of equipment.

A new alloy steel was developed by St. Lawrence Columbium and Metals Corporation of Montreal, Canada. The alloy was described as a deep-drawing, conventional low-carbon steel with columbium added at a level of 0.06 to 0.25 weight-percent. The new columbium-bearing steel was reported to have better drawability and lower fabricating costs.[15]

Researchers at Hiroshima Technical Institute developed a weldable tantalum-clad steel featuring titanium as an intermediate metal.[16]

A group of organometallic tantalum and columbium materials were discovered and described as being the most efficient superconductors yet developed.[17] If further research confirms their practical application, this new group of organometallic superconductors could prove useful for magnets, electrical devices, and high-energy physics apparatus, and possibly for advanced electric power transmission systems.

The Martin-Marietta Corp. evaluated TP Nickel-Chromium and coated T–222 Tantalum as primary materials for structural elements in hypersonic aerospace vehicles.[18] In a coating investigation for protecting T–222 tantalum above 3000° F, the Sylvania coating (R512C) was found to give better oxidation protection from quartz-lamp radiant heating in air than the other materials tested. T–222 Tantalum bolted joints, TD Nickel-Chromium riveted joints, and honeycomb panels of both materials were used as structural test specimens. Stress distribution was conducted up to 2100° F for TD Nickel-Chromium and 3200° F for T–222 Tantalum. Ultimate strength trends were defined for tension, compression, shear, and biaxial tension in the honeycomb panel specimens.

A feasibility study of clad-core columbium alloy combinations for turbine blades was completed by TRW, Inc.[19] Test results indicated that the cladding concept of using an oxidation-resistant coated cladding alloy to prevent catastrophic oxidation of a high-strength but more oxidized core alloy was feasible.

A research program was concluded at Nuclear Metals Division of the Whittaker Corp. which demonstrated that high-quality tantalum-stainless steel sleeves and tandem joints could be produced by coextrusion techniques.[20]

The continuing interest in methods of extraction and beneficiation of columbium and tantalum ores was reflected by some of the patents issued during the year.[21]

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[14] Chemical and Engineering News. Process Lowers Cost of Tantalum Linings. V. 49, No. 49, Nov. 29, 1971, p. 18.

[15] Mining and Minerals Engineering. Potential for Columbium. V. 7, July 1971, p. 32.

[16] Iron Age. Solve Problems of Welding Tantalum-Clad Steel. V. 208, No. 24, Dec. 9, 1971, p. 27.

[17] Gamble, F. R., J. H. Osiecki, M. Cais, and R. Pisharody. Intercalation Complexes of Lewis Bases and Lavered Sulfides: A Large Class of New Superconductors. Science, v. 174, No. 4008, Oct. 29, 1971, pp. 493–497.

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Copper

By Harold J. Schroeder [1]

World mine production of copper achieved a record high for the fourth consecutive year. Copper developments in progress or in advanced planning stages were in evidence in many countries.

The domestic copper industry experienced curtailed mine, smelter, and refinery outputs as a result of labor strikes lasting variously from 4 to 12 weeks at most operations during July, August, and September of 1971. Consumption of refined copper declined 1 percent from that of 1970. Imports of refined increased while imports of blister and exports of refined were reduced. Price quotations changed three times with a net decrease of 2½ cents to a yearend quote of 50¼ to 50½ cents per pound.

Legislation and Government Programs.—The total copper in the national stockpile on December 31, 1971, was 60,112 tons of oxygen-free, high-conductivity (OFHC) copper, 7,067 tons of copper in beryllium-copper master alloy, and 191,509 tons of copper in "other" classifications, for a total of 258,688 tons, 33 percent of the objective of 775,000 tons.

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Table 1.—Salient copper statistics

	1967	1968	1969	1970	1971
United States:					
Ore produced______thousand short tons__	127,066	170,054	223,752	257,729	242,656
Average yield of copper____percent__	0.63	0.60	0.60	0.59	0.55
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines____________short tons__	954,064	1,204,621	1,544,579	1,719,657	1,522,183
Value_________thousands__	$729,401	$1,008,195	$1,468,400	$1,984,484	$1,583,071
Smelters___________short tons__	841,343	1,234,724	1,547,496	1,605,265	1,470,815
Percent of world total______	15	20	r 24	r 24	22
Refineries__________short tons__	846,551	1,160,925	1,468,889	1,521,183	1,410,523
From foreign ores, matte, etc., as reported by refineries___short tons__	286,431	276,461	273,926	243,911	181,259
Total new refined, domestic and foreign____________short tons__	1,132,982	1,437,386	1,742,815	1,765,094	1,591,782
Secondary copper recovered from old scrap only_______________short tons__	482,659	520,772	574,890	504,071	445,157
Exports:					
Metallic copper_____________do____	221,066	313,741	241,254	273,577	262,838
Refined____________________do____	159,353	240,745	200,269	221,211	187,654
Imports, general:					
Unmanufactured____________do____	649,227	709,975	413,860	392,480	359,479
Refined____________________do____	330,571	400,278	131,171	132,143	163,988
Stocks Dec. 31: Producers:					
Refined____________________do____	27,000	48,000	39,000	130,000	75,000
Blister and materials in solution short tons__	220,000	272,000	291,000	340,000	303,000
Total___________________do____	247,000	320,000	330,000	470,000	378,000
Withdrawals (apparent) from total supply on domestic account:					
Primary copper_________short tons__	1,320,000	1,576,000	1,683,000	1,585,000	1,623,000
Primary and old copper (old scrap only)_______________short tons__	1,803,000	2,097,000	2,258,000	2,089,000	2,068,000
Price: Weighted average, cents per pound_	38.6	42.2	47.9	58.2	52.0
World:					
Production:					
Mine_________________short tons__	5,224,361	5,640,921	6,223,820	6,633,406	6,664,079
Smelter___________________do____	5,582,801	6,050,822	6,413,940	6,730,833	6,736,341
Price: London, average cents per pound___	51.19	56.13	66.24	62.96	48.49

r Revised.

The Office of Minerals Exploration (OME) continued to offer up to 50-percent Government participation in the authorized cost of exploration for copper deposits. There were no contracts executed in 1971 that involved copper.

Set-asides for refined copper and "ammo strip," under the program of copper controlled materials for defense purposes, were eliminated, effective January 1, 1971. However, set-asides for certain brass mill, wire mill, and foundry products were retained.

The excise tax on imported copper was reduced to 1.0 cent per pound, effective January 1, 1971. This reduction was in accord with the Kennedy Round Trade Expansion Act of 1962 designed to progressively reduce the rate to 0.8 cent by 1972. Duties have been suspended by public laws from 1966 to June 30, 1972.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—Domestic mine production was 1.52 million tons, a decrease of 11 percent and the smallest quantity since 1968. In addition to production lost during labor strikes, several mines curtailed operations during the latter part of the year owing to insufficient smelter capacity to process accumulated stocks of copper concentrates. Principal copper-producing States were Arizona with 54 percent of the total, Utah (17 percent), New Mexico (10 percent), Nevada (6 percent), Montana (6 percent), and Michigan (4 percent). These six States accounted for 97 percent of the total production.

Open-pit mines accounted for 82 percent of mine output and underground mines for 18 percent. The production of copper from dump and in-place leaching, largely recovered by precipitation with iron, was 154,500 tons, or 10 percent of mine output. Total copper recovered by leaching methods was 235,300 tons, of which 199,300 tons was precipitated with iron and 36,000 tons was electrowon.

Duval Corp., a subsidiary of Penzoil United Corp., operated the Duval Sierrita mine near Tucson, Ariz., for the first full year at an average daily rate of 70,300 tons of ore. The company temporarily suspended operations in late December at the adjacent Esperanza copper-molybdenum property owing to a shortage of smelting capacity to treat the stockpiled concentrates. Duval also operated a copper-gold-silver property at Battle Mountain, Nev.

Strikes at the Butte, Mont., and Twin Buttes, Ariz., mines plus a major pit slide at the Arizona property of The Anaconda Company resulted in reduced outputs of 88,700 and 50,700 tons of copper, respectively. Production at the Yerington, Nev., mine was approximately unchanged at 42,500 tons. Productive capacity continued to be expanded at the Montana mines with reactivation of the underground Leonard mine in the fourth quarter, a program to double production of precipitates to 42,000 tons in 1972 from leaching low-grade dump material, and improvement in the recovery of copper at the concentrator. The Anaconda Company concentrator was shutdown in the fourth quarter and all ore is now processed at the Butte concentrator.

Kennecott Copper Corp. operated mines in Arizona, Nevada, New Mexico, and Utah; these mines produced a combined total of 456,100 tons of copper, compared with the record high of 518,900 tons produced in 1970. The Utah Copper Division accounted for 261,800 tons of the total. New tailings-retreatment plants were installed in May at the Utah operations, providing an increase of approximately 15 tons of copper production per day. At the Nevada Mines Division, mining was suspended at the Tripp-Veteran pit in October, with operations transferred to the Ruth pit.

The American Smelting and Refining Co. (Asarco) operated three copper mines in the vicinity of Tucson, Ariz. The Mission unit, closed by strike during July and August, produced 40,600 tons of copper in concentrates, compared with 47,700 tons produced in 1970. The Silver Bell unit was unaffected by the strike and increased output 3 percent to 23,100 tons of copper in concentrates and precipitates. Production at the San Xavier mine was limited to copper-bearing siliceous flux ore for use at Asarco's Hayden smelter. Consideration of a fourth domestic copper mining project was advanced during the year with engineering studies for development of the Sacaton deposit near Casa Grande, Ariz.

Mines of the Phelps Dodge Corp., at Morenci, Ajo, and Bisbee, Ariz., and Tyrone, N. Mex., produced 279,800 tons of copper, 11 percent below the record high of the previous year. Output was 113,600 tons from Morenci, 53,000 tons from Ajo, 53,000 tons from Bisbee, and 60,200 tons from Tyrone. Capacity of the Tyrone mine will be increased from 60,000 tons per year to 100,000 tons by the end of 1972 and will offset closure of the Bisbee open-pit operations, anticipated in early 1973. Stripping continued at the Metcalf property near Morenci with initial output planned for late 1974 with capacity of about 50,000 tons of copper annually. Continuation of the Metcalf development is contingent upon a determination of the availability of smelter capacity to treat the concentrates.

Cities Service Co., through its North American Chemicals and Metals Group, operated copper mines in Arizona and Tennessee that produced 44,000 tons of copper, compared with 46,100 tons in 1970. Plans were in progress for mining the Pinto Valley large, low-grade copper deposit in the Miami, Ariz. area at a production rate of approximately 40,000 tons of mill feed per day. Also, an old shaft was being deepened at the Miami East prospect in preparation for more exploration at that property.

The White Pine Michigan operations of White Pine Copper Co., produced 56,000 tons of copper in concentrates, a decrease of 17 percent that reflected an 8-week strike. Excluding the strike period, the mine produced an average of 22,645 tons of 1.0 per cent copper ore per day compared with 21,387 tons of 1.08 percent copper in 1970. Research on longwall mining methods continued with encouraging results and a full-scale production test is planned for 1972.

The San Manuel and Superior Divisions of Magma Copper Co. had operations adversely affected by a 15-day strike and production was 101,100 tons of copper in concentrates, compared with 112,300 tons produced in 1970. The mine expansion program at San Manuel was completed late in the year, increasing capacity to about 65,000 tons of ore per day. The expansion at Superior to 3,300 tons per day encountered delays in shaft sinking and is now scheduled for completion in 1974.

The Inspiration Consolidated Copper Co. operated the Thornton, Live Oak, Red Hill, and Black Copper mines in the vicinity of Inspiration, Ariz.; 11.8 million tons of waste and 6.9 million tons of ore were mined. The ore processed in the plant yielded 36,633 tons of copper. An additional 9,622 tons was recovered from leaching dumps and mined-out areas and by heap leaching. At the Ox Hide mine 2.6 million tons of oxide ore was mined and 4,874 tons of copper recovered by leaching. At the Christmas open pit mine, southeast of Miami, Ariz., 6.2 million tons of waste and 1.5 million tons of ore was mined; 7,710 tons of copper was recovered. Total production of copper by the company was 56,088 tons, 15 percent less than in 1970.

Pima Mining Co. produced 64,500 tons of copper in concentrates from its copper-molybdenum mine south of Tucson, Ariz. Construction to increase milling capacity from 40,000 to 54,000 tons per day or approximately 80,000 tons of copper in concentrates per year was anticipated to be operational in February 1972.

Bagdad Copper Corp. produced 12,500 tons of copper in concentrates and 7,300 tons as cathode copper by a leach-electrowinning process from its Arizona copper mine. Grade of ore mined in 1971 averaged 0.81 percent copper. The company has a planned expansion program to increase the mining rate fivefold to 30,000 tons of ore per day. Reserves for the expanded operation are estimated to be 215 million tons averaging 0.51 percent copper and 50 million tons averaging 0.4 percent copper. Availability of smelter capacity to treat the anticipated fourfold increase in copper concentrate production is an important consideration. One of Bagdad's listed alternatives is to build a relatively small smelter experimentally developed in Australia to treat their own production.

The Bruce Mine Division of Cyprus Mines Corp. operated its copper-zinc mine near Bagdad, Ariz. at near capacity during 1971. New flotation equipment and a larger regrind mill were added to the copper circuit and output was about 2,500 tons of copper in concentrates. Ore grade averaged 3.75 percent copper and 12.4 percent zinc.

Ranchers Exploration and Development Co. moved about 3.0 million tons of overburden and 2.9 million tons of ore at their Arizona Bluebird property. The ore was placed on dumps for processing by a leaching-solvent extraction-electrowinning method of recovery. Production of refined copper cathodes by this method increased 12 percent to a record high 5,900 tons. Exploratory drilling increased reserves nearly sixfold to 75 million tons, grading 0.52 percent copper with good potential for an additional quantity. Ranchers completed shipments of direct-smelting, high-grade sulfide ore mined in 1970 from their Big Mike copper property near Winnemucca, Nev. About 300,000 tons of a mixed oxide-sulfide ore containing about 2 percent copper are stockpiled and available for processing by a planned leaching-precipitation operation. The company was investigating the feasibility of an in situ leaching operation at the Old Reliable deposit near San Manuel, Ariz., with reserves of approximately 4 million tons of 0.74 percent copper. It is estimated that about 15,000 tons of copper could be recovered by this method over a 5-year period.

Hecla Mining Co. completed 6,000 feet of a planned 15-degree decline of 7,500 feet to develop their Arizona Lakeshore copper mine. Crosscuts and development headings were being driven into both the sulfide and oxide ore zones. A pilot roasting-leaching-electrowinning plant for treating sulfide concentrates was placed in operation with good results. Another pilot plant to test an oxide ore leaching process which would consume sulfuric acid produced from roaster off gases was nearly completed.

U.S. Smelting, Refining and Mining Co. was constructing at their Grant County, N. Mex., copper deposit a 4,500-ton-per-day ore mill scheduled for completion in late 1972, to add to the 3,000-ton-rated-capacity mill completed in 1967. Exploration has delineated 15 million tons of ore grading 1.06 percent copper amenable to open-pit mining, and 14 million tons of ore grading 2.19 percent copper for underground mining. Potential is considered good for exploration to disclose additional reserves.

Smelter Production.—Output of copper at primary smelters in the United States was 1.57 million tons, a quantity 9 percent below the record high of 1970 and the smallest quantity since 1968. The reduced output reflected the labor strikes and curtailment of operations at some smelters to maintain required air quality standards during periods of adverse meteorological conditions.

Asarco estimates capital expenditures greater than $50 million and increased operating costs in excess of anticipated revenues from the sale of sulfur byproducts will be required at the company's three smelters for an environmental improvement program to meet anticipated smelter sulfur emission standards. To help finance this program Asarco obtained the agreement of the mines supplying copper-bearing materials to its smelters for a special surcharge of 1 to 1½ cents per pound of copper paid for. These surcharges are reserved for construction of facilities to recover sulfur normally discharged to the atmosphere during the conventional smelting process.

Anaconda's smelter renovation program, established to improve operations and environmental conditions, continued towards the scheduled early-1973 completion date. Kennecott completed construction of a fourth converter in September at the Hurley, N. Mex., smelter and was installing a fourth converter for operation in 1972 at the McGill, Nev., smelter. Construction completed or in progress by Phelps Dodge included new converter flues, improved electrostatic precipitators, and a sulfur absorption plant at the Ajo, Ariz., smelter; a new electrostatic precipitator at the Douglas, Ariz., smelter; and a new reverberatory furnace with improved emission controls at the Morenci, Ariz., smelter.

Magma Copper Co. permanently closed their Superior, Ariz., smelter in July in accord with a scheduled plan to process all concentrates at their enlarged San Manuel, Ariz., smelter. A modified environmental control plan in two stages was announced for the San Manuel smelter. The first phase will be the start of construction in 1972 for a sulfuric acid plant to treat converter gas. The second phase will consist of using, to the extent required, a limestone scrubbing process still under development, to treat reverberatory furnace gases.

Inspiration Consolidated Copper Co. had under way an estimated $45 million construction program to replace much of the existing smelter at Miami, Ariz. The program, slated for a 1973 completion, will replace the existing reverberatory furnace with an electric furnace, the present converters with new siphon-type converters, and provide new sulfuric acid production facilities.

Refinery Production.—Production of refined copper from all materials processed at primary refineries was 1.93 million tons, a decrease of 13 percent from the record high of the previous year. Refined copper produced at secondary plants was 58,150 tons, compared to 60,600 tons in 1970. The total production of refined copper produced from scrap in the United States was 400,700 tons, equal to 20 percent of total refined copper production.

Magma Copper Co. completed construction and placed in operation a refinery at San Manuel, Ariz. in December with a rated annual capacity of 200,000 tons of copper. Phelps Dodge permanently closed the part of the electrolytic tankhouse used to treat scrap at the Laurel Hill, N. Y. refinery, reducing total annual capacity to 72,000 tons of copper. Those facilities were built prior to 1900 and had become uneconomical to operate.

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.
Eastern Rare Metals, Inc	Baltimore, Md.
Phelps Dodge Refining Corp	Laurel Hill, N.Y., El Paso, Tex.
The Sherwin-Williams Co	Cleveland, Ohio
Van Waters & Rogers Inc., English & Bagby Co., Div	Wallace, Idaho, Midvale, Utah, Metaline Falls, Wash.

Copper sulfate production decreased for the third successive year to 34,650 tons (8,660 tons contained copper), the smallest quantity since 1935. Shipments exceeded production by 2,200 tons and ending stocks were 5,900 tons. Of the total 36,850 tons shipped, producers' reports indicated that 15,560 tons was for agricultural uses, 19,510 tons was for industrial uses, and 1,780 tons was for other uses.

Byproduct Sulfuric Acid.—Sulfuric acid was produced by six copper smelters from the sulfur contained in off gases, and output increased for the fourth consecutive year to a record 803,300 tons, on a 100-percent acid basis. Facilities for production of sulfuric acid were placed in operation late in the year at the Hayden, Ariz., smelter of Asarco. New sulfuric acid plants were under construction or in an advanced planning stage at the copper smelters at Anaconda, Mont.; El Paso, Tex.; Hurley, N. Mex.; Miami, Ariz.; McGill, Nev.; and San Manuel, Ariz.

SECONDARY COPPER AND BRASS

Domestic recovery of copper in all forms from all classes of purchased scrap totaled 1.20 million tons in 1971, a 4–percent decline from the 1970 total and the smallest quantity since 1967. Recovery from copper-base scrap decreased 4 percent to 1.18 million tons. Primary copper producers reported a decrease to 342,500 tons; however, production by secondary smelters and brass mills increased to 281,600 and 504,000 tons, respectively.

Consumption of purchased copper-base scrap in 1971 was 1.7 million tons consisting of 60 percent new scrap and 40 percent old scrap. Of the principal products obtained from scrap there were increases for brass and bronze ingots, brass mill products, and copper powder, but their gains were more than offset by decreases for refined copper, and brass and bronze castings.

CONSUMPTION

Demand for refined copper was sluggish at the start of the year, accelerated to a relatively high level during the second quarter, slumped during the labor strikes in the third quarter, and increased modestly in the last quarter. Total consumption for the year was 2.02 million tons, 1 percent below that of 1970. The decrease in consumption was shared by all principal consumer categories, such as wire mills, brass mills, and foundries.

Apparent withdrawals of primary refined copper on domestic account increased 2 percent to 1.62 million tons.

STOCKS

Stocks of refined copper at primary producers increased from 130,000 to 136,000 tons during January, declined to 31,000 tons by the end of June, then trended up to 75,000 tons by yearend. Fabricators' stocks of copper in all forms increased from 515,000 tons at the start of the year to 584,000 tons at midyear, declined to 487,000 tons by the end of October, then moved up to 511,000 tons by yearend.

PRICES

Domestic producer price quotations for wirebar copper were changed three times during the year—down 3 cents in mid-January, up 2¾ cents in late March, and down 2¼ cents in late November—for a yearend quotation of 50¼ to 50½ cents per pound compared with 53 cents at the start of the year. Average weighted prices of domestic copper deliveries in 1971 was 52.0 cents compared with 58.2 cents for those of 1970. Prices on the London Metal Exchange (LME) increased from an average of 45.2 cents per pound equivalent for January to 56.3 cents for April, then declined erratically to 46.3 cents for December. The 1971 average was 48.5 cents, compared with 63.0 for 1970.

FOREIGN TRADE

U.S. exports of copper including manufactures decreased 20 percent to 260,300 tons. The largest category, refined copper, was 187,700 tons compared with 221,200 tons the preceding year. Exports of ore, concentrates, and matte decreased from the relatively high level of 61,500 tons in 1970 to 8,100 tons. A significant increase in the exports of blister and a small advance for scrap partially offset the decreases in the other categories.

U.S. imports of unmanufactured copper decreased 8 percent to 359,500 tons. Most of the loss was in the category of blister copper, which declined 30 percent to 156,700 tons, more than offsetting the gain for refined copper, which increased from 132,100 to 164,000 tons. Imports received from Chile were 51,700 tons compared with 114,900 tons in 1970; from Peru the quantity declined 7 percent to 102,400 tons; and imports from Canada advanced 40 percent to 135,400 tons.

WORLD REVIEW

World mine production of copper attained 6.7 million tons, a record high for the fourth consecutive year. Most major producing countries contributed to the increase, with the exceptions of the United States, where production was disrupted by labor strikes, and Zambia, where production has dropped as a result of a serious cave-in at the Mufulira mine in September 1970. Expansion programs and developments in many countries indicate a continuation in the rise of copper output.

The United States continued to lead the world in mine production with 23 percent of the total, followed by Chile, Canada and Zambia, with 12, 11, and 11 percent, respectively.

Argentina.—Cities Service Co. reached an agreement in principle with the Argentine State mining agency for a contract to develop potentially large desposits of copper in the Catamarca Province. Exploratory core drilling and tunneling to evaluate the deposits were in progress.

Australia.—Mine production of copper in Australia was 195,000 tons, an increase of 12 percent. Mount Isa Mines Ltd., (ISA) 53-percent owned by Asarco, increased output 22 percent to a record high 113,400 tons of copper contained in products for the fiscal year ended June 30, 1971. Mount Isa has embarked on an expansion program to increase its productive capacity to 170,000 tons per year and the affiliated company, Copper Refineries Pty., Ltd., increased its copper refinery capacity to handle the increased supply of blister copper from ISA.

Mount Lyell Mining and Railway Co., Ltd., produced a record high 22,400 tons of copper in concentrates from 2.6 million tons of ore mined and milled. Most of the production was from open pit operations, however by mid-1972 the output will be mainly from underground mining. Reserves from all ore zones are 42 million tons of 1.42 percent copper for proven ore and 4 million tons of 1.56 percent copper for probable ore.

Bougainville Copper Pty., Ltd., anticipated initial production in 1972 from their Panguna copper ore deposit on Bougainville Island in the Territory of Papua and New Guinea. The operating company is two-thirds owned by Con Zinc Rio Tinto of Australia Ltd., and one-third owned by

New Broken Hill Consolidated Ltd. This large $475 million copper development, consisting of an open-pit mine, a 90,000-ton-per-day concentrator, two towns, port facilities, a powerstation, and other ancillary facilities, will be operational just 8 years since the start of exploration. Annual rated productive capacity is 162,500 tons of copper in concentrates to be shipped to smelters in Japan, West Germany, and Spain. The project was based on a porphyry copper deposit calculated to contain approximately 1 billion tons of ore grading 0.48 percent copper and 0.02 ounce of gold per ton.

Botswana.—Bamangwato Concessions, Ltd. (BCL) and the Botswana Government, after more than 3 years of complex negotiation completed arrangements for financing the Selebi-Pikwe nickel-copper mining project and its related infrastructure. The capital cost of the mining project is estimated at $143 million and the cost of the related infrastructure at $71 million. The Botswana Government has obtained loans for the infrastructure from the World Bank and from agencies of Canada, the United Kingdom, and the United States. Financing for the mining project will be largely from a consortium of West German private banks, the Industrial Development Corporation of South Africa, and the owners of BCL. Ownership of BCL is 15 percent by the Government of Botswana and 85 percent by Botswana Roan Selection Trust Ltd., (BRST). BRST is in turn to be owned 30 percent by American Metal Climax (AMAX), 30 percent by Anglo American Corp. of South Africa Ltd. and Charter Consolidated Ltd., and 40 percent by popular subscription.

Production is expected to start by early 1974 at an initial annual rate of 17,000 tons of refined copper, 19,000 tons of refined nickel, and 140,000 tons of sulfur. By agreement, the nickel-copper matte produced at the Pikwe smelter will be refined at AMAX's rehabilitated nickel refinery at Braithwaite, Louisiana. A West German metals firm, Metallgesellschaft A.G. will purchase most of the copper production and more than half of the nickel production. Proven and probable reserves for the Selebi-Pikwe deposits are estimated to total 45.7 million tons, grading 1.20 percent nickel and 1.26 percent copper.

Canada.—Production of copper in Canada increased 7 percent to 719,900 tons to achieve a record high for the second successive year. Ontario produced 42 percent of the total, followed by Quebec, with 26 percent; British Columbia, with 19 percent; Manitoba, with 8 percent; and the remaining Provinces, 5 percent.

Falconbridge Nickel Mines Ltd. operated nickel-copper mines in the Sudbury, Ontario, area and delivered 4.7 million tons of ore to treatment plants. Production of concentrates at the Manibridge, Manitoba, property began in July and rated capacity of 1,000 tons per day of ore is expected to be reached by mid-1972. Metal deliveries were 30,500 tons of copper compared to 28,500 tons in 1970. Ore reserves at yearend were 100 million tons averaging 1.23 percent nickel and 0.65 percent copper.

Ecstall Mining Ltd., a subsidiary of Texas Gulf Sulphur Co., mined 3.7 million tons of ore from the copper-lead-zinc-silver Kidd Creek mine near Timmins, Ontario, which yielded 45,500 tons of copper in concentrates. Development continued toward production from underground mining to supplement open-pit operations by late 1972.

The International Nickel Co. of Canada Ltd., mined 28 million tons of nickel-copper ore from 18 mines in Ontario and Manitoba. Copper deliveries from the Copper Cliff refinery were 170,000 tons compared with the record high 174,000 tons in 1970. At yearend there were 387 million tons of proven ore reserves containing 4 million tons of copper.

Noranda Mines Limited operated the Horne mine in Quebec, producing 729,000 tons of ore averaging 2.21 percent copper and 0.167 ounce of gold per ton. The operation also produced 435,000 tons of fluxing ore. Sulfide ore reserves at yearend were 1.3 million tons and are expected to be exhausted late in 1973.

Gaspé Copper Mines operated the Needle Mountain and Copper Mountain mines and associated mills and smelter near Murdochville, Quebec. The Needle Mountain mine produced 23,250 tons of copper in concentrates from milling 2.4 million tons of ore averaging 1.04 percent copper. The Copper Mountain mine produced 9,650 tons of copper from milling 1.6 million tons of 0.71 percent copper. A $108 million mine-mill-smelter expansion project was initiated in June with a mid-1973 scheduled completion. The new facilities will triple the mining-concentrating capacity to 34,000 tons per day of sulfide ore which will more than double the present output of copper in concentrate. In addition, leaching facilities for treatment of 5,000 tons per day of low-grade oxide ores will be built. The smelter expansion will add 27,000 tons per year of blister copper capacity and a sulfuric acid plant with a rated annual output of 300,000 tons, about half to be used in the copper-leaching operation.

Hudson Bay Mining & Smelting Co., Ltd. milled 1.1 million tons of ore yielding 27,000 tons of refined copper compared with 42,200 tons of copper in 1970. The reduced output resulted from a strike that closed operations for 5 months. The company operated eight mines along the Manitoba-Saskatchewan boundary and in addition, the White Lake and the Ghost Lake copper-zinc-silver mines were being developed for planned production in 1972. Total ore reserves at yearend were 18 million tons with an average grade of 2.9 percent copper, 3.3 percent zinc, and 0.6 ounce of silver per ton.

Sheritt-Gordon Mines Ltd. continued operation of the Lynn Lake mine in Manitoba and operated the nearby Fox mine for the first full year. Combined output for the year nearly doubled, to 28,458 tons of copper contained in concentrates. Reserves at the Lynn Lake property were estimated at 10.0 million tons of 0.83 percent nickel and 0.39 percent copper and at the Fox property were 14.5 million tons averaging 1.99 percent copper and 2.35 percent zinc. Development of the Ruttan Lake property was in progress with production at an annual rate of 3.5 million tons of ore scheduled for mid-1973. Reserves were 51 million tons grading 1.47 percent copper and 1.61 percent zinc.

During the first full year of operation the Granduc mine north of Stewart, British Columbia, produced 18,800 tons of copper in concentrates from 1.5 million tons of 1.31 percent copper ore. Equipment failures and a high rate of labor turnover adversely affected attainment of the planned production rate of 7,000 tons of ore per day. Also the initial sublevel caving of the ore resulted in excessive dilution with a reduced mill grade. Ore reserves at yearend were 40 million tons averaging 1.68 percent copper.

Similkameen Mining Co. Ltd., a subsidiary of Newmont Mining Corp., continued construction of a mining venture near Princeton, British Columbia. Facilities estimated to cost $73 million will permit open-pit mining and milling two deposits at a daily rate of 15,000 tons, with initial production scheduled for the second quarter of 1972. Ore reserves at the two properties are estimated at 76 million tons averaging 0.53 percent copper.

Anaconda Britannia Mines Ltd. produced 8,300 tons of copper in concentrates at their mine in British Columbia, compared with 2,700 tons in 1970. The increased output was related to new development work completed in 1970 which increased the rated annual productive capacity to 10,000 tons of copper. The Caribou Division of Anaconda brought a lead-zinc-copper deposit near Bathhurst, New Brunswick, into operation and produced 2,000 tons of copper in concentrates. However, owing to inability to attain the desired copper concentrate grade, the property was placed on a standby basis in November pending results of additional feasibility studies.

Brenda Mines Ltd. in their first full year of operation delivered 9 million tons of ore to the concentrator averaging 0.21 percent copper and 0.06 percent molybdenum. Metal recoveries in concentrates were 90 percent for copper and 86 percent for molybdenum. An additional 3.3 million tons of low grade ore was stockpiled for future treatment and 5.5 million tons of waste was stripped from the deposit.

Bethlehem Copper Co. Ltd., for 10 months ending December 31, mined approximately 5 million tons of 0.52 percent copper ore from their Highland Valley, British Columbia, operation, and produced concentrates containing 21,700 tons of copper. The company announced discovery of the J-A orebody two miles south of the operating mine, containing at least 300 million tons of copper-molybdenum ore with an average grade of about 0.45 percent copper equivalent. Reserves for the presently operated property are 45 million tons of 0.56 percent copper, for the Lake zone project 190 million tons of 0.48 percent copper, and for the Maggie ore zone at least 200 million tons of 0.40 percent copper equivalent.

Development and construction work was in progress at Lornex Mining Corporation Ltd.'s large, low-grade copper-molybdenum property in the Highland Valley of British Columbia. This mine is expected to be brought into production in the second quarter of 1972 with a rated capacity of 38,000 tons of ore per day.

Gibralter Mines Ltd. continued development and construction of facilities for an initial 1972 output at their copper-molybdenum deposit in the Cariboo District of British Columbia. Rated capacity of the concentrator is 30,000 tons per day and feed in the early years will come from an ore zone grading 0.44 percent copper, at a waste-to-ore ratio of approximately 1.45 to 1. Total ore reserves are 358 million tons with an average grade of 0.37 percent copper and 0.016 percent molybdenite, requiring a stripping ratio of 2.15 to 1.

Craigmont Mines Ltd., in the fiscal year ended October 31, 1971, produced 19,700 tons of copper in concentrates from 1.83 million tons of ore containing 1.15 percent copper from their mine near Merritt, British Columbia. Ore reserves are 14 million tons grading 1.87 percent copper.

Coast Copper Co., Ltd. operated the Benson Lake mine on Northern Vancouver Island and produced 23,000 tons of copper concentrates from milling 296,000 tons of ore averaging 1.97 percent copper. Ore reserves at the mine at yearend were 830,000 tons of 1.6 percent copper.

Chile.—A constitutional amendment providing for complete nationalization of large copper mines became law July 16, 1971. In accord with the new law, the Chuquicamata, El Salvador, Exótica, Andina, El Teniente, and Rio Blanco mines, substantially owned by United States companies, were completely nationalized. Determination of compensation by the Comptroller General included consideration of "excess profits" from the respective operations and resulted in minus amounts for Chuquicamata, El Salvador, El Teniente; $10.0 million for Exótica; and $18.3 million for Andina. The determinations of compensation as applied to The Anaconda Company and Kennecott Copper Corp. are being appealed by these companies to a special court established for that purpose.

Copper production was 791,000 tons, up 1 percent from that of 1970. Production from the large mines for 1971 was as follows: Chuquicamata, 274,000 tons compared to 292,000 in 1970; El Teniente, 155,000 tons compared to 192,000; El Salvador, 92,000 compared to 103,000; Exótica, 39,000 tons compared with 4,000 tons in the startup year of 1970; and Andina, 58,200 tons in the first year of production. Production decreases at the large mines were attributed to personnel problems related to nationalization of the mines, water shortages, and adverse weather conditions.

The Rio Blanco mine and concentrator of Compañía Mineral Andina, S.A., reached design production of 302,000 tons of ore in July with a recovery of 19,800 tons of concentrate containing 30 percent copper.

The Exótica vat leaching plant commenced operation in late 1970 and reached a rate of 16,000 tons per day in 1971. The design capacity of the completed mine and plant is 26,000 tons per day.

The 100,000-ton-per-year expansion in production capacity at El Teniente was substantially completed by July 1971, when nationalization occurred. However, a very serious drought and resignations of supervisory employees prevented the new installations from increasing overall production at El Teniente.

Cyprus.—The Cyprus Island Division of Cyprus Mines Corp. operated open-pit mines at Lefka and Skouriotissa and a pressure-leach plant for reprocessing mill tailings. Output of copper contained in concentrates and precipitates totaled about 13,000 tons. A decision has been made to proceed with the mining of lower grade (0.9 percent copper) ore reserves in the Skouriotissa area to extend the life of the mining operations about 5 years.

Finland.—Copper output declined 8 percent to 31,400 tons. Principal producing mines were the Outokumpu with 15,900 tons, the Pyhasalmi with 5,300 tons, and the Vihanti with 2,500 tons.

Indonesia.—Freeport Indonesia Inc., a subsidiary of Freeport Minerals Co., continued development of the 11,500-foot-altitude Ertsberg copper deposit in West Irian. Production is anticipated early in 1973 at an annual rate of 2.5 million tons of ore yielding about 65,000 tons of copper in concentrates plus recoverable quantities of gold and silver. Reserves are 33 million tons of ore averaging 2.5 percent copper, 0.025 ounce of gold, and 0.265 ounce of silver per ton.

Iran.—The Iranian Government announced their intention to form a Government-owned company to exploit the Sar

Cheshmeh copper deposit in the Kerman copper belt. The project, estimated to cost between $350 and $400 million, would produce, refine, and fabricate approximately 145,000 tons of copper per year about 4 years after the start of construction. Reserves upon which the project is based are 400 million tons averaging 1.12 percent copper.

Israel.—Timna Copper Mines Ltd., at its property in Aravah Valley, 18 miles north of Eilat, continued operation of one open-pit and one underground mine. A second underground mine to supplement and ultimately replace the open-pit operation was under development for production in 1973. Mining has been at the rate of 4,000 tons of ore per day which yield 35 to 40 tons of 75 to 80 percent copper cement for export.

Malaysia.—The Mamut Mines Development Co., a consortium of Japanese firms in a joint venture with the Sabah Government and other Malaysian interests, was developing a copper deposit near Mamut, Sabah. Production is scheduled for early 1974 at the rate of 18,000 tons of ore per day. Reserves are given as 80 million tons averaging 0.6 percent copper.

Mauritania.—Société Minière de Mauritanie (SOMINA), 44.6 percent owned by Charter Consolidated Ltd., had an initial output during 1971 of 5,200 tons of copper in concentrates at their mine at Akjoujt. Startup equipment failures delayed attainment of the rated capacity of 30,000 tons of copper per year. The deposit, mineable by open-pit methods, is an oxide ore concentrated in a plant using the Torco segregation process developed by the Anglo American Corp. of South Africa group.

Mexico.—Asarco Mexicana, S.A., produced 25,400 tons of blister copper compared with 27,100 tons in 1970. The company completed construction of the mine, mill, townsite, and supporting facilities at the Inguarán mine in the State of Michoacán, and initial production began in the first quarter of 1971. Some 2,200 tons of copper ore per day were processed. Mexicana de Cobre, S.A., 49 percent owned by Asarco Mexicana, continued engineering studies on designing the optimum plan for developing a porphyry copper deposit at the La Caridad property near Nacozari in the State of Sonora.

Compañía Minera Nacozari, S.A., an affiliate of Anaconda, was "Mexicanized," effective November 15 when Anaconda sold a 51-percent interest in its copper-producing operations at Cananea to Mexican investors. Simultaneously an expansion program was announced that will double production from Cananea in the next 5 years. Output in 1971 increased 6 percent to a record high of 40,000 tons of copper.

Morocco.—Copper production increased 9.6 percent to 3,470 tons and a planned expansion program is expected to double output within a few years. Private Moroccan and Belgian interests initiated production in mid-1971 from the Tanssrift mine, designed for a copper output capacity of 3,000 tons per year. A joint Romanian-Moroccan venture was constructing facilities to mine the Talaat N'Ouamane and Ouansimi deposits in southern Morocco at a rated 4,000 tons of annual copper output with initial output scheduled during 1972. Reserves are 3 million tons of 2-percent copper ore. Feasibility studies are in progress to exploit the Oumjerane deposit containing 2.6 million tons of 2.7 percent copper, and the Bleida deposit with estimated reserves of several million tons of ore grading about 2.5 percent copper.

Nicaragua.—At the Rosita mine of La Luz Mines Limited, 862,000 tons of ore were milled to produce 20,350 tons of concentrates containing 4,037 tons of copper. The average grade of ore was 0.63 percent copper, compared to 1.04 percent copper in 1970. In consideration of the declining grade of ore, the increased waste-stripping required, and foreseeable copper prices, a decision was made to curtail mining operations in November to a salvage basis.

Peru.—Copper production was 235,000 tons compared with 243,000 tons in 1970.

Operation of the principal copper producer, the Toquepala mine of Southern Peru Copper Corp., was adversely affected by strikes and output of 141,000 tons of copper was a 5-percent decline from the record high of the previous year. Cerro Corp. operations were also affected by strikes and production decreased 7 percent to 49,100 tons of copper at its La Oroya smelter, with 30 percent of the output from purchased ores.

Minero Peru, a Peruvian Government entity, announced agreement with a United Kingdom consortium headed by British Smelter Constructions Ltd. for financing, engineering, and constructing facilities for first-stage development of the former Anaconda concession, Cerro Verde. Financing for the first stage is estimated to be $65 million, with the majority from British and the minority from Canadian sources. Plans are for Cerro Verde to be producing at an annual rate of 30,000 tons of copper after 1974. Reserves are listed as 165 million tons grading 1.1 percent copper. Minero Peru was also investigating the feasibility of other copper projects, such as development of the large copper deposit of Michiquillay and a copper refinery at Ilo.

Development of the Cuajone mine by Southern Peru Copper Corp. continued during 1971 with expenditures of approximately $18 million, bringing the total investment at yearend to $46 million. Principal work accomplished during the year was the driving of 13,250 feet of railroad tunnel, removal of 17 million tons of overburden, installation of a powerline, and preparation of a future townsite. The Government of Peru approved a 15-month work program to begin in October involving the expenditure of $48 million to bring the property into production.

Philippines.—Thirteen mining companies produced 229,600 tons of copper in concentrates, precipitates, and direct-shipping-grade ore, an increase of 30 percent over that produced the previous year. Part of the increase reflects the inauguration in July of expanded production facilities by Atlas Consolidated Mining and Development Corp., the largest copper producer in the Philippines. The new milling capacity of 65,000 tons per day is nearly double the previous capacity. Ore processed averages about 0.5 percent copper, and 1971 output was 77,700 tons of copper. The second largest producer, Marcopper Mining Corp., produced 48,300 tons of copper from processing 6.7 million tons of ore containing 0.79 percent copper. Mineable ore reserves are 101 million tons of 0.64 percent of sulfide copper and 6 million tons of 0.53 percent oxide copper. Other major producing companies were Lepanto Consolidated Mining Co., Marinduque Mining and Industrial Corp., and Philex Mining Corp., with outputs of 32,500 tons, 30,600 tons, and 21,200 tons, respectively.

Poland.—A large expansion program in progress will increase productive capacity from mining through refining to around 110,000 tons of copper per year. The first stage of smelter construction at Glogow was completed with a rated annual capacity of 44,000 tons of copper. This capacity will be doubled upon completion of the second stage of construction in 1972. The smelter is to serve the mines in the Lubin-Polkowice area, where two mines have been brought into production since 1968 and a third mine is under development. The existing Legnica electrolytic refinery is being expanded to a 70,000-ton-per-year capacity, and a new one is being built at Zukowice with a planned capacity of 50,000 tons.

Rhodesia, Southern.—M.T.D. Mangula Ltd. produced 18,900 tons of copper in concentrates and precipitates from mine operations about 80 miles northwest of Salisbury. Concentrates containing 14,000 tons of copper were produced from milling 1.4 million tons of sulfide ore and precipitates containing 4,900 tons of copper were produced from treating 730,000 tons of an oxidized ore in the leach plant. Proved sulfide ore reserves are 17 million tons averaging 1.31 percent copper. Oxidized ore reserves amount to 1.4 million tons of 0.73 percent oxide copper, only sufficient to keep the leach plant in operation until early 1974. Prior to exhaustion of the leach ore, two new mines, Norah and Silverside, will be in production to offset the closing of the leach plant.

South Africa, Republic of.—O'okiep Copper Co. Ltd. milled 3.3 million tons of ore with an average grade of 1.25 percent copper from eight producing mines that yielded 38,000 tons of blister copper. Reserves declined to 27.6 million tons of ore averaging 1.55 percent copper.

Palabora Mining Co. Ltd. increased output 7 percent to 98,400 tons of copper. Ore milled was 21.0 million tons compared with 20.9 million tons in 1970.

Messina (Transvaal) Development Co., produced 12,000 tons of copper from the Messina mine. Proven ore reserves increased to 5.9 million tons averaging 1.38 percent copper.

Africa Triangle Mining Prospecting and Development Co., a holding company formed by Anglo-Vaal, Middle Witwatersrand, and United States Steel Corp, continued development of a copper-zinc ore deposit near Prieska in northwestern Cape Province. Proven reserves are estimated to be 25 million tons grading between 1.5 to

2.0 percent copper and about 3 percent zinc. It is anticipated that production will begin in early 1973 at a rate of 110,000 tons of ore per month, and increase to the planned rate of 250,000 tons per month during the second half of 1974.

South-West Africa, Territory of.—The Tsumeb Corp. Ltd. milled 566,000 tons of ore averaging 2.44 percent copper, 12.22 percent lead, and 3.91 percent zinc from their Tsumeb mine. Resulting copper concentrates and 10,000 tons of direct shipping ore were sent to the copper smelter. At the Kombat mine 423,000 tons of ore averaging 1.76 percent copper and 1.90 percent lead was mined and milled. The Matchless mine near Windhoeck, 225 miles south of Tsumeb, produced 100,000 tons of 0.99 percent copper ore in 1971, but was closed in January 1972 owing to unprofitable operations. Blister copper produced at the smelter was 27,400 tons compared with 33,100 tons in 1970.

Oamites Mining Co., Ltd., completed development of the Oamites mine, situated 35 miles south of Windhoeck and initiated production in mid-1971. Output for the year was 450 tons of copper in concentrate from milling 46,000 tons of 1.1 percent copper ore. After startup problems are corrected, mining will be at the rate of 50,000 tons of ore per month. Ore reserves are estimated to be 4.7 million tons of 1.45 percent copper.

Uganda.—The Government and Public Bodies Participation Act of 1970 was interpreted in September 1971 by the Government of Uganda to delete certain operations from application of the act. In accordance with this interpretation, ownership of the Kilembe Mines, Ltd. by Falconbridge Nickel Mines Ltd. (Canada) reverted from 31 percent back to its original 70-percent interest. Kilembe Mines processed 1.0 million tons of ore to produce 17,300 tons of blister copper in 1971. Ore reserves at yearend were estimated to be 5.7 million tons of 1.9 percent copper in the proven and probable category plus 1.3 million tons of 1.85 percent copper in the possible category.

Zaïre (formerly Congo Kinshasa).—La Générale des Carrières des Mines du Zaïre (Gecamines), the Government-owned mining company, accounted for the total copper production of 449,000 tons, an increase of 6 percent over that of 1970. The greater output represents a step towards an expansion program designed to increase Gecamines annual copper producing capacity to 500,000 tons in 1974.

The joint Japanese-Congolese concern, Société de Developpement Industriel et Miniere du Zaïre (SODIMIZA) continued development of the Mushoshi copper deposit in Katanga Province, scheduled to begin production in late 1972 at an annual rate of 58,000 tons of copper. An exploration decline was being driven to gain additional information on the Kinsenda deposit about 20 miles from Mushoshi.

A consortium of companies which includes Amoco Minerals Co., (subsidiary of Standard Oil Co. of Indiana), Charter Consolidated Ltd., and Leon Tempelsman & Son Inc., continued exploration work in their concession area of Katanga Province.

Zambia.—Copper production in 1971 was the lowest since 1966, reflecting operation of the Mufulira mine at only partially restored capacity following the disastrous September 1970 cave-in.

Nchanga Consolidated Copper Mines Ltd. (NCCM), comprised of the Rokana, Chingola, and Konkola Divisions, operated copper mines, a smelter, and a refinery. For the 15-month period ending March 31, 1971, approximately 20 million tons of ore was mined and 402,000 tons of refined copper produced. In the Rokana Division the Bwana Mkubwa concentrator began operations in May at the planned capacity of 15,000 tons of copper output per year. Slow delivery of materials and equipment delayed completion of the leach-precipitation plant at Chingola, and operations were rescheduled for late in the year. The solvent extraction—ion exchange process plant scheduled for 1973 will be delayed until 1974, which in turn will delay production from the planned reopening of the Kansanshi mine. Plans for use of the Torco process to treat Kansanshi ore were abandoned because of the substantial increase in the estimated cost of the plant.

Roan Consolidated Mines, Ltd. (RCM), comprised of the Mufulira, Chibuluma, Chambishi, Kalengwa, and Luanshya mines, produced 270,600 tons of refined copper in the year ended June 30, 1971, compared with 377,800 tons produced the previous year. The reduced output resulted largely from the Mufulira mine cave-in during September 1970. Baluba Mines, Ltd. was incorporated into the Luanshya Division of RCM in February. The Baluba mine is scheduled to begin production in 1973 at an initial annual rate of 24,000 tons of copper and at a 55,000-ton-per-year rate when full capacity is achieved. The concentrator at Luanshya was being expanded to handle the Baluba ore.

TECHNOLOGY

Articles published on copper resources included presentation of a hypothetical model of porphyry copper mineralization pieced together from observations at four major mines[2]; a description of the role of saline fluids in the metal transport mechanism[3]; and an example of age-dating ore formations by the potassium-argon method.[4] Two papers described mineral occurrences of potential copper-producing districts in Alaska and Montana.[5]

Installation of facilities for semiautomatic car dumping and full automatic loading and hoisting at a large copper mine resulted in considerable savings in manpower and increased hoist production.[6] Investigation of slope failures in mine waste dumps categorized the failures as debris flow, foundation failure, edge slump, and blowouts. Operating practices to minimize the slope failure problems were described.[7]

A study on the distribution of copper values in mill tailings disclosed that most of the acid-soluble (oxide) copper was in the minus 325-mesh fraction, whereas most of the insoluble (sulfide) copper was in the coarser fraction.[8] Research on dump leaching of copper traced the flow of leach liquids through a copper mine dump to assess the importance of semipermeable layers produced through the mechanics of dump emplacement on copper recovery efficiencies.[9]

Smelter research continued to emphasize the search for solutions to the problem of meeting new environmental standards for emission of sulfur to the atmosphere. Several publications[10] describe the dimensions of the problem and evaluate the technical feasibility and cost to achieve the proposed control standards. In February eight copper companies, accounting for virtually all primary copper smelter production, established the Smelter Control Research Association (SCRA) with the objective of developing improved methods of removing sulfur and particulates from smelter stacks. SCRA selected as its first project an operational study of the most promising processes for recovering sulfur from low gas concentrations into "throw-away" sulfur products. An initial pilot plant project investigating use of wet-scrubbing methods was placed in operation at the Kennecott smelter at McGill, Nev.

An examination was made of the heat balance and chemical equilibria involved in production of copper from a chalcopyrite concentrate in a single operation. It was concluded that two stages—one oxidizing and one reducing—will be needed and that copper losses in the slag will require a secondary recovery operation.[11] Other research determined the relative merits of recovering copper from converter slags by slow-cooled versus water-quenched

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methods.[12] Data and analysis on the mechanism and kinetics of the copper segregation process was presented in two papers.[13]

A patent was granted covering a process for removing oxygen from molten copper by injecting a natural gas-air mixture.[14] The process, in use at Kennecott's Utah Copper Division smelter since 1970, minimizes the costs and safety hazards of poling with green logs, avoids the excessive emission of pollutants encountered with the use of propane or butane, and eliminates the capital investment required for reforming natural gas. Publications on copper refining included descriptions of the deoxidation of copper by use of carbon monoxide,[15] use of electromotive force sensors for control of oxygen in liquid copper,[16] and continuous casting of copper billets and slabs.[17]

The application of hydrometallurgy to recovery of copper was reported in papers describing use of chelating agents to leach copper values from oxidized ores;[18] recovery of copper, sulfur, iron, and gold values from chalcopyrite by means of a ferric chloride leach;[19] use of chromium as a continuously recycled reducing agent to recover copper and nickel from aqueous solutions; [20] operational results obtained in in-place leaching of copper remaining after block caving an ore body; [21] and the use of entrained gas bubbles in a leach solution to improve the cupric ammonium carbonate process of leaching copper scrap.[22]

A progress report on recovery of copper and other nonferrous metals from auto shredder rejects by use of a combination air and heavy media separation indicated an overall recovery of 91 percent of the nonferrous metals in a 99 percent metal concentrate.[23]

Reports of research on copper alloys includes work on precipitation-hardening mechanisms,[24] fiber-reinforcement for increased strength,[25] and development of a modified copper-nickel-aluminum alloy for marine service.[26] Use of the spiral-elongation test to determine suitability of copper for fine wire manufacture and factors affecting copper quality for that purpose was described.[27]

Techniques were developed for preparing metallurgical grade copper powder from industrially produced cement copper with indicated favorable economics.[28] Research indicated feasibility of producing acceptable quality building bricks from waste copper mill tailings.[29]

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Table 2.—Copper produced from domestic ores, by source

(Thousand short tons)

Year	Mine	Smelter	Refinery
1967	954	841	847
1968	1,205	1,235	1,161
1969	1,545	1,547	1,469
1970	1,720	1,605	1,521
1971	1,522	1,471	1,411

Table 3.—Copper ore and recoverable copper produced, by mining method

(Percent)

Year	Open pit		Underground	
	Ore	Copper [1]	Ore	Copper [2]
1967	86	83	14	17
1968	87	82	13	18
1969	88	84	12	16
1970	[r] 89	84	11	16
1971	88	82	12	18

[r] Revised.
[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	1970	1971
January	141,038	137,479
February	132,898	130,561
March	145,457	141,802
April	142,893	141,019
May	153,304	145,215
June	149,653	149,248
July	138,130	49,155
August	145,784	105,595
September	140,597	115,142
October	149,819	135,264
November	139,839	136,830
December	140,245	134,873
Total	1,719,657	1,522,183

Table 5.—Mine production of recoverable copper in the United States, by State

(Short tons)

State	1967	1968	1969	1970	1971
Arizona	501,741	627,961	801,363	917,918	820,171
California	788	1,182	1,129	2,308	515
Colorado	3,993	3,451	3,598	3,749	3,938
Idaho	4,210	3,525	3,332	3,612	3,776
Maine	--	898	1,320	2,703	2,510
Michigan	58,458	74,805	75,226	67,543	56,005
Missouri	3,215	5,494	12,664	12,134	8,445
Montana	65,483	69,480	103,314	120,412	88,581
Nevada	50,771	77,213	104,924	106,688	96,928
New Mexico	75,008	90,769	119,956	166,278	157,419
Pennsylvania	4,401	4,850	3,382	2,539	3,349
Tennessee	14,600	14,196	15,353	15,535	13,916
Utah	168,609	228,245	296,699	295,738	263,451
Other States [1]	2,787	2,552	2,319	2,500	3,179
Total	954,064	1,204,621	1,544,579	1,719,657	1,522,183

[1] Includes Alaska, North Carolina, Oklahoma, Oregon, Washington, and Wyoming.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1971, 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	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Do.
3	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
4	Ray Pit	do	Kennecott Copper Corp	Copper ore, copper precipitates.
5	Chino	Grant, N. Mex	do	Do.
6	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
7	Pima	Pima, Ariz	Pima Mining Co	Do.
8	Sierrita	do	Duval Sierrita Corp	Do.
9	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
10	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
11	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Copper ore, copper precipitates.
12	New Cornelia	Pima, Ariz	do	Copper, gold-silver ores.
13	Twin Buttes	do	The Anaconda Company	Copper ore.
14	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co	Copper ore, copper precipitates.
15	Yerington	Lyon, Nev	The Anaconda Company	Copper ore.
16	Mission	Pima, Ariz	American Smelting and Refining Co	Do.
17	Copper Cities	Gila, Ariz	Cities Service Co	Copper ore, copper precipitates.
18	Mineral Park	Mohave, Ariz	Duval Corp	Do.
19	Tripp-Veteran Pit	White Pine, Nev	Kennecott Copper Corp	Copper ore.
20	Silver Bell	Pima, Ariz	American Smelting and Refining Co	Copper ore, copper precipitates.
21	Esperanza	do	Duval Corp	Do.
22	Bagdad	Yavapai, Ariz	Bagdad Copper Corp	Do.
23	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
24	Continental	Grant, N. Mex	U.S. Smelting, Refining & Mining Co	Do.
25	Ruth Pit	White Pine, Nev	Kennecott Copper Corp	Do.

Table 7.—Mine production of recoverable copper in 1971, by method of treatment

Method of treatment	Ore treated (thousand short tons)	Recoverable copper		Remarks
		Thousand pounds	Percent yield	
Copper ore:				
By concentration	222,121	2,499,966	0.56	See table 9.
By smelting	453	15,995	1.76	See table 10.
By leaching	20,082	[1] 161,608	.40	See table 11.
	242,656	2,677,569	.55	
Dump and in-place leaching	--	309,030	--	See table 11.
Miscellaneous from residues, tailings, and noncopper ores	--	57,767	--	--
Total	XX	3,044,366	XX	—

XX Not applicable.
[1] Includes 72,090,700 pounds of electrowon copper.

Table 8.—Copper ore shipped directly to smelters or concentrated in the United States, by State, in 1971, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand short tons)	Recoverable metal content				Value of gold and silver per ton of ore
		Copper		Gold (troy ounces)	Silver (troy ounces)	
		Thousand pounds	Percent			
Arizona	135,301	1,420,488	0.52	93,617	6,106,204	$0.10
Idaho	26	689	1.30	555	8,840	1.41
Michigan	6,891	112,010	.81	--	670,052	.15
Montana	13,493	141,004	.52	13,730	2,387,897	.32
Nevada	12,329	137,084	.56	55,593	588,202	.26
New Mexico	17,588	254,889	.72	10,562	639,478	.08
Tennessee [1]	1,704	27,832	.82	192	131,349	.12
Utah	35,008	415,094	.59	303,544	2,566,223	.47
Other States	234	6,870	1.47	488	43,796	.38
Total	222,574	2,515,960	.56	478,281	13,142,041	.18

[1] Copper-zinc ore.

Table 9.—Copper ore concentrated [1] in the United States, by State, in 1971, with content in terms of recoverable copper

State	Ore concentrated (thousand short tons)	Recoverable copper content	
		Thousand pounds	Percent
Arizona	134,908	1,404,690	0.52
Michigan	6,891	112,010	.81
Montana	13,493	141,002	.52
Nevada	12,329	137,062	.56
New Mexico	17,531	254,757	.73
Tennessee [2]	1,704	27,832	.82
Utah	35,008	415,094	.59
Other States	257	7,519	1.46
Total	222,121	2,499,966	.56

[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 1971, with content in terms of recoverable copper

State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Recoverable copper content: Percent
Arizona	393,240	15,797,900	2.01
Idaho	492	22,700	2.31
Montana	14	2,800	10.00
Nevada	368	21,600	2.94
New Mexico	57,056	131,800	[1] .12
Washington	2,000	18,000	.45
Total	453,170	15,994,800	1.76

[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 1971, 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	71,085	103,788,500	13,992,547	[1] 109,292,500	0.39
Montana	22,631	35,939,500	--	--	--
Nevada	11,489	19,971,000	[2] 6,089,903	[2] 52,315,100	.43
New Mexico	34,397	54,811,700	(2)	(2)	--
Utah	57,002	94,519,600	(2)	(2)	--
Total	196,604	309,030,300	20,082,450	161,607,600	.40

[1] Includes 72,090,700 pounds of electrowon copper.
[2] Nevada, New Mexico, and Utah combined to avoid disclosing individual company confidential data.

Table 12.—Copper ore smelted and copper ore concentrated in the United States, and average yield in copper, gold, and silver

Year	Smelting ore: Thousand short tons	Smelting ore: Yield in copper, percent	Concentrating ore: Thousand short tons [1]	Concentrating ore: Yield in copper, percent	Total: Thousand short tons [1]	Total: Yield in copper, percent	Total: Yield per ton in gold, ounce	Total: Yield per ton in silver, ounce	Total: Value per ton in gold and silver
1967	303	2.52	[2] 126,763	0.63	127,066	0.63	0.0025	0.066	$0.19
1968	383	2.46	[2] 169,671	.60	170,054	.60	.0024	.056	.21
1969	485	2.17	[3] 204,704	.62	223,752	.60	.0028	.065	.23
1970	542	3.51	[3] 235,586	.60	257,729	.61	.0023	.067	.20
1971	453	1.76	[3] 222,121	.56	242,656	.55	.0022	.059	.18

[1] Includes some ore classed as copper-zinc and minor amount of tailings (1971 excludes tailings).
[2] Includes all methods of concentration: "Dual process" (leaching followed by flotation concentration), "LPF" (leach-precipitation-flotation), tank or vat leaching, heap leaching, and froth flotation.
[3] 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
1967	841,343	20,997	70,746	933,086
1968	1,234,724	31,754	84,821	1,351,299
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

Table 14.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1967	1968	1969	1970	1971
PRIMARY					
From domestic ores, etc.: [1]					
Electrolytic	754,175	1,013,246	1,296,749	1,359,751	1,274,084
Lake	54,004	78,304	76,417	66,091	57,218
Casting	38,372	69,375	95,723	95,341	79,221
Total	846,551	1,160,925	1,468,889	1,521,183	1,410,523
From foreign ores, etc.: [1]					
Electrolytic	258,473	219,726	225,714	215,088	167,213
Casting and best select	27,958	56,735	48,212	28,823	14,046
Total refinery production of primary copper	1,132,982	1,437,386	1,742,815	1,765,094	1,591,782
SECONDARY					
Electrolytic [2]	318,709	327,549	410,749	433,394	323,913
Casting	24,568	15,869	2,094	17,623	18,599
Total secondary	343,277	343,418	412,843	451,017	342,512
Grand total	1,476,259	1,780,804	2,155,658	2,216,111	1,934,294

[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

	1970		1971	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	171	8	154	8
Cakes	114	5	116	6
Cathodes	265	12	291	15
Ingots and ingot bars	225	10	175	9
Wire bars	1,407	63	1,168	60
Other forms	34	2	30	2
Total	2,216	100	1,934	100

Table 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31 [1]
	Quantity	Copper content		
1967	40,128	10,032	40,644	3,516
1968	43,784	10,946	43,648	3,380
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

[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-percent basis) produced in the United States

(Short tons)

Year	Copper plants [2]	Lead and zinc plants [3]	Total
1967	348,497	900,170	1,248,667
1968	483,108	989,973	1,473,081
1969	685,775	1,086,938	1,772,713
1970 [r]	747,784	1,090,817	1,838,601
1971	803,284	971,946	1,775,230

[r] Revised.
[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter in 1967–68. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

Table 18.—Secondary copper produced in the United States

(Short tons)

	1967	1968	1969	1970	1971
Copper recovered as unalloyed copper	423,054	433,041	514,593	521,137	429,095
Copper recovered in alloys [1]	736,853	785,299	860,900	726,465	771,025
Total secondary copper	1,159,907	1,218,340	1,375,493	1,247,602	1,200,120
Source:					
New scrap	677,248	697,568	800,603	743,531	754,963
Old scrap	482,659	520,772	574,890	504,071	445,157
Percentage equivalent of domestic mine output	122	101	89	73	79

[1] Includes copper in chemicals, as follows: 1967—4,965; 1968—4,757; 1969—3,824; 1970—2,525; and 1971—3,206.

Table 19.—Copper recovered from scrap processed in the United States by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1970	1971
New scrap:		
Copper-base	732,055	744,294
Aluminum-base	11,335	10,504
Nickel-base	126	165
Zinc-base	15	--
Total	743,531	754,963
Old scrap:		
Copper-base	498,765	438,846
Aluminum-base	4,475	5,713
Nickel-base	792	514
Tin-base	11	8
Zinc-base	28	76
Total	504,071	445,157
Grand total	1,247,602	1,200,120

Form of recovery	1970	1971
As unalloyed copper:		
At primary plants	451,017	342,512
At other plants	70,120	86,583
Total	521,137	429,095
In brass and bronze	695,488	737,814
In alloy iron and steel	2,803	3,319
In aluminum alloys	25,516	26,492
In other alloys	133	194
In chemical compounds	2,525	3,206
Total	726,465	771,025
Grand total	1,247,602	1,200,120

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	
	1970	1971	1970	1971	1970	1971
Secondary smelters	52,770	58,741	214,459	222,819	267,229	281,560
Primary copper producers	233,674	192,390	217,343	150,122	451,017	342,512
Brass mills	433,202	479,124	16,894	24,848	450,096	503,972
Foundries and manufacturers	11,760	13,574	48,195	38,363	59,955	51,937
Chemical plants	649	465	1,874	2,664	2,523	3,129
Total	732,055	744,294	498,765	438,816	1,230,820	1,183,110

Table 21.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1970	1971
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	451,017	342,512
Refined copper by secondary smelters	60,592	58,150
Copper powder and black copper	9,399	28,353
Copper castings	129	80
Total	521,137	429,095
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	22,735	23,578
Leaded red brass and semired brass	151,852	165,414
High-leaded tin bronze	29,139	25,088
Yellow brass	15,728	18,085
Manganese bronze	10,890	11,213
Aluminum bronze	7,250	7,370
Nickel silver	3,725	3,561
Silicon bronze and brass	4,372	4,098
Copper-base hardeners and master alloys	10,280	9,804
Total	255,971	268,211
Brass-mill products	587,886	634,167
Brass and bronze castings	52,089	34,614
Brass powder	1,764	2,168
Copper in chemical products	2,525	3,204
Grand total	1,421,372	1,371,459

Table 22.—Composition of secondary copper-alloy production

(Short tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production: [1]							
1970	201,258	11,189	16,111	26,733	616	64	255,971
1971	207,952	11,501	16,817	31,214	682	45	268,211
Secondary metal content of brass-mill products:							
1970	450,758	477	3,192	128,757	4,644	58	587,886
1971	494,770	439	2,917	129,798	6,200	43	634,167
Secondary metal content of brass and bronze castings:							
1970	41,290	1,953	5,583	3,198	10	55	52,089
1971	27,975	1,093	2,760	2,725	8	53	34,614

[1] About 93 percent from scrap and 7 percent from other than scrap.

Table 23.—Stocks and consumption of purchased copper scrap in the United States in 1971

(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	2,224	31,414	2,840	27,934	30,774	2,864
No. 2 wire, mixed heavy and light copper	1,704	65,790	11,464	52,857	64,321	3,173
Composition or red brass	3,257	78,642	18,415	60,004	78,419	3,480
Railroad-car boxes	260	1,664	--	1,584	1,584	340
Yellow brass	4,753	64,940	7,421	56,814	64,235	5,458
Cartridge cases and brass	76	186	--	146	146	116
Auto radiators (unsweated)	1,498	56,526	--	55,902	55,902	2,122
Bronze	2,873	25,308	4,235	21,395	25,630	2,551
Nickel silver	631	4,274	736	3,650	4,386	519
Low brass	912	3,939	3,224	977	4,201	650
Aluminum bronze	145	287	160	124	284	148
Low-grade scrap and residues	6,914	99,685	69,017	24,589	93,606	12,993
Total	25,247	432,655	117,512	305,976	423,488	34,414
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	5,757	85,831	54,818	35,605	90,423	1,165
No. 2 wire, mixed heavy and light copper	25,471	168,074	129,836	53,266	183,102	10,443
Refinery brass	672	6,213	4,804	1,391	6,195	690
Low-grade scrap and residues	42,178	221,919	46,805	189,544	236,349	27,748
Total	74,078	482,037	236,263	279,806	516,069	40,046
BRASS MILLS [1]						
No. 1 wire and heavy copper	9,209	155,023	135,683	19,340	155,023	9,747
No. 2 wire, mixed heavy and light copper	3,639	39,666	38,361	1,305	39,666	3,335
Yellow brass	25,208	236,967	236,967	--	236,967	16,007
Cartridge cases and brass	11,483	143,800	137,419	6,381	143,800	11,018
Bronze	812	4,870	4,870	--	4,870	734
Nickel silver	2,932	23,750	23,750	--	23,750	3,645
Low brass	4,568	49,628	49,628	--	49,628	3,678
Aluminum bronze	94	436	436	--	436	118
Total [1]	57,945	654,140	627,114	27,026	654,140	48,282
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	2,037	21,853	6,747	14,785	21,532	2,358
No. 2 wire, mixed heavy and light copper	1,423	12,928	3,521	9,262	12,783	1,568
Composition or red brass	680	5,654	1,917	3,380	5,297	1,037
Railroad-car boxes	382	9,898	--	8,911	8,911	1,369
Yellow brass	755	6,093	2,551	3,505	6,056	792
Auto radiators (unsweated)	591	9,435	--	9,083	9,083	943
Bronze	229	846	289	517	806	269
Nickel silver	3	25	20	5	25	3
Low brass	30	466	217	245	462	34
Aluminum bronze	41	460	270	187	457	44
Low-grade scrap and residues	563	441	285	255	540	464
Total	6,734	68,099	[2] 15,817	[2] 50,135	[2] 65,952	8,881
GRAND TOTAL						
No. 1 wire and heavy copper	19,227	294,121	200,088	97,664	297,752	16,134
No. 2 wire, mixed heavy and light copper	32,237	286,458	183,182	116,690	299,872	18,519
Composition or red brass	3,937	84,296	20,332	63,384	83,716	4,517
Railroad-car boxes	642	11,562	--	10,495	10,495	1,709
Yellow brass	30,716	308,000	246,939	60,319	307,258	22,257
Cartridge cases and brass	11,559	143,986	137,419	6,527	143,946	11,134
Auto radiators (unsweated)	2,089	65,961	--	64,985	64,985	3,065
Bronze	3,914	31,024	9,394	21,912	31,306	3,554
Nickel silver	3,566	28,049	24,506	3,655	28,161	4,167
Low brass	5,510	54,033	53,069	1,222	54,291	4,362
Aluminum bronze	280	1,183	866	311	1,177	310
Low-grade scrap and residues [3]	50,327	328,258	120,911	215,779	336,690	41,895
Total	164,004	1,636,931	996,706	662,943	1,659,649	131,623

[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, 489 tons of new and 2,794 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
1970:						
Copper scrap	705,473	597,063	--	77,541	369,579	1,749,656
Refined copper [1]	--	660,583	1,338,740	36,938	7,042	2,043,303
Brass ingot	--	6,204	--	[2] 250,636	--	256,840
Slab zinc	--	113,506	--	6,481	7,760	127,747
Miscellaneous	--	--	--	150	5,059	5,209
1971:						
Copper scrap	516,069	654,140	--	65,952	423,488	1,659,649
Refined copper [1]	--	655,782	1,324,894	31,942	6,889	2,019,507
Brass ingot	--	13,154	--	[2] 263,225	--	276,379
Slab zinc	--	136,382	--	6,928	7,176	150,486
Miscellaneous	--	--	--	150	6,300	6,450

[1] Detailed information on consumption of refined copper will be found in table 28.
[2] Shipments to foundries by smelters minus increase in stocks at foundries.

Table 25.—Foundry consumption of brass ingot by type

(Short tons)

	1967	1968	1969	1970	1971
Tin bronze	38,739	41,758	43,772	47,474	44,279
Leaded red brass and semired brass	145,579	149,139	155,895	128,798	132,474
High-leaded tin bronze	20,928	20,021	20,278	79,960	107,700
Yellow brass	18,627	29,039	32,998		
Manganese bronze	10,254	10,274	10,680	14,545	8,555
Hardeners and master alloys	4,096	3,822	4,315	5,196	5,545
Nickel silver	4,094	3,870	4,041	3,265	3,466
Aluminum bronze	7,953	10,202	8,498	7,903	7,478
Total	250,270	268,125	280,477	287,141	309,497

Table 26.—Foundry consumption of brass ingot by type, refined copper, and copper scrap, in the United States in 1971, 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	Manganese bronze	Hardeners and master alloys	Nickel silver	Aluminum bronze	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:											
Connecticut	794	3,113	77	1,955	88	5		127	6,160	232	812
Massachusetts	1,890	3,459	344	187	315	32	491	41	6,553	403	150
Maine, New Hampshire, Rhode Island, and Vermont	205	1,843	94	177	247	4		15	2,790	22	2
Total	2,889	8,415	515	2,319	650	41	491	183	15,503	657	964
Middle Atlantic:											
New Jersey	1,199	2,021	72	184	209	10	60	92	3,847	2,623	2,259
New York	4,596	5,944	685	458	571	27	53	706	13,040	1,054	1,862
Pennsylvania	5,876	14,259	1,067	1,074	765	1,438	492	1,055	26,026	5,641	8,587
Total	11,671	22,224	1,824	1,716	1,545	1,475	605	1,853	42,913	9,318	12,708
East North Central:											
Illinois	2,903	14,142	1,970	589	668	154	111	674	21,211	1,834	1,409
Indiana	1,104	21,143	483	197	242	1,705	359	84	25,317	1,159	7,023
Michigan	16,278	5,590	[1] 7,753	W	1,607	430	5	1,252	[1] 21,953	4,949	1,050
Ohio		12,425			1,235	229	31	513		3,350	7,522
Wisconsin	837	7,527	2,342	489	82	1,113	1,015	195	13,600	4,684	610
Total	21,122	60,827	[1] 88,428	[2] W	3,834	3,631	1,521	2,718	182,081	15,976	17,614
West North Central:											
Iowa, Kansas, and Minnesota	392	5,418	73	271	438	101	43	123	6,859	276	1,232
Missouri, Nebraska, and South Dakota	129	1,148	533	1,003	222	10	--	692	3,737	771	3,274
Total	521	6,566	606	1,274	660	111	43	815	10,596	1,047	4,506
South Atlantic:											
Delaware, District of Columbia, Florida, Georgia, and Maryland	584	946	1	78	80	76	271	62	2,023	179	1,479
North Carolina, South Carolina, Virginia, and West Virginia	3,251	5,268	337	341	150		--	540	9,962	1,832	4,413
Total	3,835	6,214	338	419	230	76	271	602	11,985	2,011	5,892
East South Central:											
Alabama, Kentucky, Mississippi, and Tennessee	956	9,300	617	5,422	605	49	127	54	17,130	416	6,839
West South Central:											
Arkansas, Louisiana, Oklahoma, and Texas	1,599	5,473	297	1,691	345	18	349	827	10,599	760	882
Mountain:											
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah	132	208	12	41	132	3	--	30	558	159	322
Pacific:											
California	1,252	13,157	336	1,772	446	141	59	240	17,403	46	10,948
Oregon and Washington	302	90	50	23	108	--	--	156	729	41	1,994
Total	1,554	13,247	386	1,795	554	141	59	396	18,132	87	12,942
Grand total	44,279	132,474	[1] 107,700	[2] W	8,555	5,545	3,466	7,478	309,497	30,431	62,669

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)

	1967	1968	1969	1970	1971
Production from domestic and foreign ores, etc.	1,132,982	1,437,386	1,742,815	1,765,094	1,591,782
Imports [1]	330,571	400,278	131,171	132,143	163,988
Stocks Jan. 1 [1]	43,000	27,000	48,000	39,000	130,000
Total available supply	1,506,553	1,864,664	1,921,986	1,936,237	1,885,770
Copper exports [1]	159,353	240,745	200,269	221,211	187,654
Stocks Dec. 31 [1]	27,000	48,000	39,000	130,000	75,000
Total	186,353	288,745	239,269	351,211	262,654
Apparent withdrawals on domestic account [2]	1,320,000	1,576,000	1,683,000	1,585,000	1,623,000

[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 consumer

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1970:							
Wire mills	85,925	1,245,470	W	--	--	7,345	1,338,740
Brass mills	154,174	27,862	120,880	156,770	200,785	112	660,583
Chemical plants	--	--	578	--	--	1,663	2,241
Secondary smelters	3,286	--	3,749	--	--	7	7,042
Foundries	2,127	1,687	11,941	W	W	483	16,238
Miscellaneous [1]	1,474	744	8,573	282	1,262	6,124	18,459
Total	246,986	1,275,763	145,721	157,052	202,047	15,734	2,043,303
1971:							
Wire mills	108,498	1,206,895	W	W	W	9,501	1,324,894
Brass mills	192,617	28,042	99,087	154,667	181,259	110	655,782
Chemical plants	--	--	191	--	--	1,320	1,511
Secondary smelters	4,221	--	2,666	--	--	2	6,889
Foundries	2,183	1,659	8,950	W	W	852	13,644
Miscellaneous [1]	1,907	332	7,447	170	1,000	5,931	16,787
Total	309,426	1,236,928	118,341	154,837	182,259	17,716	2,019,507

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]
1967	27	220
1968	48	272
1969	39	291
1970	130	340
1971	75	303

[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] (5)
1967	479,572	98,716	415,765	269,474	−106,951
1968	514,553	128,919	420,186	273,469	−50,183
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

[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 1971

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	23.45	24.55	28.20	32.02	28.60	27.14
No. 1 composition scrap	26.45	26.34	29.17	32.57	30.55	30.00
No. 1 composition ingot	49.83	49.00	51.96	56.46	56.75	55.00
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	27.60	27.00	26.86	28.34	28.95	28.14	27.57
No. 1 composition scrap	30.50	30.50	30.36	31.05	31.95	29.55	29.92
No. 1 composition ingot	55.00	55.00	53.67	52.58	50.55	49.50	52.94

Source: Metal Statistics, 1972.

Table 32.—Average weighted prices of copper deliveries [1]

(Cents per pound)

Year	Domestic copper	Foreign copper
1967	38.6	48.2
1968	42.2	51.4
1969	47.9	63.2
1970	58.2	64.1
1971	52.0	49.3

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States.

Source: Metals Week.

Table 33.—Average monthly quoted prices of electrolytic copper for domestic delivered, in the United States, and for spot copper at London

(Cents per pound)

Month	1970			1971		
	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	55.92	56.25	72.57	51.48	51.52	45.18
February	56.12	56.50	74.09	50.38	50.35	45.86
March	56.12	56.50	78.45	50.48	50.55	51.45
April	59.74	59.80	77.56	52.88	52.83	56.26
May	60.12	60.20	71.45	52.88	52.84	50.11
June	60.12	60.20	64.98	52.88	52.84	48.29
July	60.12	60.10	60.60	52.88	(2)	50.14
August	60.12	60.10	56.23	52.88	52.90	49.02
September	60.12	60.10	55.30	52.88	52.89	47.13
October	59.03	59.00	50.71	52.88	52.84	46.44
November	56.12	56.10	48.22	52.19	52.24	45.24
December	53.12	53.10	46.46	50.38	50.32	46.32
Average	58.07	58.20	62.96	52.09	52.01	48.49

[1] Based on average monthly rates of exchange by Federal Reserve Board.
[2] Suspended.

Table 34.—U.S. exports of copper by class and country

Year and country	Ore, concentrates, and matte (copper content)		Refined		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1970	61,538	$58,366	221,211	$296,929	16,555	$15,228
1971:						
Africa	--	--	1	1	17	19
Argentina	--	--	115	126	--	--
Belgium-Luxembourg	1,182	832	4,766	4,592	2,493	2,118
Brazil	11	7	18,940	19,486	21	19
Canada	5,368	6,296	15,399	16,133	3,906	3,025
Denmark	--	--	578	561	--	--
France	--	--	21,930	22,241	65	53
Germany, West	--	--	43,012	41,147	3,869	3,519
India	--	--	14,652	14,940	267	252
Italy	--	--	24,329	24,189	760	615
Japan	816	438	10,468	10,042	2,099	1,789
Korea, Republic of	--	--	1,545	1,629	1,293	1,163
Mexico	224	441	17	26	410	266
Netherlands	--	--	7,108	7,435	43	22
Oceania	--	--	29	35	--	--
Pakistan	--	--	385	403	--	--
Philippines	--	--	1,320	1,689	--	--
Spain	525	416	31	41	2,505	2,184
Sweden	--	--	2,518	2,428	77	66
Switzerland	--	--	1,819	2,009	--	--
Taiwan	--	--	4,926	5,160	70	54
United Kingdom	--	--	13,243	13,085	217	183
Yugoslavia	--	--	407	410	43	43
Other	--	--	116	140	280	231
Total	8,126	8,430	187,654	187,948	18,435	15,621

Year and country	Blister		Pipes and tubing		Plates and sheets	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1970	7,805	$7,503	1,064	$2,491	358	$655
1971:						
Africa	--	--	57	142	--	--
Belgium-Luxembourg	12,843	9,458	2	6	--	--
Brazil	--	--	6	20	(1)	1
Canada	126	110	553	960	218	376
Denmark	--	--	(1)	1	--	--
France	--	--	117	299	5	22
Germany, West	15,514	12,492	1	2	4	10
India	55	54	142	300	--	--
Italy	--	--	1	3	5	12
Japan	--	--	2	7	3	6
Korea, Republic of	--	--	3	8	--	--
Mexico	--	--	17	49	13	34
Netherlands	--	--	1	3	--	--
Oceania	8	7	1	1	--	--
Pakistan	28	23	35	72	--	--
Philippines	--	--	41	75	5	16
Spain	121	95	8	23	--	--
Switzerland	1	1	--	--	4	11
Taiwan	--	--	8	33	--	--
United Kingdom	2	2	14	34	3	6
Other	--	--	240	503	27	56
Total	28,698	22,242	1,249	2,541	287	550

Year and country	Wire and cable, bare		Wire and cable, insulated		Other copper manufactures [2]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1970	2,982	$3,983	23,602	$66,327	6,057	$8,568
1971:						
Africa	63	129	1,508	2,809	129	221
Argentina	121	185	93	323	--	--
Belgium-Luxembourg	23	29	101	964	3	7
Brazil	6	14	399	1,078	55	60
Canada	364	731	10,432	32,457	628	917
Denmark	--	--	36	205	--	--
France	13	19	483	699	4	10
Germany, West	46	74	253	1,367	47	65
India	4	3	5	23	31	33
Italy	1	2	97	689	34	41
Japan	14	32	132	745	3	7
Korea, Republic of	35	48	136	302	(1)	1
Mexico	149	265	3,031	10,297	62	156

See footnotes at end of table.

Table 34.—U.S. exports of copper by class and country—Continued

	Wire and cable, bare		Wire and cable, insulated		Other copper manufactures [2]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Netherlands	2	$4	306	$979	14	$28
Oceania	21	49	242	730	23	31
Pakistan	4	10	50	110	1,629	1,897
Philippines	36	59	846	1,823	75	85
Spain	5	11	81	295	3	5
Sweden	38	69	66	329	--	--
Switzerland	1	1	91	330	88	103
Taiwan	68	42	253	992	4	8
United Kingdom	28	51	283	1,747	20	44
Yugoslavia	--	--	6	26	--	--
Other	883	1,380	5,660	13,738	4,894	5,426
Total	1,925	3,207	24,590	73,057	7,746	9,145

[1] Less than ½ unit.
[2] Does not include wire cloth: 1970, 1,151,648 square feet ($476,767); 1971, 1,472,504 square feet ($495,858).

Table 35.—U.S. exports of copper, by class

Year	Ore, concentrate, and matte (copper content)		Blister		Refined copper and semimanufactures	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	1,177	$1,195	4,340	$3,918	236,914	$303,386
1970	61,538	58,366	7,805	7,503	249,217	370,388
1971	8,126	8,430	28,698	22,242	215,705	267,303

Year	Other copper manufactures [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	4,602	$6,160	247,033	$314,659
1970	6,057	8,568	324,617	444,825
1971	7,746	9,145	260,275	307,120

[1] Does not include wire cloth: 1969, 842,072 square feet ($480,389); 1970, 1,151,648 square feet ($476,767); 1971, 1,472,504 square feet ($495,858).

Table 36.—U.S. exports of copper-base alloy (including brass and bronze), by class

Class	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Ingots	211	$693	181	$467
Scrap and waste	110,365	89,762	76,852	58,099
Bars, rods, and shapes	3,028	5,645	6,434	8,453
Plates, sheets, and strips	2,276	7,871	2,112	7,362
Pipes and tubing	1,654	3,864	2,563	5,064
Pipe fittings	2,594	8,537	3,651	10,246
Plumbers' brass goods	954	2,785	1,072	3,034
Welding rods and wire	2,016	4,755	1,737	4,092
Castings and forgings	1,684	2,746	945	1,607
Powder and flakes	1,502	2,811	1,942	3,125
Foil	1,309	4,544	466	1,436
Articles of copper and copper-base alloys, n.e.c	(1)	4,314	(1)	3,844
Total	127,593	138,327	97,955	106,829

[1] Quantity not reported.

Table 37.—U.S. exports of unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, sheets, and strip

Year	Short tons	Value (thousands)
1969	4,737	$12,793
1970	5,515	14,209
1971	8,727	16,282

[1] Includes brass and bronze

Table 38.—U.S. exports of copper sulfate

(Blue vitriol)

Year	Short tons	Value (thousands)
1969	3,127	$2,385
1970	2,485	1,543
1971	2,815	2,078

Table 39.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper alloy scrap			
	1970		1971		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Austria	--	--	--	--	1,904	$1,361	316	$210
Belgium-Luxembourg	4,004	$3,204	2,493	$2,118	17,154	13,430	5,254	4,060
Canada	1,301	1,052	3,906	3,025	3,688	3,225	6,592	5,520
France	26	21	65	53	244	200	372	269
Germany:								
East	--	--	--	--	--	--	127	103
West	4,242	4,045	3,869	3,519	18,751	16,676	10,127	8,459
Hong Kong	--	--	81	69	416	347	342	277
India	239	257	267	252	210	236	362	339
Israel	1,134	1,072	33	33	1,991	1,686	150	125
Italy	861	692	760	615	9,149	6,998	7,036	5,006
Japan	2,133	2,069	2,099	1,789	45,309	36,232	30,919	22,642
Korea, Republic of	--	--	1,293	1,163	576	652	3,271	2,793
Mexico	17	14	410	266	729	735	2,824	2,250
Netherlands	86	94	43	22	876	881	212	194
Spain	496	557	2,505	2,184	3,240	2,907	3,210	2,242
Sweden	26	24	77	67	3,322	1,968	3,548	1,849
Taiwan	--	--	70	54	342	232	1,147	965
United Kingdom	712	626	217	182	2,051	1,643	523	349
Yugoslavia	1,077	1,319	43	43	188	181	121	112
Other	201	182	204	167	225	171	419	346
Total	16,555	15,228	18,435	15,621	110,365	89,761	76,872	58,110

Table 40.—U.S. imports for consumption of copper scrap, by country

Country	Unalloyed copper scrap (copper content)			
	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Bahamas	36	$17	84	$68
Bermuda	--	--	17	15
Canada	472	528	5,063	4,741
Chile	95	104	(1)	(1)
Dominican Republic	35	31	231	188
France	--	--	1	2
Germany, West	7	13	39	29
Guatemala	47	36	22	15
Honduras	85	87	45	57
Jamaica	--	--	99	77
Mexico	1,345	1,025	1,719	1,319
Netherlands	4	8	--	--
Panama	5	5	52	42
Spain	73	57	2	4
United Kingdom	82	117	77	121
Other	22	16	8	1
Total	2,308	2,044	7,459	6,679

Country	Copper alloy scrap					
	1970			1971		
	Gross weight short tons	Copper content short tons	Value (thousands)	Gross weight short tons	Copper content short tons	Value (thousands)
Bahamas	36	24	$33	105	75	$67
Bermuda	--	--	--	4	2	2
Canada	1,978	1,292	1,555	8,186	5,562	5,584
Dominican Republic	43	31	26	197	156	135
Guatemala	120	103	86	18	12	10
Jamaica	--	--	--	174	113	90
Mexico	303	225	188	238	169	140
Panama	21	14	14	240	190	167
United Kingdom	--	--	--	55	47	57
Other	27	22	23	10	6	6
Total	2,528	1,711	1,925	9,227	6,332	6,258

[1] Less than ½ unit.

Table 41.—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
1969	38,724	$46,075	324	$419	237,949	$229,865
1970:						
Australia	1,336	1,460	--	--	--	--
Belgium-Luxembourg	--	--	--	--	22	32
Canada	3,395	4,250	1,047	1,300	119	115
Chile	--	--	--	--	97,952	93,531
Germany, West	--	--	--	--	1	3
Japan	6	2	--	--	--	--
Mexico	135	88	--	--	2,504	3,011
Netherlands	--	--	23	40	--	--
Peru	8,949	11,149	--	--	94,868	115,350
Philippines	18,700	23,391	--	--	--	--
South Africa, Republic of	--	--	--	--	28,946	33,855
Other	220	54	30	49	4	6
Total	32,741	40,394	1,100	1,389	224,416	245,903
1971:						
Australia	1,243	809	--	--	--	--
Canada	6,986	5,088	339	253	12	18
Chile	--	--	--	--	40,594	38,668
Germany, West	--	--	2	2	28	41
Japan	--	--	--	--	36	32
Mexico	4	2	--	--	4,926	5,012
Netherlands	--	--	98	204	--	--
Peru	8,999	8,562	--	--	89,901	81,890
Philippines	13,616	13,041	--	--	--	--
South Africa, Republic of	--	--	--	--	21,247	21,467
Other	--	--	1	1	--	--
Total	30,848	27,502	440	460	156,744	147,128

Year and country	Refined		Scrap		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	131,171	$132,573	5,692	$5,183	413,860	$414,115
1970:						
Australia	1,654	2,535	--	--	2,990	3,995
Belgium-Luxembourg	1	2	--	--	23	34
Canada	91,814	99,245	470	528	96,845	105,438
Chile	16,928	18,267	--	--	114,880	111,798
Germany, West	--	--	7	13	8	16
Japan	13,132	14,990	--	--	13,138	14,992
Mexico	377	477	1,345	1,025	4,361	4,601
Mozambique	750	1,029	--	--	750	1,029
Netherlands	--	--	4	8	27	48
Norway	113	139	--	--	113	139
Peru	6,209	8,110	--	--	110,026	134,609
Philippines	--	--	--	--	18,700	23,391
South Africa, Republic of	--	--	--	--	28,946	33,855
United Kingdom	59	76	31	79	90	155
Zambia	1,102	1,217	--	--	1,102	1,217
Other	4	6	223	188	481	303
Total	132,143	146,093	2,080	1,841	392,480	435,620
1971:						
Australia	338	338	--	--	1,581	1,147
Belgium-Luxembourg	551	599	--	--	551	599
Canada	123,028	122,753	5,063	4,741	135,428	132,853
Chile	11,057	11,003	(2)	(2)	51,651	49,671
France	443	414	1	2	444	416
Germany, West	4,387	4,953	39	29	4,456	5,025
Japan	--	--	--	--	36	32
Mexico	991	997	1,719	1,319	7,640	7,330
Netherlands	1,603	1,815	--	--	1,701	2,019
Norway	116	121	--	--	116	121
Peru	3,510	3,913	--	--	102,410	94,365
Philippines	--	--	--	--	13,616	13,041
Poland	434	46	--	--	434	46
South Africa, Republic of	--	--	--	--	21,247	21,467
Sweden	1,764	1,764	--	--	1,764	1,764
United Kingdom	5,513	5,990	77	121	5,590	6,111
Yugoslavia	3,585	4,346	--	--	3,585	4,346
Zambia	6,668	6,634	--	--	6,668	6,634
Other	--	--	560	467	561	468
Total	163,988	165,686	7,459	6,679	359,479	347,455

[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 42.—U.S. imports for consumption of copper (copper content) by class

(Short tons and thousand dollars)

Year	Ore and concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	3,588	$3,274	6	$17	241,712	$233,265
1970	64,540	77,367	247	346	224,289	245,778
1971	5,547	4,091	119	220	153,625	144,395

Year	Refined		Scrap		Total value
	Quantity	Value	Quantity	Value	
1969	131,171	$132,573	5,692	$5,183	$374,312
1970	132,143	r 149,169	r 2,308	r 2,044	r 474,704
1971	163,988	165,686	7,459	6,679	321,071

r Revised.

Table 43.—Copper: World mine production, by country [1]

(Short tons)

Country	1969	1970	1971 p
North and Central America:			
Canada [2]	r 573,245	672,717	719,900
Cuba e	3,300	3,300	3,300
Dominican Republic	526	468	--
Haiti [3]	r 1,800	1,589	--
Mexico	r 72,937	67,254	69,611
Nicaragua [3]	4,583	3,705	4,037
United States [2]	1,544,579	1,719,657	1,522,183
South America:			
Argentina	503	508	e 515
Bolivia	[4] 8,800	[4] 9,655	[5] 9,070
Brazil [6]	r 3,289	4,233	5,622
Chile	770,593	783,391	790,910
Colombia	8	55	62
Ecuador	588	562	622
Peru	219,143	242,756	234,665
Europe:			
Albania [7]	5,756	6,160	e 7,000
Austria	2,589	2,493	2,920
Bulgaria	43,300	47,500	50,000
Czechoslovakia	r 4,300	4,400	5,300
Finland	36,525	34,100	31,416
France	429	276	330
Germany, East e [7]	r 17,000	11,000	13,000
Germany, West	1,592	1,404	1,524
Hungary e	1,100	1,100	1,300
Ireland	r 6,910	9,128	13,007
Italy	r 2,502	2,326	1,500
Norway [8]	23,307	21,988	24,790
Poland e	53,200	79,400	99,200
Portugal [8]	4,491	4,103	6,850
Romania e [2]	r 14,000	14,300	15,700
Spain [8] [9]	11,626	10,496	30,999
Sweden	27,723	28,972	30,300
U.S.S.R. e [7]	610,000	630,000	680,000
Yugoslavia	90,032	100,099	104,049
Africa:			
Algeria	r 606	633	e 660
Angola	222	40	--
Congo (Brazzaville) [3]	12	60	456
Kenya	85	87	80
Morocco [3]	2,507	3,167	3,472
Mozambique [3]	--	166	456
Rhodesia, Southern [10]	r 27,385	29,241	32,338
South Africa, Republic of	139,096	164,470	173,581
South-West Africa, Territory of [2] [11]	r 35,940	34,605	35,317
Uganda	r 20,844	21,119	18,802
Zaire (formerly Congo-Kinshasa)	393,421	425,138	449,000
Zambia	824,658	754,100	718,300

See footnotes at end of table.

Table 43.—Copper: World mine production, by country [1]—Continued

(Short tons)

Country	1969	1970	1971 p
Asia:			
Burma e 12	r 77	77	77
China, People's Republic of e	110,000	110,000	110,000
Cyprus 8	18,996	20,019	13 20,490
India	11,373	11,312	11,867
Iran e 14	r 50	55	55
Israel	r 8,832	9,084	11,161
Japan 3	133,516	131,740	133,411
Korea, North e	13,000	14,000	14,000
Korea, Republic of	1,466	1,807	1,955
Philippines	144,872	176,696	229,600
Taiwan e	2,500	2,700	2,700
Turkey	29,072	30,010	21,429
Oceania:			
Australia	r 144,464	173,933	195,096
Fiji	472	--	--
New Zealand	r 78	52	94
Total	r 6,223,820	6,633,406	6,664,079

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 concentrates produced.

4 COMIBOL production plus exports by medium and small mines.

5 Exports by country's medium and small mines.

6 Partly estimated, partly calculated on the basis of data furnished by CEBRACO.

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 Output of Tsumeb Corporation Ltd. and Klein Aub Koper Maatskappy Beperk for years ending June 30 of that stated.

12 Content of matte produced.

13 Exports.

14 Year beginning March 21 of that stated.

Table 44.—Copper: World smelter production by country [1]

(Short tons)

Country	1969	1970	1971 p
North America:			
Canada	r 450,154	538,700	526,450
Mexico [2]	r 71,515	65,708	68,273
United States [3]	1,585,491	1,641,338	1,499,996
South America:			
Brazil [4]	3,583	4,189	4,299
Chile [5]	729,496	725,547	705,267
Peru	r 185,619	195,020	183,779
Europe:			
Albania	5,756	6,160	e 7,000
Austria [6]	21,204	24,160	23,474
Belgium e [7]	11,000	11,000	11,000
Bulgaria	42,000	48,200	50,000
Czechoslovakia [8]	r 4,300	4,400	5,300
Finland	37,343	37,530	35,648
Germany, East e	r 17,000	11,000	13,000
Germany, West	r 102,300	93,000	91,100
Hungary e [8]	r 1,100	1,100	1,300
Norway [9]	30,743	35,375	37,762
Poland	60,300	79,600	102,200
Romania e	r 11,000	11,000	12,000
Spain	r 59,805	43,899	77,765
Sweden [6] [10]	r 43,142	40,412	38,042
U.S.S.R. e	610,000	630,000	680,000
Yugoslavia	102,095	116,736	122,692
Africa:			
Rhodesia, Southern [11]	r 23,312	22,830	29,765
South Africa, Republic of	140,300	159,500	167,900
South-West Africa, Territory of [12]	r 30,294	31,519	29,676
Uganda	18,259	18,693	17,340
Zaire (formerly Congo-Kinshasa)	400,974	424,988	444,701
Zambia	r 766,046	753,153	698,221
Asia:			
China, People's Republic of e	110,000	110,000	110,000
India	10,749	10,264	10,668
Japan [13]	r 552,376	668,066	728,871
Korea, North e	13,000	14,000	14,000
Korea, Republic of [14]	r 6,133	5,641	7,550
Taiwan	3,576	4,136	4,045
Turkey	25,904	20,894	19,352
Oceania: Australia	128,071	123,075	157,905
Total	r 6,413,940	6,730,833	6,736,341

e Estimate. p Preliminary. r Revised.

1 Unless otherwise noted, data presented for each country represent the non-duplicative sum of production of primary blister copper, primary refined copper of nonblister origin, and any primary refined copper derived from unreported quantities of domestically smelted blister copper.

2 Copper content of impure bars and electrolytic copper.

3 Smelter output from domestic and foreign ores, exclusive of that produced from scrap. Production from domestic ores only was as follows: 1969—1,547,496; 1970—1,605,265; and 1971—1,470,815.

4 Includes secondary copper (production from scrap). Partly estimated, partly calculated on the basis of data furnished by CEBRACO.

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 copper 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 Refined.

7 Belgium reports a large output of refined copper, but this is produced largely from imported blister; estimate of domestic smelter production is based chiefly on reported imports of ores and concentrates.

8 Series revised; data presented are output of primary smelter. Data presented in previous editions of this chapter represented output of refined metal including secondary (production from scrap).

9 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: 1969—r 6,000; 1970—6,300; 1971—6,500.

10 Series revised to exclude secondary copper; data presented in previous editions of this chapter included secondary refined copper.

11 Year ending September 30 of that stated.

12 Year ending June 30 of that stated.

13 Series revised; data presented are output of blister copper (including a relatively small quantity of secondary blister, derived from scrap). Data presented in previous editions of this chapter represented output of refined copper, including a substantial quantity produced from scrap as well as quantities produced from imported blister copper.

14 Refined including secondary.

Table 45.—Chile: Exports of copper, by principal type

(Short tons, copper content)

Destination	1970 r				1971			
	Refined		Blister	Total	Refined		Blister	Total
	Electrolytic	Fire refined			Electrolytic	Fire refined		
Argentina	21,900	4,900	--	26,800	28,200	4,400	--	32,600
Austria	1,200	--	--	1,200	900	--	700	1,600
Belgium	14,900	1,300	8,300	24,500	3,300	1,300	6,900	11,500
Brazil	10,500	1,600	--	12,100	9,700	1,900	--	11,600
Canada	--	--	--	--	1,400	--	--	1,400
China	--	--	--	--	9,100	--	8,800	17,900
Colombia	--	400	--	400	--	300	--	300
Czechoslovakia	--	--	--	--	1,100	--	--	1,100
Denmark	2,100	--	--	2,100	2,000	--	--	2,000
Finland	2,300	--	--	2,300	1,800	--	100	1,900
France	30,500	24,500	--	55,000	34,300	17,400	--	51,700
Germany, West	119,700	18,400	31,300	169,400	114,800	13,100	41,700	169,600
Greece	600	--	--	600	700	--	--	700
Italy	51,400	20,100	2,100	73,600	56,300	13,800	2,300	72,400
Japan	19,600	--	34,100	53,700	32,300	--	35,200	67,500
Korea	--	--	--	--	500	--	--	500
Netherlands	6,400	--	--	6,400	6,500	--	1,100	7,600
Norway	2,500	--	--	2,500	2,100	--	--	2,100
Poland	--	--	--	--	--	--	600	600
Spain	6,200	1,300	2,900	10,400	6,000	500	3,600	10,100
Sweden	17,800	8,500	3,600	29,900	16,200	6,000	1,600	23,800
Switzerland	2,100	1,300	--	3,400	2,000	800	--	2,800
United Kingdom	59,400	18,100	31,200	108,700	55,800	12,500	43,500	111,800
United States	14,400	1,100	96,100	111,600	18,300	--	38,800	57,100
Yugoslavia	--	--	--	--	3,600	--	2,800	6,400
Other	--	--	--	--	400	--	--	400
Total	383,500	101,500	209,600	694,600	407,300	72,000	187,700	667,000

p Preliminary. r Revised.
Source: Corporación del Cobre de Chile.

Table 46.—Peru: Copper production

(Short tons)

	Blister	Refined	Other	Total
1969	147,628	37,991	33,524	219,143
1970 r	155,140	39,879	47,737	242,756
1971 p	147,887	35,892	50,886	234,665

p Preliminary. r Revised.

Table 47.—Canada: Copper production (all sources) by Province [1]

(Short tons)

Province	1970 r	1971 p
British Columbia	105,822	134,110
Manitoba	47,906	56,464
New Brunswick	8,022	9,958
Newfoundland	15,193	12,875
Northwest Territories	660	150
Nova Scotia	27	17
Ontario	295,092	303,631
Quebec	172,642	187,062
Saskatchewan	19,473	7,690
Yukon Territories	7,880	2,550
Total	672,717	714,507

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, Dominion of Canada. Canada's Mineral Production, Preliminary Estimate. 1971.

Diatomite

By Benjamin Petkof [1]

Domestic diatomite production declined 10 percent in quantity, but increased 5 percent in value from the previous year. The United States retained its position as a major world producer. Exports of diatomite to nations throughout the world declined almost 8 percent.

DOMESTIC PRODUCTION

Domestic production declined in all of the Western producing States except Nevada, where a slight increase was noted. California remained the largest producing State, followed by Nevada, Washington, Arizona, and Oregon.

Eight companies, with a total of 10 operations, mined and prepared diatomite for various end uses during the year. This was a decline of one producing company from the number reported in 1970. The bulk of the diatomite produced during the year was supplied by the following companies: Johns-Manville Products Corp., with facilities near Lompoc, Calif.; GREFCO, Inc., with operations in Esmeralda County, Nev., and Santa Barbara County, Calif.; Eagle-Picher, Inc., with operations in Pershing and Storey Counties, Nev.; and Kenite Corp., Division of Whitco Chemical Corp., with operations in Grant County, Wash. No plans were announced by any diatomite producer to increase production capacity.

Interest continued during the year in the underwater diatomite deposits of Lake Umbagog in New Hampshire. Hearings were held on the State level to determine whether authorization to exploit the deposit would have adverse effects on the lake ecology.

Table 1.—Diatomite sold or used by producers in the United States

	1966–68 [1]	1969	1970	1971
Domestic production (sales) short tons	1,881,877	598,482	597,636	535,318
Average value per ton	$54.18	$60.96	$54.63	$64.25

[1] Annual figures are confidential, prior to 1969.

CONSUMPTION AND USES

Almost all major end uses registered significant declines in consumption. However, the percentage of total consumption for various end uses changed only slightly from that of 1970. Filtration continued to be the major end use and required almost three-fifths of the total material sold or used by producers in 1971. The remainder was used for industrial fillers, insulation, lightweight aggregates, pozzolans, soil conditioners, and other miscellaneous uses.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Domestic consumption of diatomite, by principal use, in percent of total consumption

Use	1967	1968	1969	1970	1971
Filtration	48	55	58	58	59
Fillers	18	21	20	19	W
Insulation	4	4	4	4	3
Miscellaneous	30	20	18	19	38

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 1971, increased 18 percent from that of 1970 and also increased significantly over the comparable value for 1969.

Almost all end uses registered significant increases in value per ton: filtration, 18 percent; abrasives, 17 percent; fillers, 24 percent; lightweight aggregates, 2 percent; and miscellaneous uses, 13 percent. Material required for insulation declined 5 percent in value per ton. The increase in price per ton of material for most end uses may indicate the reliance of consuming industries on the better qualities of processed diatomite.

Table 3.—Average annual value per ton of diatomite, by uses

Use	1970	1971
Filtration	$61.67	$72.64
Insulation	47.84	45.34
Abrasives	119.19	139.04
Fillers	53.26	65.92
Lightweight aggregate	42.08	42.97
Miscellaneous	33.58	37.91
Weighted average	54.63	64.25

FOREIGN TRADE

Exports of prepared diatomite continued to decline for the second year since 1969 when exports peaked at 176,000 tons. This decline may be due to the effect of increasing cost of overseas transportation and greater competition from foreign sources of diatomite. Exports of prepared diatomite declined 8 percent in quantity and 5 percent in value from those of 1970. Canada received about one-fourth of the material exported; West Germany, 13 percent; United Kingdom, 8 percent; and Japan, 8 percent. The remainder was exported to many other industrialized and nonindustrialized countries. The average value of exported material was $82.79 per ton. Imports of crude and processed material totaled 132 tons valued at $7,962. Canada was the major source of imported material.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1969	176	$13,510
1970	154	12,363
1971	142	11,752

WORLD REVIEW

World diatomite production in 1971 declined almost 70,000 tons from that of 1970.

Table 5.—Diatomite: World production, by countries

(Short tons)

Country[1]	1969	1970	1971 p
North America:			
Canada	487	e 480	e 500
Costa Rica	e 17,000	21,000	e 21,000
Mexico	12,318	25,127	e 25,400
United States	598,482	597,636	535,318
South America:			
Argentina	11,397	9,070	e 8,800
Peru	20,597	2,821	e 3,000
Europe:			
Austria	1,946	4,158	e 4,400
Denmark:			
Diatomite e	22,000	22,000	22,000
Moler e	240,000	240,000	240,000
Finland	2,003	734	e 770
France e	190,000	190,000	190,000
Germany, West (marketable)	125,301	100,924	e 95,000
Iceland	8,378	14,593	e 14,700
Italy	65,848	e 66,000	e 66,000
Portugal	3,091	3,522	e 3,400
Spain e	20,000	20,000	20,000
Sweden	r 6,669	e 6,700	e 6,700
U.S.S.R.	400,000	410,000	410,000
United Kingdom	14,311	e r 14,300	e 14,300

Table 5.—Diatomite: World production, by countries—Continued

(Short tons)

Commodity[1]	1968	1969	1970 p
Africa:			
Algeria	11,624	(2)	--
Arab Republic of Egypt	992	2,564	e 2,600
Kenya	2,539	1,765	e 1,800
Mozambique	132	e 130	e 130
South Africa, Republic of	567	935	358
Asia: Korea, Republic of	3,214	2,848	e 2,900
Oceania:			
Australia	2,659	2,516	e 1,370
New Zealand	2,384	6,485	e 6,600
Total	r 1,783,939	1,766,308	1,697,046

e Estimate. p Preliminary. r Revised.
[1] In addition to the countries listed, Brazil, Bulgaria, Colombia, Hungary, Japan, Romania, and Yugoslavia produce diatomite, but available information is inadequate to make reliable estimates of output levels.
[2] Revised to zero. Output was terminated during 1969; export shipments during 1970 were from accumulated stocks.

TECHNOLOGY

Properly prepared diatomite has been incorporated into the formulation for polyethylene as an antiblocking agent. When polyethylene is extruded or blown in an envelope or sleeve, the polyethylene and the sleeve surfaces are smooth, and therefore, as they come together, they block or stick together. The addition of the diatomite into the polyethylene film serves to inhibit the blocking effect, but preserves the properties of the polyethylene film.[2]

Experiments using narrow pass-band, thermal infrared imagery in the 3- to 4- and 4.5- to 5.5-micron range have indicated that diatomite and other minerals have significant thermal characteristics that can be recognized from properly instrumented aircraft by selecting the correct band.[3]

Patents issued during the year in both the United States and Canada indicate interest in the development of techniques to remove clay and other contaminants from impure or low-grade diatomites.[4]

A method was described for removing manganese from well water. The manganese in the water was oxidized by adding potassium permanganate. Diatomite and soda ash were added to the water, and the oxidized manganese was precipitated from solution and removed by diatomite vacuum filters.[6]

[2] Kadey, F. L., Jr. Diatomite. Min. Eng., v. 24, No. 1, January 1972, pp. 38–39.
[3] Carter, William D. ERTS-A-A, New Apogee for Mineral Finding. Min. Eng., v. 23, No. 5, May 1971, pp. 51–53.
[4] Kouloheris, A. P., (assigned to Cities Service Co.). Beneficiation of Diatomacious Earth. U.S. Pat. 3,572,500, Mar. 30, 1971.
Visman, J., and J. L. Picard (assigned to Canadian Department of Energy, Mines, and Resources). Canadian Pat. 89,249, Jan. 11, 1972.
[6] Castabile, J., and H. Preston. Diatomite Filter Ends Manganese Problem. J. Am. Water Works Assoc., v. 63, No. 4, April 1971, pp. 230–232.

Feldspar, Nepheline Syenite, and Aplite

By J. Robert Wells [1]

FELDSPAR

Production and consumption of crude feldspar in the United States increased in 1971 and more than compensated for the 1970 decline, climbing to within 2 percent of the alltime record tonnage of 1969. The total value of the 1971 output was the highest on record, 3 percent more than the 1970 figure and almost 50 percent above the annual average of the previous decade. These feldspar statistics, together with those showing U.S. consumption in 1971 of aplite and Canadian nepheline syenite in record or near-record quantities, attested to the solid prosperity of the container-glass industry, which provides by far the largest domestic market for these feldspathic materials. The dimensions of this industry can be visualized by noting that the year's total of glass-container shipments came to 38 billion units—equivalent in volume to the Great Pyramid of Cheops 20 times over.

Events in 1971 indicated that the throw-away bottle is probably here to stay but that a better means needs to be devised for channeling the discarded glass into recycling or alternative-utilization schemes that have the potential of being profitable. Achievement of that end would be beneficial to the producers of feldspathic materials, to the manufacturers of glass containers, and to the general public. Intensive research sponsored by private organizations and Government agencies is now being directed toward that goal.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient feldspar statistics

	1967	1968	1969	1970	1971
United States:					
Crude:					
Sold or used by producers_____long tons__	615,397	667,679	673,985	648,276	663,223
Value__________________thousands__	$7,086	$8,265	$8,869	$9,638	$9,969
Average value per long ton______	$11.51	$12.38	$13.16	$14.87	$15.03
Imports for consumption______long tons__	280	--	46	225	120
Value__________________thousands__	$8	--	$7	$23	$19
Average value per long ton______	$28.04	--	$158.36	$102.22	$158.33
Consumption, apparent [1]______long tons__	615,677	667,679	674,031	648,501	663,343
Ground:					
Sold by merchant mills________short tons__	663,220	730,737	793,052	647,995	601,618
Value__________________thousands__	$8,843	$9,242	$10,465	$9,458	$8,716
Average value per short ton_____	$13.33	$12.65	$13.20	$14.60	$14.48
Imports for consumption______long tons__	2,783	3,377	4,644	3,247	2,120
Value__________________thousands__	$72	$91	$128	$93	$65
Average value per long ton______	$26.00	$26.86	$27.72	$28.64	$30.66
World Production____________thousand long tons__	2,005	2,208	2,408	2,346	2,231

[1] Measured by quantity sold or used by producers plus imports.

DOMESTIC PRODUCTION

Crude Feldspar.—North Carolina has held first place as a domestic source of crude feldspar since 1916, and the industry's production facilities in that State have been expanded notably in recent years. In 1971, International Minerals & Chemical Corp. placed in operation a completely new and modern feldspar flotation plant near Spruce Pine, adding substantially to that firm's production capacity. Also near Spruce Pine, Lawson-United Feldspar and Mineral Co. brought near to completion a program initiated in 1968 for major expansion and modernization of the Minpro feldspar processing plant. Feldspar was mined in 1971 in 10 States, eight of which reported production increases. These increases compensated for declines in two other States (as well as for Maine's withdrawal from the list of feldspar producers, the first such absence for that State in 77 years), and carried the year's production beyond that of 1970 by 2 percent in quantity and 3 percent in total value. North Carolina, California, Connecticut, and South Carolina (in order of output) jointly accounted for 88 percent of the 1971 tonnage and 86 percent of the total value; Georgia, South Dakota, Virginia, Wyoming, Arizona, and Colorado supplied the remainder.

Leading feldspar producers were The Feldspar Corp., with mines in Mitchell County, N.C., Middlesex County, Conn., and Jasper County, Ga.; International Minerals & Chemical Corp., with mines in Mitchell County, N.C., Custer County, S. Dak., and Mohave County, Ariz.; and Wedron Silica Co. in Monterey County, Calif.

In 1971, 6 percent of the total tonnage of crude felspar sold or used by producers in the United States was hand-cobbed material, 60 percent was flotation concentrate, and 34 percent was feldspar in feldspar-silica mixtures. As indicative of trends, the corresponding figures for 1966 were 18 percent, 62 percent, and 20 percent, respectively; for 1961, the figures were 23 percent, 62 percent, and 15 percent, respectively.

Ground Feldspar.—For glass-furnace feed, feldspar customarily is ground no finer than 20 mesh; feldspar to be used for ceramics and filler applications is pulverized to minus 200 mesh or finer. Seven companies, operating 13 plants in seven States, ground feldspar for market in 1971, supplying ground material (7 percent less in total tonnage than in 1970) for shipment to destinations in 30 States and four foreign countries. Listed in order of output tonnages, North Carolina had six grinding mills, Connecticut had one, and California had two; these were the leaders in ground feldspar production and jointly supplied 78 percent of the 1971 total. Following in order, South Carolina, Georgia, South Dakota, and Arizona were the four States that made up the remaining 22 percent.

Table 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar							
	Hand-cobbed		Flotation concentrates		Feldspar-silica mixtures [1]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1967	97,409	$848	385,005	$4,900	132,983	$1,338	615,397	$7,086
1968	78,401	670	427,770	5,845	161,508	1,750	667,679	8,265
1969	60,685	494	331,519	4,912	281,781	3,462	673,985	8,869
1970	47,116	543	370,603	5,395	230,557	3,699	648,276	9,638
1971	40,409	749	395,378	5,454	227,436	3,766	663,223	9,969

[1] Feldspar content.

Table 3.—Production of ground feldspar, by uses

(Short tons)

	1970		1971	
	Quantity	Value	Quantity	Value
Hand-cobbed:				
Glass	W	W	W	W
Pottery	18,488	$391,769	12,294	$284,706
Enamel	W	W	W	W
Other	27,967	579,826	24,435	530,426
Total	46,455	971,595	36,729	815,132
Flotation concentrates:				
Glass	304,279	3,132,444	W	W
Pottery	W	W	174,660	2,902,224
Other	200,858	3,898,960	255,513	2,759,837
Total	505,137	7,031,404	430,173	5,662,061
Feldspar-Silica Mixtures: [1]				
Glass	W	W	W	W
Pottery	W	W	W	W
Other	96,403	1,454,878	134,716	2,238,450
Total	96,403	1,454,878	134,716	2,238.450
Total Feldspar:				
Glass	357,196	3,729,281	306,919	3,532,706
Pottery	232,921	4,441,267	W	W
Enamel	W	W	W	W
Other	57,878	1,287,329	294,699	5,182,937
Total	647,995	9,457,877	601,618	8,715,643

W Withheld to avoid disclosing individual company confidential data; included with "Other".
[1] Feldspar content.

CONSUMPTION AND USES

Crude Feldspar.—In 1971, as usual, little or no feldspar was consumed as the unprocessed mine product; the majority of users received their supplies of the mineral already ground and sized either by the primary producers or by merchant grinders. Some manufacturers of pottery, soaps, and enamels, however, purchased comparatively small quantities of crude feldspar for grinding to their preferred specifications in their own mills.

Ground Feldspar.—The 1971 pattern of ground feldspar consumption in the United States was similar to that of the previous year, but the confidential status of some of the 1971 data precludes direct comparison. The 1971 end-use distribution, insofar as publishable, showed that 51 percent of the total was consumed for glassmaking. and 49 percent for pottery, enamel and miscellaneous uses, combined; compared with 1970 data, which showed 55 percent for glass, 36 percent for pottery, and 9 percent for enamel, and other uses. The comparable averages of the annual end-use figures for the decade of the 1960's showed that 55 percent of the total was used for glass, 30 percent for pottery, 4 percent for enamel, and 11 percent for other purposes.

These data suggest a trend toward relatively greater consumption of feldspar for pottery and less for enamel. The proportion of feldspar consumption allotted to glass manufacture has remained comparatively stable since the early 1950's, even though the container-glass industry has expanded spectacularly in the interim (shipments of glass containers in 1970 were up from 1950 by a factor of 2½). It seems that the static position of glass-grade feldspar in the consumption pattern is a reflection of the increasing utilization of imported nepheline syenite (5½ times more in 1970 than in 1950), most of which serves, at the expense of feldspar, as a feldspathic material for glassmaking.

Table 4.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1967	1968	1969	1970	1971
California	100,235	W	W	W	W
Illinois	59,837	64,628	51,899	44,801	W
Indiana	W	25,897	21,944	23,853	25,344
Kentucky	15,433	10,180	9,077	15,004	8,732
Maryland	W	W	5,057	W	W
Massachusetts	3,539	3,896	4,072	W	W
Michigan	W	W	1,438	W	W
Mississippi	7,845	8,685	8,931	15,187	16,060
New York	W	20,311	19,668	W	W
Ohio	72,701	87,202	120,756	94,010	56,783
Oklahoma	W	18,385	31,203	14,200	W
Pennsylvania	26,188	27,333	23,566	21,884	19,479
Tennessee	32,998	26,898	29,153	W	W
Texas	23,269	24,449	21,776	32,365	31,984
West Virginia	W	34,720	29,465	30,339	W
Other destinations [1]	321,175	378,153	415,047	356,352	443,236
Total	663,220	730,737	793,052	647,995	601,618

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

[1] Includes Arkansas, Colorado, Kansas (1967); Louisiana, Minnesota, Missouri (1967–68, 1971); New Jersey, Rhode Island, Washington, Wisconsin (1967–70); and shipments indicated by symbol W. Also includes exports to Africa (1967), Canada, Mexico, Philippines (1967–70); Panama (1967); Venezuela (1968, 1971); and other countries.

STOCKS

Comparison of reported figures for production and sales of feldspar indicated that industrial stocks of that mineral may have approximately doubled during 1971. It was estimated that producers had 257,000 long tons of crude feldspar on hand on December 31, 1971, compared with yearend stocks of 133,000 tons in 1970, 65,000 long tons in 1969, and 100,000 long tons in 1968.

PRICES

Engineering and Mining Journal, December 1971, cited the following prices per short ton for feldspar (generally 2 to 15 percent higher than comparable 1970 quotations), f.o.b. mine or mill, carload lots, depending on grade:

North Carolina:	
20 mesh, flotation	$12.00
40 mesh, flotation	$14.00– 20.00
200 mesh, flotation	21.50– 26.00
Georgia:	
40 mesh, granular	20.00
200 mesh	24.50
325 mesh	25.50
Connecticut:	
20 mesh, granular	15.50
200 mesh	22.50
325 mesh	23.50

These quotations were probably indicative of price ranges, but rates involved in actual transactions, settled upon in buyer-seller negotiations, were not publicly disclosed.

Feldspar prices quoted by Industrial Minerals (London), December 1971 (when converted from pounds sterling per long ton to dollars per short ton) were as follows:

Ceramic-grade, powder, 200 mesh, bagged, ex-store	$47–$51
Lump, imported, c.i.f.	23– 28

FOREIGN TRADE

Exports from the United States in 1971 included 3,557 long tons of material indeterminately classified by the Bureau of the Census as feldspar, leucite, nepheline, or nepheline syenite (but presumably all or mostly feldspar) with a total value of $141,234, 28 percent below comparable figures for 1970.

Feldspar imports in 1971 were at the lowest level since 1965 in tonnage and since 1961 in total value. Conforming to the usual pattern, 1971 imports of feldspar were more than balanced by corresponding exports, but both of these items were of minor significance compared with imports of Canadian nepheline syenite. U.S. imports in 1971, in addition to materials specifically listed in the feldspathic category, included 4,297 long tons of material valued at $376,391 that was classified as "natural mineral fluxes, crushed, ground, or pulverized."

The appropriate tariff schedule called for a duty of 2 cents per long ton on crude feldspar and of 4 percent ad valorem on ground feldspar during 1971 (down from 5 cents per long ton and 5 percent ad valorem, respectively, in 1970).

Table 5.—U.S. imports for consumption of feldspar

Country	1970 Long tons	1970 Value	1971 Long tons	1971 Value
Crude:				
Canada	223	$21,351	120	$19,020
South Africa, Republic of	2	1,630	--	--
Total	225	22,981	120	19,020
Ground, crushed or pulverized:				
Canada	3,087	86,426	1,831	54,858
Japan	--	--	1	432
Mexico	--	--	14	288
Sweden	160	6,688	108	4,230
United Kingdom	--	--	166	5,113
Total	3,247	93,114	2,120	64,921

Kennedy-round reductions effective on January 1, 1972, eliminated the duty on crude feldspar and reduced the duty on ground felspar to 3½ percent ad valorem. A 10-percent surcharge on all dutiable imports (not to exceed the statutory limit) was imposed August 16, 1971, and abrogated December 20, 1971. No duty is charged on imports of nepheline syenite.

WORLD REVIEW

Canada.—The total value of feldspar production in Canada in 1970, all from mines in Quebec, was $291,000, corresponding to a unit value of $27 per long ton, and the unit value of the 1971 output was estimated at $30 per short ton. Both figures are notably higher than either producers' estimates or journal quotations in the United States.[2] About 45 percent of Canada's 1970 feldspar production was exported to the United States, but only one-fifth to one-fourth of the 1971 output had been disposed of in that manner at yearend.

Indusmin, Ltd., a subsidiary of Falconbridge Nickel Mines, Ltd., started mining nepheline syenite at Nephton, Ontario, more than 35 years ago and recently marked a milestone by shipping the 4-millionth ton of that mineral, valued as basic raw material in the manufacture of glass, porcelain enamel, and ceramics, and also as a filler for paints, paper, plastics, and foam rubber. Canada's total 1970 production of nepheline syenite, also mined in Ontario by International Minerals & Chemical Corp. (Canada), amounted to 435,000 long tons valued at $5.8 million; a preliminary estimate showed closely similar figures for 1971. Approximately 80 percent of the 1970 total was exported to the United States, but in 1971 the general economic decline kept U.S. demand at a comparatively low level.

India.—Market value of India's 1970 feldspar production was 248,000 rupees, equivalent to $32,000, one-fifth less than the corresponding figure for 1969.

Mexico.—Feldspar, kaolin, fluorspar, and wollastonite, all from local sources, together with talc and ball clay imported from the United States, are the principal raw materials used by Cerámica Regiomontaña Monterrey, one of Mexico's leading producers of ceramic tile. The firm currently turns out finished ware in 160 shapes and sizes, 100 colors, and 350 decorative schemes at the rate of 17 million pieces monthly, and an expansion is now underway that is expected to increase the plant capacity 20 percent. About one-fifth of the present production is marketed in the United States.[3]

Norway.—Production of feldspathic materials in 1970, principally for export, amounted to 280,000 long tons consisting of potash or plagioclase feldspar and nepheline syenite in roughly equal proportions. A/S Norsk Nefelin, a subsidiary of Christiania Spigerverk, produced nepheline syenite at an open pit operation on Stjernøy, one of the Lofoten Islands. Norsk's facility, far above the Arctic Circle and one of Europe's farthest north mines, now supplies one-third of the world's current requirement of nepheline syenite and is scheduled for a twofold expansion in production capacity during the present decade.

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[2] Canadian Mining Journal. Canadian Mineral Production 1970–71, in Detail. V. 93, No. 2, February 1972, pp. 50–51.

[3] Vincent, George. Mexican Tile Production Matches World Efficiency. Ceram. Ind., v. 96, No. 3, March 1971, pp. 32–33.

Table 6.—Feldspar: World production by country

(Long tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada (shipments)	11,058	9,514	8,929
Mexico	82,174	81,515	[p] 82,000
United States (sold or used)	673,985	648,276	663,223
South America:			
Argentina	21,491	29,070	[e] 29,500
Chile	1,283	3,543	636
Colombia	21,702	22,786	24,444
Peru	1,019	[e] 1,000	[e] 1,000
Uruguay	1,218	1,088	1,189
Europe:			
Austria	1,777	1,187	2,614
Finland	52,555	61,145	[e] 64,000
France [2]	197,000	118,000	[e] 120,000
Germany, West	355,573	402,352	294,725
Italy	209,286	174,338	189,458
Norway [3]	126,033	[e] 128,000	[e] 128,000
Poland [e]	29,000	30,000	30,000
Portugal	28,620	30,322	16,036
Spain [2]	43,044	54,214	[e] 55,000
Sweden	[r] 32,699	31,396	[e] 31,500
U.S.S.R. [e]	245,000	245,000	245,000
United Kingdom (china stone)	32,579	[e] 33,000	[e] 33,000
Yugoslavia	44,272	48,722	[e] 49,000
Africa:			
Arab Republic of Egypt (formerly United Arab Republic)	2,953	1,759	[e] 2,000
Ethiopia	11,459	--	--
Kenya	1,535	881	2,608
Malagasy Republic	NA	1	NA
Mozambique	197	29,188	16,036
South Africa, Republic of	21,688	18,598	12,047
Asia:			
Burma	920	625	2,220
Ceylon	594	1,273	[e] 1,280
Hong Kong	1,909	1,595	1,127
India	31,712	28,793	34,316
Japan [4]	60,029	57,459	51,286
Korea, Republic of	23,065	27,677	16,620
Pakistan (formerly West Pakistan)	420	136	300
Philippines	34,832	19,916	[e] 19,500
Oceania: Australia	4,937	3,328	[e] 2,000
Total	[r] 2,407,618	2,345,697	2,230,594

[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 South-West Africa produce feldspar, but available information is inadequate to make reliable estimates of output levels.

[2] Includes pegmatite.

[3] Described in source as lump feldspar; does not include nepheline syenite as follows, in long tons: 1969—126,978; 1970—144,722; 1971—157,563.

[4] In addition, the following quantities of aplite and saba were produced: aplite: 1969—421,038, 1970—459,382, 1971—434,195; saba: 1969—8,540, 1970—9,597, 1971—5,535.

Rhodesia, Southern.—Feldspar was produced in 1970 from the Augustus and the Mistress mines, both in the Salisbury district and owned by Augustus Beryllium Co. (Pvt.), Ltd., and Rhodesian Base Minerals Production Co., respectively. Specific quantitative data concerning these operations are not available, but it was reported that in 1970 the total value of all minerals produced in Rhodesia was 13 percent more than in 1969 and 46 percent more than in 1968.[4]

South Africa, Republic of.—Exports of feldspar during the first 9 months of 1971 amounted to 8,681 long tons valued at $466,000, compared with 8,045 long tons and $362,000 in the same period of the preceding year. Twelve-month totals for feldspar exports were 12,919 long tons and $586,000 in 1970; 15,719 long tons and $526,000 in 1969. Local sales of feldspathic materials, January through September, totaled $598,000 and $588,000 in 1971 and 1970, respectively, compared with $771,000 for all of 1970 and $686,000 for all of 1969.[5] The Republic's feldspar production tonnages for 1969, 1970, and 1971 (preliminary) are listed in Table 6.

United Kingdom.—A mapping and core drilling reconnaissance carried out by

[4] Central Statistical Office, Salisbury. Monthly Digest of Statistics, February 1972, p. 16.

[5] Republic of South Africa. Department of Mines Quarterly Information Circular. October–December 1970, pp. 28, 30; July–September 1971, pp. 29, 31.

Charter Exploration, Inc., revealed that a deposit at Durness, northwest Scotland, contains more than 2 million tons of recoverable feldspar in grades suitable for the manufacture of glass and ceramics. Plans were announced for the operation during the next 18 months of a pilot mill and for the eventual construction of a full-scale plant for the beneficiation of the Durness mineral. Nearby Lock Eribol provides convenient deep-water shipping, and an assured market for the product exists within the United Kingdom, which is now entirely dependent upon imports for its feldspar requirements.

TECHNOLOGY

A series of articles published in a British journal reviewed technologies involved in modern processes for the beneficiation of a number of nonmetallic minerals including feldspar. Specific mention was made of feldspar in discussion of processing costs in the United Kingdom and the availability of pertinent engineering services in the United Kingdom [6]; of size reduction (crushing, grinding, and related subjects including feldspar grinding mill capacity and performance) [7]; and of applicable separation/concentration methods based on size and shape (hand picking), electromagnetic characteristics, and surface properties (froth flotation with specified reagents).[8]

The research program of the Bureau of Mines in 1971 included a continuing effort to devise advantageous procedures for converting a waste material (the unwanted fines resulting from crushed granite production) to marketable products such as feldspar and glass sand and/or usable feldspar-silica mixtures. Progress was reported in the study of undersize fractions from both Georgia and South Carolina granites.

Other Bureau research with a potentially significant influence, even though indirect, upon the domestic consumption of feldspathic materials was aimed at finding profitable applications for presently discarded waste glass, especially container glass, by far the largest outlet for these minerals. Two approaches among those explored—incorporation of waste glass in clay mixtures for the making of brick or tile and utilization of waste glass as a major raw material in the manufacture of lightweight building units—appeared especially promising. A number of non-Government organizations, including the Glass Container Manufacturers Institute, the Coca Cola Co., and others, also actively pursued parallel or divergent avenues in search of technologies for the economical recycling or alternative utilization of junked container glass.

Information published in a magazine described recent design and computer control innovations for bottle forming machines that make it possible to achieve faster production rates for higher quality glass containers at lower unit cost. Feldspar-formulated glass is especially favorable for automated-machine fabrication, so that an obvious implication is a continuing expansion of feldspar consumption for this purpose.[9] A related development with similar implications was described in another journal article.[10] Technological details of a modern production facility for color TV picture tubes were published in an industrial magazine. Two distinct batch formulations, melted in separate furnaces, are required to produce the glass funnel and faceplate units that are the major components of the tubes. Descriptions were included of the automated forming machines and of the equipment used in the storage and handling of an extensive list of raw materials including glass sand, soda ash, potash, strontium carbonate, dolomite, potassium nitrate, potassium silicofluoride, lead oxide, and nepheline syenite from Canada.[11]

The manufacture of ceramics holds second place after glassmaking in the feldspathic end-use pattern, and 1971 witnessed a number of significant technological advances affecting that industry. Pertinent

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[6] Jones, G. K. Engineering for Industrial Minerals Treatment Plant. Ind. Miner. (London). No. 45, June 1971, pp. 37–43.

[7] Jones, G. K. Size Reduction and Size Enlargement. Ind. Miner. (London), No. 47, August 1971, pp. 33–43.

[8] Jones, G. K. Concentration of Minerals by Size and Gravity. Ind. Miner. (London), No. 49, October 1971, pp. 43–50.

———. Separating Minerals by Froth Flotation, Electrical Properties, and Other Methods. Ind. Miner. (London), No. 51, December 1971, pp. 39–50.

[9] The Glass Industry. The Continuous Motion Concept. V. 52, No. 7, July 1971, pp. 230–233.

[10] Svec, J. J. Automated Batch Plant Improves Glass Quality. Ceram. Ind., v. 97, No. 1, July 1971, pp. 34–35.

[11] The Glass Industry. RCA's $19-Million Glass Plant. V. 52, No. 6, June 1971, pp. 208–211, 212–213.

details of some of these developments and of others expected in the near future were published in several magazine articles.[12]

Of theoretical interest, although perhaps with little immediate commercial significance for the feldspar industry, was the announced production of superior electronic components consisting of 99-percent-pure anorthite, the lime-rich end member of the plagioclase feldspar solid-solution series. No more than minuscule quantities of material were involved in the fabrication of these microscopic articles, and the naturally occurring mineral was too impure to compete with the artificial substance synthesized for the purpose by reacting calcite with kaolinite.[13]

A major feldspar outlet, ranking third after glassmaking and pottery, is the preparation of mixtures for porcelain enameling. In one of the conventional procedures, the coating materials are sprayed on metal as water-dispersed slurries and then dried for firing. Exploratory consideration was given to a process based on a U.S. discovery, but developed primarily in Europe for paint, that may make it possible to realize important advantages by applying the enamel powders dry in the form of electrically charged particles sprayed on a grounded metal surface.[14]

A process was patented in which feldspar ore is treated with a cationic, surface-active substance to establish a differential in electrostatic susceptibility between particles of the desired mineral and those of the accompanying gangue. The treated ore is then subjected at ambient temperature to an electrostatic field in a fluidized bed to accomplish a separation of the components.[15] Also in the field of minerals beneficiation technology, a patent was issued for an improved frothing agent obtained by reacting primary or secondary butanol with ethylene and propylene oxides, use of which was claimed to increase recovery in the flotation treatment of feldspar ores.[16] Advantages were claimed for a patented process for the drying of feldspar flotation concentrate in which the dewatered feed material in a dough-like condition is formed into pellets either before or after entering a fluidized bed composed of dried pellets of the same material suspended and kept in motion by a rising column of heated gas.[17]

Patents were granted for the use of ground feldspar as a filler for producing filled polyamide plastic articles with superior impact strength[18] and to serve as a bonding flux in mixtures with pulverized granite and other specified ingredients for the manufacture of ceramic structural tiles with the appearance of natural stone.[19]

NEPHELINE SYENITE

Nepheline syenite is a feldspathic igneous rock similar in texture to granite that is finding a growing application in place of feldspar as an alumina-bearing raw material for glassmaking and in the whitewares industry both as a body component and in glazes. In a comparatively recent development, substantial and increasing quantities of this mineral commodity are being ground to extreme fineness for use as a filler in plastics, foam latex products, and paint. Nepheline syenite mined in the United States (Arkansas) is used only as stone (chiefly for roofing granules or road metal); all nepheline syenite consumed domestically in feldspar-competitive applications is imported from Canada, the world's foremost producer. Canada's 1971 output of nepheline syenite, all from two operations at Blue Mountain in Ontario, was estimated at 500,000 short tons (446,000 long tons), valued at $6 million, of which approximately 20 percent was consumed in Canada, mostly in the

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[12] Bryan, Arthur. 20th Century Revolution Coming in Pottery. Ceram. Ind., v. 96, No. 5, May 1971, pp. 18–19, 22–23.
Ceramic Industry. Unbreakable Ceramics by the Year 2000? V. 97, No. 1, July 1971, p. 5.
———. A Solution to Mass Feeding—Disposable China. V. 97, No. 1, July 1971, pp. 28–29.

[13] Gdula, R. A. Anorthite Ceramic Dielectrics. Am. Ceram. Soc. Bull., v. 50, No. 6, June 1971, pp. 555–557.

[14] Svec, J. J. Dry Electrostatic Deposition—A Porcelain Enameling Process? Ceram. Ind., v. 97, No. 1, July 1971, pp. 33, 46–47.

[15] Robert, D. (assigned to Ste. de Produits Chimiques d'Auby, Neuilly-sur-Seine, France). Method of Selectively Separating Particles by Electrostatic Sorting in Fluidized Bed. U.S. Pat. 3,563,375, Feb. 16, 1971.

[16] Booth, R. B. (assigned to American Cyanamid Co.). Canadian Pat. 882,949, Oct. 5, 1971.

[17] Brociner, R. E. (assigned to English Clays, Lovering Pochin & Co., Ltd.). British Pat. 1,254,-105, Nov. 17, 1971.

[18] Hermann, K. H. (assigned to Farbenfabriken Bayer A.G.). Canadian Pat. 881, 594, Sept. 21, 1971.

[19] Wittels, W. (assigned to Certels, Ltd.). British Pat. 1,249,858, Oct. 13, 1971.

manufacture of glass and ceramics; 80 percent was exported, 75 percent to the United States and 5 percent to destinations in at least 10 other countries.[20] The average unit values reported for Canadian production and U.S. imports of nepheline syenite in 1971, $12.00 and $11.88 per short ton, respectively, were below the midpoint of the price range cited in Ceramic Industry Magazine for January 1972 ($8 per ton, to $22 per ton), compared with the range of $8 to $21 per ton quoted the previous year.

Table 7.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1969	166	$2	346,513	$4,449
1970	538	9	352,937	4,634
1971	568	12	369,520	4,912

[20] Killin, A. F. Industrial Minerals. Can. Min. J., v. 93, No. 2, February 1972, pp. 146–148.

APLITE

Aplite is a granitic rock of variable composition with a high proportion of albite (soda feldspar) or plagioclase (lime-soda feldspar), either of which gives it potential value as a raw material for the manufacture of container glass. To become acceptable for that purpose, however, the as-mined material usually must first be processed to eliminate all but a small fraction of the iron-bearing minerals it contains. Aplite of glassmaking quality was produced in the United States in 1971 from two mines in central Virginia. The Feldspar Corp. mined aplite ore near Montpelier, Hanover County, and removed iron from it by an electrostatic process. International Minerals & Chemical Corp., operated a mine near Piney River in Nelson County and subjected the crude aplite to a high-intensity magnetic treatment to separate iron minerals. Aplite mine production in 1971, continuing the upward trend of recent years, was 8 percent greater in tonnage than in 1970 and established a new alltime high in total value, 1 percent above that of the previous year. Ceramic Industry Magazine, January 1972, quoted a 1971 aplite price range of from $6.30 to $12.40 per ton, with the midpoint 38 percent higher than that of the comparable quotations for 1970. Specific annual data on aplite production, sales, and value have not been released for publication since 1962.

Ferroalloys

By Frank L. Fisher [1]

The structure of the domestic ferroalloy processing industry was unchanged from 1970. Worldwide recession in the iron and steel industry, as well as a growing trend toward processing ferroalloys within the country of resource origin, resulted in a significant loss in the United States exports. The net reduction in export tonnage from 1970 to 1971 was approximately 64,000 tons with a value loss of about 58 percent or $33 million. Most ferroalloy prices remained unchanged during the year.

Detailed information concerning the more significant ferroalloys may be found in chapters for the alloying elements: manganese, chromium and silicon.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Government inventory of ferroalloys (stockpile grade), December 31, 1971

(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	33	59
Ferrocolumbium (contained columbium)	(1)	--	(1)
Ferromanganese:			
High-carbon	143	1,033	1,176
Medium-carbon	29	--	29
Ferromolybdenum (contained molybdenum)	4	--	4
Ferrotungsten (contained tungsten)	1	--	1
Ferrovanadium (contained vanadium)	1	--	1

[1] Less than ½ unit.

Table 2.—Ferroalloys produced and shipped from furnaces in the United States

	1970				1971			
	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]	835,463	78.5	807,368	$134,456	759,896	78.6	799,593	$134,594
Silicomanganese	193,219	66.0	172,988	32,024	164,682	66.0	144,062	28,064
Ferrosilicon	709,287	59.2	659,216	136,238	687,166	64.2	678,369	155,850
Silvery iron	196,369	18.2	207,664	16,853	171,778	17.7	174,160	15,902
Chromium alloys:								
Ferrochromium [2]	309,613	69.0	289,395	100,667	248,165	68.3	252,766	100,841
Other chromium alloys [3]	96,163	45.0	81,552	25,606	107,493	44.0	102,009	36,518
Total	405,776	63.2	370,947	126,273	355,658	61.0	354,775	137,359
Ferrotitanium	3,360	29.0	3,291	3,503	3,363	28.2	3,094	3,261
Ferrophosphorus	164,107	24.0	176,065	6,539	101,353	24.0	89,252	4,527
Ferrocolumbium	1,260	56.7	1,421	9,385	830	61.4	1,627	7,204
Other [4]	86,347	38.0	90,689	82,807	86,329	44.1	81,275	71,579
Grand total	2,595,188	60.5	2,489,649	548,078	2,331,055	62.6	2,326,207	558,340

[1] Includes briquets and fused-salt electrolytic.
[2] Includes low- and high-carbon ferrochromium and chromium briquets.
[3] Includes ferrochrome-silicon, exothermic chromium additives, and other chromium alloys.
[4] Includes Alsifer, ferroboron, ferronickel, ferromolybdenum, ferrotungsten, ferrovanadium, Simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, and other miscellaneous ferroalloys.

DOMESTIC PRODUCTION

The number of ferroalloy producers remained the same as in 1970; 29 companies reported ferroalloy production. This production originated in 48 locations, a decrease of two from 1970. The drop in production was approximately 10 percent. The volume of shipments also declined, although the value increased owing to higher prices.

Table 3.—Producers of ferroalloys in the United States in 1971

Producer	Plant location	Product [1]	Type of furnace
Agrico Chemical Co	Pierce, Fla	FeP	Electric.
Airco Alloys & Carbide	Calvert City, Ky; Charleston, S.C; Mobile, Ala; Niagara Falls, N.Y	FeCr, FeCrSi, FeMn, FeSi, SiMn, Silvery iron.	Do.
Alabama Metallurgical Corp	Selma, Ala	FeSi	Do.
Bethlehem Steel Co	Johnstown, Pa	FeMn	Blast.
Chromium Mining & Smelting Co	Woodstock, Tenn	FeMn, SiMn, FeCr, FeSi, FeCrSi.	Electric.
Climax Molybdenum Co	Langeloth, Pa	FeMo	Aluminothermic.
Diamond Shamrock Corp	Kingwood, W. Va	FeMn	Electric.
FMC Corp	Pocatello, Idaho	FeP	Do.
Foote Mineral Co	Cambridge, Ohio; Graham, W. Va; Keokuk, Iowa; Vancoram, Ohio; Wenatchee, Wash	FeB, FeCb, FeTi, FeV, FeCr, FeCrSi, FeSi, Silvery iron, other.[2]	Do.
Hanna Furnace Corp	Buffalo, N.Y	Silvery iron	Blast.
Hanna Nickel Smelting Co	Riddle, Oreg	FeNi	Electric.
Hooker Chemical Corp	Columbia, Tenn	FeP	Do.
Interlake Steel Corp	Beverly, Ohio	FeCr, FeCrSi, FeSi, SiMn.	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.
NL Industries, Inc	Niagara Falls, N.Y	FeCTi, FeTi, other [2]	Do.
New Jersey Zinc Co	Palmerton, Pa	Spln	Do.
Ohio Ferro-Alloys Corp	Brilliant, Ohio; Philo, Ohio; Powhatan, Ohio; Tacoma, Wash	FeCr, FeSi, FeB, FeMn, SiMn, other.[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	Mt. Pleasant, Tenn; Silver Bow, Mont	FeP	Electric.
Tennessee Alloys Corp	Bridgeport, Ala	FeSi	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.
Tenn-Tex Alloy Chemical 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; FeCTi, ferrocarbontitanium.

[2] Includes Alsifer, Simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

CONSUMPTION

The downward trend in the consumption of ferroalloys in steel production continued in 1971. Total consumption dropped approximately 1 percent. A major increase was registered for silicon alloys consumed as additives; consumption of ferromanganese was the largest volume during the year. Silicon and ferrophosphorus increased and ferromanganese, silicomanganese, ferrotitanium, and ferroboron decreased for the six categories reporting. The major consuming segment was for carbon steels. The use of ferroalloys as an additive in cast iron was the second major end use.

The drop in consumption of ferroalloys as alloying elements was primarily due to a decline in the consumption of ferrochrome, the major consuming segment. Approximately 95 percent of the ferrochrome consumed is used as an alloy element, the majority of which is used in the manufacture of stainless steel.

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1971

(Short tons)

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]	14,517	138,496	717,316	1,318	28,187	342	15,984	28,413	944,573
Silicomanganese	6,213	30,530	74,206	8	3,512	W	2,297	6,147	122,913
Silicon alloys [3]	18,458	76,638	128,027	3,306	405,621	332	54,833	83,380	770,595
Ferrotitanium [4]	343	594	893	W	74	564	1,002	1,978	5,448
Ferrophosphorus [5]	13	1,344	9,198	--	2,141	------	375	5,742	18,813
Ferroboron	W	112	W	4	--	W	W	113	229
Total	39,544	247,714	929,640	4,636	439,535	1,238	74,491	125,773	1,862,571

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 and silvery iron.
[4] Includes other titanium materials.
[5] Includes other phosphorus materials.

Table 5.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1971

(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]	128,967	39,806	5,325	1,608	5,501	8,476	3,284	5,315	198,282
Ferromolybdenum [3]	792	967	227	374	1,316	155	428	211	4,470
Ferrotungsten [4]	40	42	--	205	W	25	18	54	384
Ferrovanadium [5]	28	2,511	741	388	52	10	73	368	4,171
Ferrocolumbium	282	394	404	--	--	244	13	21	1,358
Ferrotantalum-columbium	W	W	W	--	--	W	W	16	16
Total	130,109	43,720	6,697	2,575	6,869	8,910	3,816	5,985	208,681

W Withheld to avoid disclosing individual company confidential data; included in "Other uses."
[1] Includes unspecified uses.
[2] Includes other chromium ferroalloys and chromium metal.
[3] Includes calcium molybdate.
[4] Includes melting base self-reducing tungsten.
[5] Includes other vanadium-carbon-iron ferroalloys.

STOCKS

Consumers' stocks of ferroalloys increased sharply during the year; significant upward trends were reported for manganese and silicon stocks, while ferrophosphorus and ferroboron stocks increased slightly. The other ferroalloys showed downward trends.

Producers' stocks of manganese ferroalloys, and silicon alloys dropped during 1971 compared with those of 1970. Total stocks at producers were down, although ferrotitanium, ferrophosphorus, and ferrochromium showed increases. Stocks of ferromanganese, the major consuming ferroalloy, dropped about 35 percent during the year.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States, December 31, 1971

(Short tons)

	Producer		Consumer	
	1970, gross weight	1971, gross weight	1970, gross weight	1971, gross weight
Manganese ferroalloys [1]	198,378	128,238	144,850	179,198
Silicon alloy[2]	134,880	130,231	66,055	124,914
Ferrochromium [3]	52,550	79,991	33,875	24,397
Ferrotitanium [4]	1,351	1,639	775	701
Ferrophosphorus [5]	45,628	53,911	2,553	3,333
Ferroboron	703	630	48	55
Total	433,490	394,640	248,156	332,598
	1970, contained element	1971, contained element	1970, contained element	1971, contained element
Ferromolybdenum [6]	W	W	677	588
Ferrotungsten [7]	W	W	181	119
Ferrovanadium	577	1,187	903	544
Ferrocolumbium	426	349	410	379
Ferrotantalum-columbium	--	--	8	17
Total	1,003	1,536	2,179	1,647

W Withheld to avoid disclosing individual company confidential data.
[1] Includes ferromanganese, silicomanganese, spiegeleisen, and manganese metals.
[2] Includes ferrosilicon, silvery iron, and miscellaneous silicon alloys. Consumers' stocks also include silicon metal.
[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

Ferroalloy prices showed no general price trend during 1971. Eight categories posted no change in their price quotations. These were low-carbon ferrochrome, standard ferromanganese, ferromolybdenum, ferrosilicon, ferrotitanium, ferrotungsten (three grades), ferrovanadium (two grades), and silicomanganese. Price increases were noted for special grades of high-purity ferrocolumbium, Solvan brand ferrovanadium, and spiegeleisen.

The price increases were attributed to increased costs in labor and materials. The major ferroalloys (ferrochrome, ferromanganese, and ferrosilicon) showed only minor price changes. High-carbon ferrochrome decreased 1 cent per pound; contained chromium to 26.7 cents per pound. Also, imported ferromanganese registered a decline from $180 to $76 per long ton.

FOREIGN TRADE

A sharp drop in U.S. exports occurred in 1971 as a result of the influx of Soviet ferroalloys into the West European market. Expansion in Japanese ferroalloy industry designed as an aid in supplying their domestic requirements but actually providing an exportable surplus, was also a factor. Sharpest declines in exports were for ferromanganese, ferrochromium, and ferrosilicon. The dollar value of exports dropped from $56 million in 1970 to $23 million in 1971.

Table 7.—U.S. exports of ferroalloys

Alloys	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ferrocerium and alloys	52	$351	39	$275	30	$164
Ferrochromium	24,573	5,679	28,373	8,259	9,164	3,620
Ferromanganese	1,759	483	21,747	4,356	4,526	1,205
Ferromolybdenum	728	2,381	1,007	3,088	677	1,978
Ferrophosphorous	37,351	912	33,106	1,199	35,111	1,419
Ferrosilicon	6,487	1,666	44,694	11,887	25,506	5,603
Ferrotungsten [1]	--	--	--	--	60	411
Ferrovanadium	644	2,834	2,154	12,127	1,351	3,490
Ferroalloys, n.e.c	34,057	9,720	19,964	14,486	10,905	5,249
Total	105,651	24,026	151,084	55,677	87,330	23,139

[1] Classification established Jan. 1, 1971.

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1970			1971		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Chromium metal	1,892	(1)	$3,052	1,632	(1)	$2,966
Ferrocerium and other cerium alloys	9	(1)	54	8	(1)	82
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	12,333	7,592	1,874	44,589	26,965	8,375
Containing less than 3 percent carbon	28,972	r 18,852	7,746	40,598	26,973	14,322
Ferromanganese—						
Containing not over 1 percent carbon	3,148	2,554	1,036	3,773	3,128	1,199
Containing over 1 and less than 4 percent carbon	20,127	16,524	4,247	30,200	24,760	7,274
Containing not less than 4 percent carbon	267,671	207,901	26,280	208,805	161,372	23,919
Ferromolybdenum, molybdenum metal, compounds, alloys, and scrap (molybdenum content)	122	12	779	1	1	5
Ferronickel	r 14,251	(1)	r 9,834	26,233	(1)	16,986
Ferrosilicon	22,404	10,060	4,117	24,467	12,684	5,988
Ferrosilicon-chromium	--	--	--	772	(1)	207
Ferrosilicon-manganese (manganese content)	14,539	9,624	1,774	29,928	19,970	3 949
Ferrotitanium and ferrosilicon-titanium	73	(1)	48	87	(1)	154
Ferrovanadium	24	18	114	69	55	360
Ferrozirconium	660	(1)	260	1,126	(1)	477
Ferrophosphorus	288	(1)	16	916	(1)	45
Manganese metal	1,277	(1)	518	2,870	(1)	1,203
Tungsten metal (lump, grains, or powder) and tungsten carbide (tungsten content)	90	74	1,010	125	116	1,413
Tungsten alloys (unwrought) and scrap (tungsten content)	2	1	29	9	1	6
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)	549	43	1,141	11	7	502
Ferroalloys n.e.c	917	(1)	2,287	1,244	(1)	3,042

r Revised.
[1] Not recorded.

WORLD REVIEW

A new table initiated in the 1971 Minerals Yearbook tabulates world production by country and furnace type. Reduction in output by some countries were offset by output increases in others resulting in a relatively small change over the past three years. Denmark, the U.S.S.R. and West Germany showed decreases of 8, 11, and 13

Table 9.—World production by country [1] and furnace type

(Thousand short tons)

Country	1967	1968	1969	1970	1971 [p]
BLAST FURNACE [2]					
Europe:					
Belgium	--	21	14	3	--
Czechoslovakia	49	(3)	(3)	(3)	(3)
Denmark	8	8	7	10	8
France	355	412	472	536	491
Germany, West [4]	280	362	262	277	231
Hungary	11	13	--	7	8
Italy	20	18	17	24	20
Poland	128	140	147	151	[e] 220
Portugal	8	8	12	8	--
Romania	--	15	9	1	--
U.S.S.R.	1,496	1,552	1,305	1,239	[e] 1,100
United Kingdom	170	185	172	183	170
Africa:					
South Africa, Republic of	57	58	81	51	[e] 60
Asia: Korea, Republic of [5]	8	[e] 10	12	15	16
ELECTRIC FURNACE [6]					
North America:					
Canada [2]	168	167	204	210	213
Mexico	60	62	64	83	[e] 83
United States [2]	2,750	2,621	2,629	2,595	2,692
South America:					
Argentina	20	27	27	35	[e] 34
Brazil	65	[r] 73	81	99	[e] 98
Chile	11	11	13	13	[e] 13
Europe:					
Austria	6	6	7	6	6
Bulgaria	[e] 31	31	41	55	47
Czechoslovakia	107	111	107	115	134
Finland	--	9	29	36	39
France	289	301	341	374	386
Germany, West	177	230	277	297	258
Hungary	15	10	15	11	11
Italy	168	168	168	193	192
Norway	[r] 657	[r] 787	[r] 837	610	714
Poland	119	115	126	131	[e] 132
Spain	89	107	105	123	144
Sweden	230	[r] 254	272	257	[e] 250
Switzerland	2	7	7	[e] 10	25
Yugoslavia	87	94	99	112	128
Africa:					
South Africa, Republic of	338	326	386	389	[e] 430
Asia:					
India	167	186	221	236	235
Japan	1,042	1,175	1,430	1,835	2,083
Taiwan	2	2	2	6	8
Turkey	9	9	10	[e] 10	[e] 10
Oceania: Australia [2] [7]	96	71	87	87	[e] 86
Total	9,295	9,762	10,095	10,433	10,775

[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, Norway, 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 United States included under electric furnace output.

[3] Production not reported separately from that of pig iron, which is presented in the Iron and Steel chapter.

[4] Blast furnace ferromanganese and spiegeleisen only; other blast furnace ferroalloys are included with pig iron production in the Iron and Steel chapter.

[5] Includes electric furnace ferroalloys if any are produced.

[6] 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.

[7] Year ended November 30 of that stated.

percent respectively, while Poland, Japan and Norway increased output 45, 17, and 13 percent respectively.

Canada.—Union Carbide Metals Ltd. announced plans to spend $13.7 million on expansion of its plant at Beauharnois, Quebec. The expansion plans will include a new 80,000-ton-per-year furnace to produce ferromanganese and silicomanganese.

Japan.—Nippon Kokan's Toyama Works started operating its 40,000 kilovolt-ampere Heroult-type electric furnace. It is currently the world's largest electric furnace and replaces 11 smaller conventional electric furnaces.

South Africa, Republic of.—The ferroalloy industry in South Africa is in a sound position in the world market. Supplies of manganese and chrome ore are sufficient to meet demand and are available for export to world markets. Preliminary estimates on exports indicate they will be 10 percent or more above the 1970 figures. Included in the increase in production is Rand Carbide Ltd.'s plant at Witbank, South Africa. Most of the 25,000-ton-per-year production is scheduled for export. South Africa has four major producers. The largest producer is the African Metals Corp. (AMCOR). The required raw materials for establishing an important integrated ferroalloy industry in South Africa are available with the exception of metallurgical-grade coke.

TECHNOLOGY

The steel refining process of electroslag remelting was introduced in several U.S. plants during the year. The electroslag remelting process reportedly permits production of improved quality steels at no increase in cost. Its competitors are vacuum arc remelting and other processes for improving and purifying alloy steels.

Eastern Stainless will use Linde's new process for making stainless steel. It is a two-step method in which (1) the electric furnace melts the charge, and (2) a refining vessel is injected with oxygen and argon for decarburization. The use of argon protects the chromium from oxidation during carburization. This allows the use of less expensive ferrochrome instead of special low-carbon ferrochrome.

Fluorspar and Cryolite

By H. B. Wood [1]

FLUORSPAR

As a whole, the U.S. fluorspar industry continued through 1971 at about the same pace as in 1970. There was a slight increase in domestic shipments of finished fluorspar and a slight decrease in imports for consumption. In 1970, the reported consumption plus a large increase in consumer stockpiles totaled 1,501,680 tons, which was 3.8 percent more than the supply. In 1971, the reported consumption plus a small increase in consumer stockpiles, totaled 1,361,755 tons, which was 5.7 percent less than the supply. (See table 1 and paragraph on producers and consumers stockpiles). Prior to 1970, the usual tendency was for the reported consumption to be less than the reported supply. The 1970 reversal was unusual, owing to a large buildup of consumers' stockpiles after the 1969 labor stoppages.

The reported use by the iron and steel industry was about the same in 1971 as in 1970, but the reported use to make hydrofluoric acid (HF) decreased about 6.5 percent. This reflected the general stagnation of U.S. industry during 1971. Consumption of acid-grade fluorspar by the aluminum industry was less in 1971 owing to (1) salvaging and recycling of fluorine compounds normally emitted from the aluminum electrolytic potlines, and (2) the manufacture of cryolite and aluminum fluoride from formerly wasted fluosilicic acid.

The imports minus exports constituted about 79 percent of the Nation's total requirements for 1971. Mexico continued to be the largest U.S. supplier, providing 79 percent of the imports, or 63 percent of U.S. consumption.

Exploration activities continued at about the same rate as in 1970. Drilling was reported in Idaho, Nevada, Arizona, New Mexico, Texas, Colorado, and Kentucky. Old mines were reopened north of the Big Bend area of west Texas, in the Truth or Consequences area of New Mexico, in the Tonto Basin northeast of Phoenix, Ariz., and in the Meyers Cove area of Idaho.

Legislation and Government Programs.—No contracts for fluorspar exploration were made by the Office of Minerals Exploration during 1971. The percentage depletion allowance rates established in 1969 remained the same; domestic, 22 percent and foreign, 14 percent. In compliance with instructions from the Office of Emergency Preparedness, and Public Law 91–320 dated July 10, 1970, the General Services Administration (GSA) sold 112,643 short dry tons of acid-grade fluorspar (acid-spar) from government stockpiles, receiving $8,295,000. Government inventories as of December 31, 1971, included 890,000 tons of acid-spar containing 350,000 tons of acid-spar credited as 438,000 tons of metallurgical-grade fluorspar (met-spar). Government stocks also included an additional 411,788 tons of met-spar. No future sales were planned since the stockpile objective had been obtained.

During 1971 the U.S. Government, in compliance with the President's economic stabilization program by proclamation No. 4074, imposed a 10-percent ad valorem surcharge on the value of dutiable imports at point of import, not to exceed the statutory limit. Then on December 20, 1971, by proclamation No. 4098, the ad valorem surcharge was removed. Consequently, from August 16 to December 21, the import duty on acid-spar selling for over $32 per ton was increased temporarily from $1.87 to $5.00 per ton, equal to the statutory limit. The import duty on met-spar remained the same because it was already at the statutory limit.

Although some spot orders for foreign-produced fluorspar, mainly from Europe, were effected during this National Emer-

[1] Mining geologist, Division of Nonmetallic Minerals.

gency Program period, the overall flow of imports was not affected greatly because most of the foreign purchase contracts were on an annual basis and could not be modified. Annual imports for consumption did decrease 1.8 percent during 1971, but this was caused mainly by a decrease in demand.

During 1971 Congressional Bills HR 11696, HR 11735, HR 11767, and HR 11976 were introduced into the U.S. Congress to suspend the current import duty on fluorspar until January 1, 1974. No action on these bills was taken during 1971, and as of yearend the bills were still pending in the House Ways and Means Committee.

DOMESTIC PRODUCTION

The Illinois fluorspar mining districts, consisting of Hardin and Pope Counties in southern Illinois, continued as the major sources of domestic fluorspar in 1971 and provided 51 percent of the total shipments for the year. The lead and zinc byproducts of the fluorspar mines were also important to the operations. The mines in Colorado, Montana, Nevada, New Mexico, Idaho, Utah, Arizona, and Kentucky provided the remainder of the total fluorspar shipments but no significant byproducts. Production from Colorado continued at the same rate, thereby maintaining Colorado's position as the second largest fluorspar-producing State in the United States.

In 1971, the mining industry operated about 10 percent above the normal operating level. The market softened during the last quarter of the year, and the major companies reduced their operations to normal. The small increase in total production was due to new mines opening in Texas, Idaho, and Nevada, to Calvert City Chemical Co. reopening its Mexico City mines and mill in Kentucky, and to Kentucky Fluorspar Co. temporarily reopening the Haffaw mine. Throughout the United States, six mines were reported closed or failed to report any production, and six new mines were opened or were rehabilitated and reported production. During the year, 28 mines were operated, but some only intermittently, and 1,200 people were employed by 22 companies operating the mines. In addition, nonoperating companies and individuals reported 30 or more people in prospecting parties.

There were six froth flotation plants in continuous operation, but one of these, operated by Kentucky Fluorspar Co., at Rosiclare, Ill., closed in November and did not announce a reopening date. Another flotation plant operated by Rosiclare Lead and Fluorspar Co. at Rosiclare, Ill., operated intermittently. There were six heavy-media separating plants in operation; another was being moved and under construction; another was operating part-time; and another at Marion, Ky., was closed.

In the Illinois district, in compliance with Bureau of Mines Health and Safety Division orders, Minerva Oil Co. closed its Jefferson and Fairburn mines, and Ozark Mahoning Co. closed its Hill Ledford mine. According to company personnel, the small remaining reserves in the old mines did not warrant the expenditures necessary to modernize and comply with safety requirements. After 2 years of exploration and

Table 1.—Salient fluorspar statistics

	1967	1968	1969	1970	1971
United States:					
Production:					
Crude:					
Mine production short tons	838,631	749,219	533,030	627,212	815,046
Material beneficiated do	914,616	765,531	520,084	698,232	758,169
Material recovered do	284,300	237,000	160,000	252,128	247,250
Finished (shipments) do	295,643	252,411	182,567	269,221	272,071
Value thousands	$13,164	$11,656	$8,411	$13,923	$17,263
Exports short tons	10,345	12,614	3,605	14,952	12,491
Value thousands	$517	$496	$213	$1,145	$525
Imports for consumption short tons	911,870	1,050,107	1,149,546	1,092,318	1,072,405
Value thousands	$24,485	$28,699	$32,818	$32,758	$34,530
Consumption short tons	1,091,158	1,243,414	1,356,624	1,372,404	1,344,742
Stocks Dec. 31:					
Domestic mines:					
Crude do	126,716	97,522	82,177	51,471	165,610
Finished do	22,522	12,557	9,751	12,370	28,259
Consumer plants do	303,718	323,121	290,470	419,746	436,759
World: Production do	3,498,755	4,006,971	4,285,010	4,597,008	5,112,365

development, the Spivey mine of Minerva Oil Co. located near Cave-in-Rock, Ill., was readied for production by November 1971 and placed on standby to await better market conditions. Minerva Oil Co. obtained the Keystone mine in Illinois from Inland Steel Co., rehabilitated the mine, and commenced production from it in 1971.

In Colorado, Ozark-Mahoning Co. started production from the Crystal mine, which is located about 45 miles from the company's flotation plant. Allied Chemical Co. was doing extensive development drilling at its Burlington mine near Jamestown. Although fluorspar prospecting was active throughout Colorado, no other new mines were opened.

In Kentucky, three mines operated during the year and the Calvert City Chemical Co. operated its flotation plant. Numerous companies and private parties scouted the State for fluorspar prospects and many exploration leases were obtained. In Crittenden County, a joint venture exploration program by Cerro Corp., Frontier Resources Inc., Five Resources Inc., and J. Fred Landers discovered and drilled out a commercial ore body averaging 40 percent fluorspar that lies 250 to 700 feet deep. Cerro Corp., which is to be the operator, was to start in 1972 to develop the mine by sinking an 800-foot shaft and to build a froth flotation plant with an annual output capacity of 60,000 tons of acid-spar.

Ore production was reported from the La Mina Pisana in the Big Bend area of Texas and from the Crystal Mountain mine of Roberts Mining Co. in Montana.

In Nevada, intermittent production of fluorspar was reported from three mines, and numerous companies were reported to be scouting the State for commercial deposits.

In Utah, three mines in the Spor Mountain district northwest of Delta reported a little fluorspar production. Also Vedco Wah Wah Mines Inc. announced that it had drilled out a fluorspar ore body containing 24 percent calcium fluoride (CaF_2) and extractable quantities of tungsten. The prospect is located in Beaver County near the town of Milford.

In Idaho, Seaforth Minerals and Ore Co. obtained the Meyers Cove mine in Lemhi County, completed a heavy-media separating plant, and produced some finished met-spar. The plant is fed with 30 percent CaF_2 crude ore and has an output capacity of about 250 tons per day. Both Ozark-Mahoning Co. and NL Industries, Inc. were drilling on fluorspar prospects in the Lemhi County fluorspar area. Also, P. J. Cutting was reported to have done some exploration drilling on the Keystone prospect near Meyers Cove.

In New Mexico, the Valencia and Turley mines were operated. Exploration drilling was performed on the Volcano prospect in Hidalgo County. Minerals Inc. prospected in the Wilcox Mining District, Catron County, and on the Huckleberry property east of Glennwood. Win Industries was building near Truth or Consequences, a froth flotation plant that will have an output capactiy of 100 tons per day.

In Arizona, four mines were operated intermittently and shipped a few truck loads during the year: Two by Tonto Basin Mining and Milling Co. northeast of Phoenix; and two by Environmental Engineering and Chemical Co. near Pearce and Bisbee in Cochise County. Tonto Basin Mining and Milling Co. started constructing a small flotation plant that had a 100-ton-per-day output capacity at Punkin Center.

In Alaska, Lost River Mining Co., Ltd., a subsidiary of P.C.E. Exploration Ltd., has done extensive drilling and testing of its fluorite-tin-tungsten deposit on the West Point of Seward Peninsula, northwest of Nome, As a result, according to the company's 1971 annual report, it has developed about 32 million tons of indicated and inferred reserves containing 17.5 percent CaF_2. Of the total reserves, about 26 million tons contain 0.286 percent tin, and 0.037 percent tungsten oxide (WO_3). In 1971, additional feasibility studies on probable mining methods, on the design of surface plant and harbor facilities, and on metallurgical problems were performed by Colorado Research Institute and Battelle Memorial Institute. The reports indicated a planned mining and milling operation of 4,000 tons per day. The project of building a town and a harbor and of developing the mine during the short summer working period when surface operations may be carried out is of such magnitude that the company does not anticipate any production until 1976. Lost River Mining officials claimed that financing arrangements to proceed with the project have been completed.

It is evident by the renewed activity throughout the United States that many companies have been encouraged by the higher prices, and have spent considerable sums of money and time in exploration for new fluorspar deposits. Whether this exploration effort will be effective in the discovery of new ore deposits and will result in increased domestic production will not be known until 1973 or 1974. It requires 4 to 6 years to explore, develop, and bring a new deposit into production, and widespread interest in fluorspar exploration did not start until 1969.

On April 12, 1971, a serious accident caused the death of seven men at the Barnett mine of Ozark-Mahoning Co., near Rosiclare, Ill. The industry had been relatively free from such disasters since 1925. The Bureau of Mines, reported that the deaths were caused by lethal concentrations of hydrogen sulfide gas at the mine's 800-foot level. Failure of the ventilation system allowed the hydrogen sulfide gas to accumulate at this low level, and the area was not "dangered off" as a followup to any oral warnings that may have been given to the men.[2]

The manufacture of fluorspar briquets from either acid-spar or met-spar is one phase of the fluorspar industry that has increased rapidly in the past 2 years. Most of the briquet makers buy ore on the open market and process it to comply to the requirements of their steel company customers. Baked briquets containing from 50 to 92 percent effective CaF_2 are produced with most of the briquets containing about 76 percent effective CaF_2. The briquets are used as a flux for the iron foundry and steel industry. Ozark-Mahoning is the only briqueting company that had its own domestic supply of fluorspar; all the other briqueting companies purchased the fluorspar from producing companies or from traders. Ozark-Mahoning operated two briquet plants, one at Rosiclare, Ill. and the other at Cowdrey, Colo. Cometco Corp. operated a plant at Duquesne, Pa. and Mercier Corp. operated a plant at Dearborn, Mich. Three companies operated plants at Brownsville, Tex.: Delhi Foundry Sand Co., Ogleby-Norton and Co. and Pennwalt Corp. Although the total annual capacity of these plants was over 400,000 tons, in 1971 their combined production was about 235,000 tons.

CONSUMPTION AND USES

Reported U.S. consumption in 1971 totaled about 1,345,000 tons, which was 2 percent less than in 1970. The major reduction was in the consumption of acid-spar to make hydrofluoric acid. There was a slight decrease in the consumption by the glass, ceramic, and steel industries, which was a reflection of the sluggish business conditions in the United States.

In the steel industry, consumption of met-spar averaged about 9 pounds per ton of steel. Consumption ranged from 2 to 5 pounds per ton of steel in open hearth furnaces, 8 to 15 pounds per ton in basic oxygen furnaces and 5 to 8 pounds per ton in electric furnaces. The total used by the iron and steel castings and steel furnace industries was 572,475 tons or 43 percent of the total consumption. Due to the variable grades of met-spar used by the foundry, glass, and ceramic industries, consumption rates were not quoted.

Consumption of acid-spar to make cryolite and aluminum fluoride for the aluminum industry was estimated formerly to be about 135 pounds (64 pounds contained

[2] Jarrett, S. M., R. O. Pynnonen, and R. L. Bernard. Report on Major Hydrogen Sulfide Disaster Barnett Complex Mine, Ozark Mahoning Co. Rosiclare, Pope County, Ill. Apr. 12, 1971, 26 pp.

Table 2.—Shipments of finished fluorspar, by State

State	1970 Short tons	1970 Value Total (thousands)	1970 Value Average per ton	1971 Short tons	1971 Value Total (thousands)	1971 Value Average per ton
Illinois	148,208	$8,637	r $58.28	138,051	$9,883	$71.59
Utah	19,214	595	30.97	10,947	341	31.15
Other States [1]	101,799	4,691	46.08	123,073	7,039	57.19
Total	269,221	13,923	r 51.72	272,071	17,263	63.45

r Revised.
[1] Includes Arizona and Idaho, 1971; Colorado, Kentucky, Montana, Nevada, and New Mexico 1970–71.

fluorine) per ton of aluminum, but verbal information received in 1971 from aluminum industry personnel indicated that the consumption rate should be lowered to 128 pounds of acid-spar (60 pounds of fluorine) per ton of aluminum. It is believed that in the future there will be less consumption of primary fluorspar per ton of aluminum, due to more efficient operation of the electrolytic potlines, to more common use of lithium carbonate pellets to reduce fluorine emissions, and to more efficient recovery and recycling of fluorine effluents.

About 702,000 tons of acid-spar, 52 percent of the total, was used to make hydrofluoric acid (HF) (table 3). Although this represents a 6.5-percent decrease from 1970 to 1971, the decrease is mostly in the amount of primary acid-spar used to make HF for the aluminum industry. This decrease resulted from the introduction of a new primary source of fluorine, which replaces the fluorine formerly obtained from HF. The new primary source is fluosilicic acid (H_2SiF_6), a byproduct of fluorine gases emitted during the processing of phosphates to make fertilizers. (See section on Technology.) It is estimated that in 1971 aluminum companies produced from H_2SiF_6 about 40,000 tons of Na_3AlF_6 and AlF_3, equivalent to about 51,000 tons of acid-spar. These 51,000 tons replaced primary acid-spar allocated to the aluminum industry, which left about 200,200 tons or 15 percent of the total consumption allocated to aluminum production.

It is assumed that the remaining 501,800 tons of acid-spar, 37 percent of the total, that was used to make HF was used by the chemical industry. According to the foregoing distribution, the use was about as follows:

	Short tons	Percent
Iron and steel industry	572,500	43
Chemical industry	501,800	37
Aluminum industry	200,200	15
Other (ceramics, glass, cement), etc	70,200	5
Total	1,344,700	100

Current proposed plans to build new hydrofluoric acid plants or to enlarge currently operating plants in North America, if fulfilled, could result in an oversupply of 15 percent or more by 1976 or 1977. This probability was discussed fully by H. L. Noble [3] of Allied Chemical Corp, and W. R. Jones [4] of E. I. du Pont de Nemours & Co. Inc. On the other hand, the future growth of the chemical industry particularly the fluorocarbons is optimistic and was estimated to grow at 6 to 8 percent annually. This phase of the industry is dependent on the properties of one of the most active of all elements, fluorine. New uses are discovered monthly, and include applications in the medical field, in propulsion motors for a nonpolluting automo-

[3] Noble, H. L. Fluorocarbon Makers Can Expect Over-Supply to Persist Until '76. Chem. Marketing Reporter, v. 201, No. 20, May 15, 1972, p. 7.
[4] Jones, W. R., HF Consumption at 500,000 Tons Foreseen in 1977. Chem. Marketing Reporter, v. 201, No. 19, May 8, 1972, p. 3.

Table 3.—Consumption, by end use and stocks, by grade of fluorspar (domestic and foreign) in the United States in 1971

(Short tons)

End use or product	Containing more than 97 percent calcium fluoride	Containing not more than 97 percent calcium fluoride	Total
Hydrofluoric acid	701,844	(1)	701,844
Glass	6,632	6,243	12,875
Enamel	413	1,845	2,258
Welding rod coatings	1,043	(2)	1,043
Primary aluminum	938	--	938
Primary magnesium	22,260	(2)	22,260
Other nonferrous metal	198	10,517	10,715
Iron and steel castings	271	31,294	31,565
Open-hearth furnaces	--	82,133	82,133
Basic oxygen furnaces	--	377,266	377,266
Electric furnaces	3,511	78,000	81,511
Other uses or products [3]	5,714	14,620	20,334
Total	742,824	601,918	1,344,742
Stocks Dec. 31	102,171	334,588	436,759

[1] Small tonnages included under fluorspar containing more than 97 percent calcium fluoride.
[2] Included with "Other uses or products."
[3] Includes fluorspar used to make ferroalloys and other furnace products.

Table 4.—Fluorspar shipped from mines in the United States, by grade and use

Grade and use	1970				1971			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total (thousands)	Average per ton	Short tons	Percent of total	Total (thousands)	Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	105,839	53.1	$5,912	$55.86	106,263	52.4	$7,604	$71.56
Glass	21,637	10.9	1,302	60.17	20,712	10.2	1,540	74.35
Ceramic and enamel	9,912	5.0	365	36.82	14,106	7.0	561	39.77
Nonferrous	3,326	1.7	203	61.03	1,333	.7	103	77.27
Ferrous [1]	54,916	27.6	3,278	59.69	56,733	27.9	3,221	56.77
Miscellaneous [1]	3,495	1.7	206	58.94	3,561	1.8	246	69.08
Total	199,125	100.0	11,266	56.58	202,708	100.0	[2] 13,277	65.50
Fluxing gravel and foundry lumps:								
Ferrous	67,956	97.0	2,528	37.20	67,480	97.3	3,842	56.94
Miscellaneous	2,140	3.0	129	60.28	1,883	2.7	143	75.94
Total	70,096	100.0	2,657	37.91	69,363	100.0	[2] 3,986	57.47

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

Table 5.—Fluorspar (domestic and foreign) consumed in the United States, by State
(Short tons)

State	1971
Alabama, Kentucky, Tennessee	72,813
Arizona, Colorado, Utah	21,633
Arkansas, Kansas, Louisiana, Missouri	215,292
California	45,133
Connecticut, Massachusetts, New York, Rhode Island	32,989
Illinois	89,971
Indiana	69,167
Iowa, Minnesota, Nebraska, Wisconsin	2,287
Michigan	79,639
New Jersey	68,019
Ohio	153,361
Oklahoma	1,059
Oregon, Washington	1,364
Pennsylvania	155,408
Texas	264,013
West Virginia	50,677
Other States [1]	21,917
Total	1,344,742

[1] Includes Florida, Georgia, Maryland, North Carolina, Virginia, Delaware, Mississippi, and South Carolina.

bile, in fluorocarbon paint to resist fires, in new polymerization catalysts, in electrochemical cells, and in new fluorinating agents.

STOCKS

Both the producers stockpiles of finished fluorspar and the consumers stockpiles increased in 1971, which indicates an abundant supply. The producers stocks (table 1 finished fluorspar) increased 128 percent, and the stocks at the consumers plants increased 4 percent. At the end of 1971 the fluorspar supply and demand was nearly in balance throughout the world.

GSA sold 100,159 short dry tons of acid-grade fluorspar in 1970, and 112,643 tons in 1971, which completed the fluorspar sales necessary to obtain the inventory objective of 1,390,000 tons of combined acid-spar and met-spar in the stockpile inventory.

PRICES

Domestic fluorspar prices increased about 22 percent in the first half of 1971, but in the last half they leveled off. The December 1971 issue of the Engineering and Mining Journal (E&MJ) reported acid-spar f.o.b. Illinois at a high of $85 per short ton, but prices f.o.b. Wilmington, duty paid, were quoted verbally at $70 per short ton. Domestic metallurgical-grade fluorspar pellets were reported in the E&MJ to be

Table 6.—Stocks of fluorspar at mines or shipping points in the United States, by State, Dec. 31

(Short tons)

State	1970		1971	
	Crude	Finished	Crude	Finished
Illinois	17,328	3,841	97,012	5,582
Utah	1,100	--	300	--
Other States [1]	33,043	8,529	68,298	22,677
Total	51,471	12,370	165,610	28,259

[1] Includes Arizona, Colorado, Kentucky, Montana, and New Mexico.

$68.50 per ton f.o.b. Illinois; prices in the west, at mine railheads, were reported verbally to range from $28 to $60 per ton for gravel met-spar. Mexican met-spar at the Texas border ports and at New Orleans, according to E&MJ, ranged from $30 to $50 per ton, duty paid, but prices reported verbally were at least $5 per ton lower. At the end of 1971, fluorspar prices were firm, and supplies of all grades were available on the international market.

A tabulation of prices for various grades follows:

	1970	1971
Domestic f.o.b. Illinois-Kentucky:		
Metallurgical-grade, 72½ percent effective CaF_2	$47.50–48.50	NA
Pellets, 70 percent effective CaF_2	$52.00	$68.50
Acid-grade concentrates, dry basis, 97 percent CaF_2:		
Carloads	62.00–75.00	78.50–85.00
Less than carloads	62.50–77.00	78.50–85.00
Bags, extra	6.00	6.00
Pellets, 90 percent effective CaF_2	56.00–60.00	76.50
Ceramic-grade, 95 to 96 percent CaF_2	60.00–70.00	76.50–80.00
European: F.o.b., Wilmington/Philadelphia:		
Acid-grade, duty paid, dry basis	53.00	72.50–73.50
Mexican: Border Ports:		
Metallurgical-grade, 70 percent effective CaF_2-border, all rail, f.o.b. cars	30.15	48.33–50.33
Tampico, Mex. f.o.b. vessel	r30.15	47.33–49.33
Acid-grade, 97+ percent, Eagle Pass, Tex., bulk	52.00	62.67

NA Not available.

Source: Engineering and Mining Journal, December, 1970 and 1971.

FOREIGN TRADE

U.S. exports of combined acid-spar and met-spar decreased about 16 percent. No report was received on Japan and India purchases. The material exported is mostly for special usage and is of variable grade and value.

The United States produced about 5 percent of the world fluorspar output and consumed about 26 percent of the supply. Mexico continued to be the largest U.S. supplier, providing 79 percent of the U.S. imports for consumption. Spain provided 11 percent, Italy 7 percent, and Canada, France, the Republic of South Africa, Switzerland, and West Germany, combined, 3 percent. The foreign importers share of the U.S. market consumption, adjusted for stockpile changes during calendar years 1970 and 1971, was less than 79 percent, the lowest it has been since 1963, indicating a slight increase in the domestic producers share of the U.S. market.

The 10 percent ad valorem surcharge that was imposed in 1971 on imported fluorspar, as explained under Legislation and Government Programs, apparently reduced imports from European countries but did not reduce the imports from Mexico. In 1971 imports from Mexico increased 1.7 percent, whereas from 1969 to 1970, the Mexican imports had decreased 3.5 percent. In contrast, imports from all of the other countries in 1971 decreased 13 percent. The largest decreases were from Spain and Italy, whereas the Republic of South Africa and Switzerland imports were increased notably.

Table 7.—U.S. exports of fluorspar

Country	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	1,627	$84,339	2,670	$137,533	12,033	$484,890
Colombia	--	--	17	1,650	40	4,843
Germany, West	450	16,189	279	13,046	220	15,620
India	1,429	93,242	55	7,426	--	--
Japan	--	--	11,720	960,896	--	--
Switzerland	--	--	28	2,410	39	1,419
United Kingdom	24	1,090	50	1,792	63	2,274
Yugoslavia	--	--	--	--	72	7,003
Other countries	75	18,441	r 133	r 20,108	24	9,440
Total	3,605	213,301	14,952	1,144,861	12,491	525,489

r Revised.

Table 8.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
CONTAINING MORE THAN 97 PERCENT CALCIUM FLUORIDE				
Canada:				
Laredo, Tex	--	--	74	$3
Ogdensburg, N.Y	--	--	24	1
Total	--	--	98	4
France: New Orleans, La	--	--	4,489	267
Germany, West: Philadelphia, Pa	4,152	$220	5,341	288
Italy:				
Detroit, Mich	8,496	340	4,989	200
Galveston, Tex	33,133	1,168	27,223	1,441
New Orleans, La	38,136	1,373	33,518	1,843
Philadelphia, Pa	4,910	198	5,164	207
Total	84,675	3,079	70,894	3,691
Mexico:				
El Paso, Tex	67,718	1,754	69,026	1,727
Houston, Tex	1,045	36	751	30
Laredo, Tex	292,159	9,139	320,606	11,231
New Orleans, La	38,438	1,582	13,936	645
Nogales, Ariz	18,742	669	25,172	900
Philadelphia, Pa	15,314	535	3,801	116
San Diego, Calif	1,987	64	59	3
San Francisco, Calif	--	--	263	9
Total	435,403	13,779	433,614	14,661
South Africa, Republic of:				
Galveston, Tex	--	--	6,501	246
Philadelphia, Pa	--	--	2,816	100
Total	--	--	9,317	346
Spain:				
Cleveland, Ohio	14,005	603	24,800	1,334
Detroit, Mich	27,788	1,154	18,304	782
New Orleans, La	--	--	4,536	196
Philadelphia, Pa	98,773	4,200	68,918	3,448
Total	140,566	5,957	116,558	5,760
Switzerland: Cleveland, Ohio [1]	--	--	12,367	668
United Kingdom:				
Cleveland, Ohio	7,006	278	--	--
Detroit, Mich	3,967	63	--	--
Total	10,973	341	--	--
Grand total	675,769	23,376	652,678	25,685
CONTAINING NOT MORE THAN 97 PERCENT CALCIUM FLUORIDE				
Brazil: New Orleans, La	10,587	298	--	--
Italy: Houston, Tex	662	48	--	--

See footnotes at end of table.

Table 8.—U.S. imports for consumption of fluorspar, by country and customs district—Continued

Country and customs district	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
CONTAINING NOT MORE THAN 97 PERCENT CALCIUM FLUORIDE—Continued				
Mexico:				
Baltimore, Md	37,349	1,300	19,630	827
Buffalo, N.Y	7,238	283	19,143	768
Chicago, Ill	8,478	317	--	--
Cleveland, Ohio	19,787	795	26,732	1,154
Detroit, Mich	11,683	409	82,264	1,118
El Paso, Tex	42,815	826	36,490	709
Laredo, Tex	231,827	3,638	211,194	3,304
New Orleans, La	15,222	394	11,044	411
Nogales, Ariz	--	--	64	2
Philadelphia, Pa	24,432	886	10,089	436
San Francisco, Calif	1,455	34	--	--
Total	400,286	8,882	416,650	8,729
Mozambique: Philadelphia, Pa	4,913	151	--	--
South Africa, Republic of:				
Baltimore, Md	101	3	--	--
New Orleans, La	--	--	1,120	46
New York City	--	--	271	18
Philadelphia, Pa	--	--	1,686	52
Total	101	3	3,077	116
Grand total	416,549	9,382	419,727	8,845

[1] Apparently a transshipment.

WORLD REVIEW

Canada.—The bulk of Canada's fluorspar continues to come from the Burin Peninsula of Newfoundland. In 1971, production decreased 42 percent to 80,000 tons owing to a 5-month shutdown, which was caused by labor disputes. Imports increased to about 169,000 tons mostly from Mexico.

Allied Chemical Canada Ltd. imported acid-grade fluorspar for the production of hydrofluoric acid at the company's plant at Valleyfield, Quebec and Amherstburg, Ontario. Huntingdon Fluorspar Mines Ltd. imports met-spar to make 5 pound briquets at its North Brook, Ontario plant.

In northeastern British Columbia near Fort Nelson, a fluorspar discovery first reported in 1970 was subjected to exploratory drilling. Exploration results indicate that an economically minable deposit may be found in this district.

France.—Fluorspar production increased about 3 percent to 330,000 tons, maintaining France's position as the fifth largest fluorspar producer in the world. French producers exported about one-third of their production, mainly to other European countries and to the United States.

Italy.—Italy, the sixth largest producer in the world, increased production by less than 1 percent to about 321,000 tons. This increase was much lower than in past years owing to general sluggish business conditions throughout the year. Italy exports mostly to the United States and European countries. The fluorspar-mining industry is dominated by Montecatini-Edison, S.p.A., and Mineraria Silius of the C.E. Giulini group. At the Assemini flotation plant on Sardinia, Montedison is following the modern trend by utilizing waste fines to make fluorspar pellets. The capacity of the pellet plant was raised to 50,000 tons per year. Southland Mining Ltd. of Australia and Soricom S.p.A. of Italy announced that exploration of the Pianciano fluorspar deposit, located 25 miles northwest of Rome, has developed about 8 million tons of 55 percent fluorspar ore. They planned to build a plant to produce pelletized metallurgical-grade fluorspar at the rate of about 200,000 tons per year.

Mexico.—Mexico continued to be the largest producer of fluorspar in the world and has the largest reported reserves. Mexico produced 1,302,000 tons in 1971, an increase of 21 percent above the 1970 production. Mexico's exports to the United States, which totaled 1,072,000 tons, consisted of 51 percent acid-spar and 49 percent met-spar. About 80 percent of the total comes from 16 companies located in the States of Coahuila, San Luis Potosi, Guanajuato, and Chihuahua. Over 96 percent of Mexico's production is exported.

Table 9.—Fluorspar: World production, by country

(Short tons)

Country [1]	1969	1970	1971 p
North America:			
Canada	131,600	136,800	e 80,000
Mexico	1,089,420	1,078,594	1,301,779
United States (shipments)	182,567	269,221	272,071
South America:			
Argentina	32,383	32,689	33,000
Brazil e	38,600	38,600	38,600
Europe:			
Czechoslovakia e	r 66,000	90,000	100,000
France (marketable) e	303,000	320,000	330,000
Germany, East e	90,000	90,000	90,000
Germany, West (marketable)	93,438	96,173	96,787
Italy	284,161	318,861	320,810
Romania e	17,000	17,000	17,000
Spain (marketable)	336,771	376,621	440,785
United Kingdom [2]	209,767	213,044	269,920
U.S.S.R. e	440,000	450,000	460,000
Africa:			
Kenya	2,051	4,303	7,232
Rhodesia, Southern e	165	165	165
South Africa, Republic of	165,651	190,693	263,497
Tunisia	13,665	33,841	36,331
Asia:			
Burma	140	e 140	e 140
China, People's Republic of	280,000	300,000	280,000
India	r 2,072	5,122	3,203
Japan	14,067	8,853	14,022
Korea, North e	33,000	33,000	33,000
Korea, Republic of (South)	43,181	52,668	63,808
Mongolia e	86,000	88,000	88,000
Thailand	328,003	350,785	471,015
Turkey	2,308	1,835	e 1,200
Total	r 4,285,010	4,597,008	5,112,365

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, Bulgaria and Morocco also produce fluorspar, but information is inadequate to make reliable estimates of output levels.

[2] Includes material recovered from lead-zinc mine dumps.

The Mexican Government is encouraging the establishment of HF plants within the country. Three such projects were announced in 1971. Union Carbide Mexicana announced that it planned to build a plant at Apodaca, Nuevo Leon, with an output capacity of 35,000 tons per year. Continental Ore Corp. in a joint venture with the Fundidora Group of Monterrey, planned to build a plant with a capacity of 77,000 tons per year at Matamoros, Tamaulipas. E. I. du Pont de Nemours & Co., Inc. with Minera Frisco S.A., Financiera Bancomer S.A., and the Mexican Comisión de Fomento Minero, also announced plans to build a plant with a capacity of at least 70,000 tons per year at Matamoros, Tamaulipas. These announcements indicated a planned production of about 190,000 short tons of HF. Production would require about 427,000 short tons of acid-spar as input feed, which is almost equal to the total Mexico acid-spar exports to the United States in 1971. However, by July 1972 only the E. I. du Pont de Nemours & Co. plant was under construction, and it appeared that no significant quantity of HF will be produced by 1976.

La Cuesta Co. of Mexico and Mitsui Mining and Smelting Co. Ltd. of Japan announced plans to develop the Santa Rosa fluorspar mine in Sonora. The ore will be shipped to Japan. Throughout Mexico, fluorspar exploration and mining continued unabated during 1971.

South Africa, Republic of.—Fluorspar production increased 38 percent to 263,000 tons, raising South Africa to the 10th largest producer in the world. South African companies export mostly to Japan, Australia, United States, West Germany, and Sweden. The Republic of South Africa and South-West Africa have large fluorspar reserves, but estimates are variable, ranging from 26 million tons of 40-percent CaF_2 to 200 million tons of 15- to 20-percent CaF_2.

Spain.—Fluorspar production increased 17 percent to 441,000 tons, but even with the increase, Spain dropped to the position of fourth largest producer in the world. Although fluorspar had been produced in Spain before records were kept, their reserves are still estimated at 8 to 10 million

Table 10.—World trade in fluorspar [1] in 1970

(Short tons)

Sources	Destinations														Total receipts	Total recorded exports
	Australia [2]	Austria	Belgium-Luxembourg	Canada	Germany, West	India	Italy	Japan	Netherlands	Poland	Sweden	U.S.S.R.	United States	Other [3]		
Argentina	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	748
Brazil	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NA
Canada	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	NA
China, People's Republic of	3,799	--	1,685	--	--	--	--	134,621	--	11,048	9,629	7,826	--	1,898	170,506	NA
France	701	13,405	11,718	--	--	--	14,684	--	2,495	--	NA	--	--	456	43,459	5,087
Germany, East	--	89,611	2,457	--	--	--	--	--	--	11,442	2,352	--	--	20,895	126,757	NA
Germany, West	--	22,152	2,809	--	--	32	88	--	184	--	NA	--	4,152	3,090	32,507	636
Italy	--	24,458	--	--	7,416	1,824	--	--	--	--	--	--	85,337	10,692	129,727	5,972
Japan	--	--	--	--	--	--	--	--	--	--	--	31,636	--	--	31,636	1,494
Korea, North	--	--	--	--	--	--	--	6,792	--	--	--	--	--	--	6,792	NA
Korea, Republic of (South)	--	--	--	--	--	--	--	35,666	--	--	--	--	--	--	35,666	37,068
Mexico	540	--	112	63,314	27,943	--	11,199	5,057	--	--	--	--	835,689	--	943,854	1,365,555
Mongolia	--	--	--	--	--	--	--	--	--	--	--	84,437	--	--	84,437	NA
Mozambique	151	--	--	--	999	--	--	1,130	--	--	NA	--	--	2,401	4,681	--
South Africa, Republic of	21,124	--	--	--	37,555	--	4,323	80,935	--	--	3,004	--	5,014	28,867	180,822	121,775
Spain	--	--	--	--	50,370	--	2,921	--	--	--	--	--	140,566	5,244	199,101	187,868
Thailand	28	--	--	--	16,399	--	--	284,037	--	--	--	29,101	--	--	329,565	384,989
Tunisia	--	--	--	--	--	--	9,295	--	--	--	--	--	--	7,826	17,121	NA
U.S.S.R.	55	--	--	--	--	--	--	13,374	--	--	--	--	--	--	13,429	NA
United Kingdom	10,518	--	--	17,731	--	557	--	10,113	--	--	NA	--	10,973	11,373	61,265	NA
United States	--	--	--	13,637	--	55	--	--	--	--	--	--	--	--	13,692	14,952
Other and unspecified	--	--	251	--	155,354	7,804	22,411	2,358	39,262	2,962	2,791	6,504	--	6,149	245,846	NA
Total	36,916	149,626	19,032	94,682	296,036	10,272	64,921	574,083	41,941	25,452	17,776	159,504	1,081,731	98,891	2,670,863	NA

NA Not available.

[1] Details on origin are derived from import data of countries listed as destinations, and total receipts by listed destinations are simply a summation of this detail for each country listed. Data in column headed total recorded exports are taken from export statistics of listed source countries. Differences between total receipts and total recorded exports are attributed chiefly to the time lag between date of shipment and date of receipt, but some differences may result from concealment policies of certain countries and/or from reshipment of material by intermediate countries which may be credited as the origin in sources of final recipient countries.

[2] Data for year beginning July 1, 1970.

[3] Countries included and total imports by each in short tons are: Denmark—41,673; Finland—8,225; France—13,854; Israel—338; Norway—27,521; Yugoslavia—7,508. Totals for Denmark, Finland, France, Norway, and Yugoslavia are distributed by source country, details on source countries for imports of Israel are not available, but the total has been entered under "Other and unspecified."

[4] Recorded receipts from Japan exceed both recorded Japanese production and exports; apparently material was shipped from other countries by way of Japan.

[5] Includes leucite, nepheline, and nepheline syenite in addition to fluorspar.

[6] Mozambique records no production or exports of fluorspar; apparently material was shipped from other countries by way of Mozambique.

tons, indicating continued production for many years. Spanish producers export predominantly to the United States, West Germany, and other European countries.

Thailand.—In 1971 fluorspar production rose by about 34 percent to 471,000 tons, establishing Thailand's position as the second largest fluorspar producer in the free world. All shipments were of met-spar, but prices, which depend heavily on Japanese demand, fell sharply in the second half of the year from $47 to $35 per ton f.o.b. Bangkok. Large surpluses accumulated, and production had to be cut back at yearend. It was thought that the Soviet Union would remedy the situation with purchases of 100,000 tons or more, but it purchased only 43,000 tons. The Thai Government and the Thai Fluorite Miners' Association tried to halt the price decline by organizing a fluorite marketing cooperative for all sellers, but failed because most of the miners were too deeply committed to long-term sales contracts to participate.

Exports of fluorspar totaled 382,000 tons in 1971, a 2 percent increase over the 1970 export of 375,000 tons about 86 percent of the exports went to Japan.[5]

Improvement in Thailand's fluorspar trade may come from beneficiation of its ore. Until now Thailand has exported only crude hand-sorted ore. Last year the Government awarded special promotional incentives to projects which will become Thailand's first two fluorite beneficiating plants. One, a Thai venture to be built by Universal Mining Co. Ltd., will operate a British-built, heavy-media plant to produce refined metallurgical-grade ore. The second, Thai Fluorite Processing Co., Ltd., owned jointly by Kaiser Cement & Gypsum Corp. and by Jalaparthan Cement Co. was building a froth flotation plant with an output capacity of 30,000 tons per year. Joy Manufacturing Co. supplied the equipment, and Kaiser Engineering was building the plant, which was planned to go on stream by July 1972. This was to be the first plant in Southeast Asia to produce acid-grade fluorite.[6]

The most productive mines are in the Northern Province of Lamphun, which contributes between 80 and 95 percent of the total fluorspar output. Of the 17 Thai companies engaged in fluorspar mining, the five largest companies accounted for 65 percent of the production. There was no large-scale systematic fluorspar prospecting or mining program in Thailand, and no one really knows the extent of the reserves. It appeared probable, however, that only the most visible and accessible deposits have been mined by open pit methods thus far, and that the reserves are substantial.

United Kingdom.—Fluorspar production in the United Kingdom increased 27 percent to 270,000 tons and allowed the United Kingdom to maintain its position as ninth largest producer in the world. Laporte Industries Ltd. continued to be the largest producer. A new froth flotation plant with capacity of 80,000 tons-per-year of acid-spar was placed on stream by C. E. Giulini Ltd. at Hopton. Aided by the 1970 revision of mining and tax laws, which encourage leasing of mining property within Peak District National Park, mining activity increased in the Derbyshire District and the park. However, the British nonferrous extractive industry was waiting for proposed legislation to clarify some phases of the mineral rights position. Although fluorspar production increased in 1971, labor strikes in the steel industry slowed consumption. Expansion of one hydrofluoric acid plant in 1971 to increase the campany's fluorocarbon output is expected to increase the demand. Industries in the United Kingdom consume most of domestic production, but a little fluorocarbon is exported to Canada, Australia, and the United States.

TECHNOLOGY

In the last 3 years, owing to pressure from the Federal Environmental Protection Agency, progress has been made on controlling one of the serious air pollutants of the aluminum industry. Gaseous fluorine compounds are emitted from the electrolytic reduction cells containing aluminum oxide dissolved in molten sodium aluminum fluoride. The high reactivity of gaseous fluorine compounds is at the root of serious difficulties encountered in sampling and collecting these gases and particulates. A large percentage of the solids that are absorbed in the aluminum potlinings and in the spent electrodes may be reclaimed and recycled, and some of the fluoride particulate effluents are susceptible to direct

[5] Bureau of Mines. Mineral Trade Notes. Thailand. V. 69, No. 8, August 1972, p. 15.
[6] Industrial Minerals. Progress in Modernizing Thailand's Fluorspar Industry. No. 56, May 1972, pp. 31 and 33.

mechanical separation and are recycled to the cells. Gaseous fluorides are amenable to nearly complete emission control by chemisorption on activated alumina or by solution in aqueous media, but the reconversion process to usable compounds has yet to be proven economical.

Interest is continuing in processes to recover fluorine compounds, predominantly fluosilicic acid (H_2SiF_6) as a byproduct from processing phosphate rock. Normally phosphate rock contains about 3.5 percent fluorine. During the manufacture of different phosphate fertilizer products, 20 to 40 percent of the fluoride is emitted as fluorine gas, and a percentage of this gas is recovered as the byproduct fluosilicic acid. The dilute solution of 14 to 25 percent H_2SiF_6 is used to produce synthetic cryolite and aluminum fluoride for use as an electrolyte in the aluminum cell potlines. If the process proves economically sound, and construction of recovery and processing plants continues, this source of fluorine could, in the near future, satisfy a large portion of the aluminum industry's demand. At the same time, pollution from a dangerous substance could be reduced.

In 1971 numerous plants were salvaging fluosilicic acid, but only two were known to be making synthetic cryolite or aluminum fluoride from the byproduct. Kaiser Aluminum & Chemical Co., completed expansion of its Chalmette, La., plant to a capacity of 60,000 tons of synthetic cryolite per year. The raw material was sodium fluosilicate ($NaSiF_6$), a phosphate rock byproduct shipped from Mulberry, Fla. Aluminum Co. of America, in a pilot plant with a reported capacity of 20,000 tons per year at Ft. Meade, Fla., converted fluosilicic acid from a nearby phosphate rock plant to aluminium fluoride and cryolite. In July 1971, Gulf Coast Fluoride Co. announced that it had purchased land near Pierce, Fla., to build a plant to produce synthetic cryolite and aluminum fluoride from fluosilicic acid. The 80,000-ton combined capacity of the two operating plants, converted to the equivalent amount of approximately 100,000 tons of acid-spar, could possibly replace about one-third of the normal acid-spar demand of the aluminum industry.

Plants to produce either cryolite or aluminum fluoride from waste fluosilicic acid were in operation or were being built in Canada, Mexico, the U.S.S.R., India, Japan, West Germany, China, and Austria.

Many steel companies throughout the world are actively searching for and testing fluxing compounds that can be substituted for fluorspar in iron foundry and steel furnaces. The higher consumption of fluorspar per ton of steel in basic oxygen furnaces, recent fluorspar price increases, and the shortage of suitable deposits from which gravel fluorspar can be mined have made this search more urgent. In 1970, Nippon Steel Co. announced the patenting of a mixture of 60 percent CaO, 25 percent Fe_2O_3, 10 percent Al_2O_3 and 5 percent SiO_2 as a substitute flux for fluorspar, but during 1971 no large steel companies, including Nippon Steel Co., were reported to have adopted this substitute.

Colemanite and other borates are still being considered as a substitute for cryolite, but their high cost is the biggest obstacle. Pellets of lithium carbonate are reported to improve the thermal stability of any electrolytic aluminum potline cell, enabling all cells to have similar operating characteristics. The primary aluminum producers reported reduced fluorine emissions of 25 to 50 percent, and a reduction in operating costs.

CRYOLITE

Imports of synthetic cryolite increased 8 percent to 23,127 tons (table 11). Twenty-two tons of crude natural cryolite were imported from Greenland stockpiles. Throughout the world, manufactured synthetic cryolite made from acid-grade fluorspar or from fluosilicic acid has replaced natural cryolite except for a few special uses. The 1971 price of synthetic cryolite ranged from $257 to $336 per ton in carload lots.

Table 11.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value (thousands)
1968	33,772	$5,455
1969	20,406	4,251
1970:		
Canada	1,328	294
Czechoslovakia	77	18
Denmark	606	r 153
France	7,320	1,518
Germany, West	3,393	817
Italy	7,776	1,546
Japan	480	114
Netherlands	2	(1)
Spain	40	8
Switzerland	26	3
U.S.S.R.	r 351	115
Total	r 21,399	r 4,586
1971:		
Belgium-Luxembourg	(1)	2
Canada	4,584	1,228
Czechoslovakia	86	23
Denmark	896	267
France	6,753	380
Germany, West	2,122	793
Greenland [2]	22	6
Iceland	44	15
Italy	5,729	1,372
Japan	1,420	414
Mexico	100	16
Netherlands	1	9
Poland	569	224
Spain	331	110
Switzerland	30	7
Yugoslavia	440	190
Total	23,127	5,056

r Revised.
[1] Less than ½ unit.
[2] Crude natural cryolite.

Gem Stones

By Robert G. Clarke [1]

Gem stone production was estimated to be $2.6 million dollars in 1971, an increase of 8 percent over 1970 figures. Individual collectors reported more finds of gem materials in both quantity and value. Since the United States has no formal gem stone mining industry, activity was principally the result of recreational mining by hobbyists. A few deposits were operated to produce rough material for direct sale to wholesale or retail outlets, or for raw material to manufacture finished jewelry.

DOMESTIC PRODUCTION

Collectors in 38 States produced gem materials estimated at $1,000 or more for each State. Of these, the following States supplied 78 percent of the total, in thousand dollars, as follows: Oregon, $755; California, $205; Arizona, $160; Texas $155; Washington, $155; Wyoming, $135; Colorado, $125; Montana, $114; Nevada, $105; and Idaho, $100.

Emeralds from Hiddenite, N.C. made news in that the largest emerald crystal, 59 carats, ever found in North America was discovered there August 1970. The stone was fashioned, cut to 13.14 carats as a gem, named the Carolina Emerald and displayed by Tiffany's of New York.[2] Reports of emerald recoveries from Hiddenite were published in newspapers and journals.[3] A jade boulder, 8 feet long and weighing over 5 tons, was taken from the Pacific Ocean near Jade Cove, just south of the town of Big Sur, Calif.[4] Similar nephrite boulders, weighing up to 1 ton, were reported to have been found at a site on the Rib River in Marathon County in Wisconsin.[5]

Black opal from Virgin Valley, Nev., has an unfortunate tendency to craze. A process has now been developed which stabilizes the opal and allows it to become one of the most treasured gems of the world.[6]

Descriptions of field trips, events, and reports of mineral and gem stone finds were reported in periodicals.[7]

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) increased to $311 million, compared with $292 million in 1970, because of greater imports of diamond.

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1 Physical scientist, Division of Nonmetallic Minerals.

2 Crowningshield, R. America's Largest Faceted Emerald. Lapidary J., v. 25, No. 1, April 1971, p. 40.

3 Knoxville (Tenn.) News-Sentinel. Rockhound Finds Gems in N. C. Hole. Aug. 18, 1971, p. 40. The State, Columbia, S. C. Raw Emeralds. Aug. 1, 1971, p. 26A.

4 The Evening Star, Washington, D.C. $180,000 Jade Slab. V. 110, No. 215, Aug. 3, 1971, p. A3.

5 Kraege, H. Another Prospectors Mecca. Rocks and Minerals, v. 46, No. 12, December 1971, p. 737.

6 Zeitner, June C. Precious Opal from Nevada. Lapidary J. v. 24, No. 12, March 1971, pp. 1534–1542.

7 Gems and Minerals. Field Trips, News Notes of Collecting Areas. No. 400, January 1971–No. 411, December 1971.

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The Mineralogical Record. Friends of Mineralogy. V. 2, No. 1, January–February 1971–V. 2, No. 6, November–December 1971.

PRICES

During the year, representative price ranges for first quality, cut and polished, unmounted gem diamond were 0.25 carat, $100 to $450; 0.5 carat, $250 to $950; 1 carat $650 to $3,000; 2 carats, $2,000 to $10,000; and 3 carats, $3,000 to $18,000. The median price for each range was 0.25 carat, $210; 0.5 carat, $525; 1 carat, $1,600; 2 carats, $4,500; and 3 carats, $8,700.

FOREIGN TRADE

Exports of all gem materials amounted to $132.9 million, and reexports, to $85.1 million. Diamond was 94 percent of the value of each, exports and reexports. United States exports of diamond in 1971, on which work was done prior to reexport amounted to 349,136 carats valued at $125.3 million. Of this, diamonds, cut but unset, suitable for gem stones, not classified by weight, were 62,904 carats valued at $4.9 million; cut but unset, not over 0.5 carat, were 109,932 carats valued at $8.6 million; and cut but unset, over 0.5 carat, were 176,300 carats valued at $111.8 million.

Reexports of diamond, on which no work was done, amounted to 1,226,755 carats valued at $79.8 million in the following categories: Cut, but unset, suitable for gem stones, not classified by weight, 1,173,727 carats valued at $65.2 million; cut but unset, not over 0.5 carat, 20,851 carats valued at $4.4 million; cut but unset, over 0.5 carat, 32,177 carats valued at $10.2 million.

The seven leading countries for diamond exports and reexports combined, accounting for 95 percent of the carats and 93 percent of the value were as follows: Israel, 577,121 carats valued at $32.2 million; Belgium, 335,274 carats valued at $23.7 million; Switzerland, 282,846 carats valued at $27.5 million; Hong Kong, 119,124 carats valued at $59.0 million; The Netherlands, 117,363 carats valued at $23.8 million; Japan, 39,969 carats valued at $21.1 million; and the United Kingdom 23,809 carats valued at $3.1 million.

Exports of all other gem materials amounted to $7.6 million. Of this total, pearls, natural and cultured, not set or strung, were valued at $0.4 million. Natural precious and semiprecious stones, unset, were valued at $5.7 million; and synthetic stones, unset, were valued at $1.6 million. Reexports of all other gem materials amounted to $5.3 million. Reexports of pearls amounted to $0.3 million; of natural precious and semiprecious stones, unset, to $4.9 million; and of synthetic precious and semiprecious stones, to $0.1 million.

Imports of gem material increased 8 percent in value compared with that of 1970. Diamond accounted for 88 percent of the total value of gem stone imports.

The four leading countries from which diamond imports came, in total carats and in total value were as follows: Belgium-Luxembourg, 1,123,193 carats valued at $122.7 million; the United Kingdom, 959,516 carats valued at $120.3 million; the Republic of South Africa, 928,896 carats valued at $89.8 million; and, Israel, 717,470 carats valued at $73.0 million.

Imports of emeralds increased 8 percent in quantity and less than 1 percent in value. Of 33 countries supplying natural emeralds to the United States, India furnished 190,358 carats valued at $3.6 million; Brazil, 67,519 carats valued at $0.7 million; Hong Kong, 34,818 carats valued at $0.4 million; and Colombia, 18,622 carats valued at $1.3 million. These four countries furnished 89 percent of the quantity (in carats) and 78 percent of the value of total emerald imports. The United Kingdom, Switzerland, France, West Germany, Israel, and Italy accounted for most of the remainder, but the country of origin was unknown.

Imports of rubies and sapphires increased 42 percent and came from 27 countries. Seven countries accounted for 92 percent of the value of rubies and sapphires, as follows: Thailand, $4.4 million; India, $0.8 million; Ceylon, $0.7 million; Hong Kong $0.5 million; France, $0.4 million; Switzerland, $0.4 million; and the United Kingdom, $0.3 million.

Synthetic materials, gem stone quality, cut but not set, amounted to $9.6 million in imports. From West Germany, the value of synthetics was $3.5 million; from Japan, $1.4 million; from Switzerland, $1.3 million; from Israel, $1.1 million; and from France, $0.9 million.

Table 1.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1970 Quantity	1970 Value	1971 Quantity	1971 Value
Diamonds:				
Rough or uncut	2,633	$234,164	2,742	$254,575
Cut but unset	1,642	190,733	1,925	208,667
Emeralds: Cut but unset	326	7,715	351	7,731
Rubies and sapphires: Cut but unset	NA	5,769	NA	8,206
Marcasites	NA	4	NA	1
Pearls:				
Natural	NA	371	NA	364
Cultured	NA	10,184	NA	6,895
Imitation	NA	1,493	NA	5,013
Other precious and semiprecious stones:				
Rough and uncut	NA	10,001	NA	3,532
Cut but unset	NA	12,034	NA	13,456
Other, n.s.p.f.	NA	590	NA	734
Synthetic:				
Cut but unset ... number	7,333	4,363	11,040	9,492
Other	NA	526	NA	137
Imitation gem stones	NA	8,096	NA	7,180
Total	NA	486,043	NA	525,983

NA Not available.

Table 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by country

(Thousand carats and thousand dollars)

Country	1969				1970				1971			
	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	59	$6,729	916	$113,114	64	$6,572	863	$103,705	88	$9,092	1,036	$113,626
Brazil	29	1,033	1	58	31	1,184	1	80	3	129	2	232
Canada	8	1,307	(1)	54	2	462	1	60	--	--	1	69
Central Africa Republic	232	9,806	--	--	165	5,826	--	--	208	6,785	--	--
France	10	379	20	2,484	4	195	27	2,550	21	634	31	2,514
Germany, West	1	13	5	507	2	117	4	516	1	121	2	210
Guyana	20	1,020	--	--	26	1,074	(1)	19	1	49	(1)	19
India	--	--	30	2,663	--	--	40	3,475	--	--	80	6,429
Israel	36	4,155	658	73,777	52	6,723	604	61,753	47	3,425	671	69,569
Japan	(1)	5	1	71	(1)	20	(1)	18	(1)	33	2	203
Liberia	13	2,976	--	--	6	1,893	--	--	17	3,797	(1)	66
Netherlands	48	12,810	27	3,561	23	7,886	13	1,899	31	6,190	20	2,440
Sierra Leone	224	8,331	10	1,447	--	--	6	814	281	14,331	4	527
South Africa, Republic of	361	41,585	28	8,713	593	54,571	26	6,868	904	83,389	25	6,388
Switzerland	6	1,043	3	919	4	354	1	262	16	3,149	11	1,156
U.S.S.R	--	--	43	6,629	--	--	44	6,826	--	--	24	3,324
United Kingdom	1,697	185,278	9	1,496	1,432	140,243	6	970	947	118,913	12	1,366
Venezuela	157	5,439	--	--	223	6,333	--	--	177	4,283	--	--
Western Africa, n.e.c	27	5,210	--	--	1	366	--	--	--	--	--	--
Other countries	4	447	7	1,588	5	345	6	918	--	255	4	529
Total	2,932	287,566	1,758	217,081	2,633	234,164	1,642	190,733	2,742	254,575	1,925	208,667

[1] Less than ½ unit.

WORLD REVIEW

Angola.—A new firm, Consorcio Mineiro de Diamantes (CONDIAMA), formed by Companhia de Diamantes de Angola (DIAMANG) of Lisbon, and De Beers Consolidated Mines Ltd. of Kimberley, Republic of South Africa, was granted exclusive rights to concession areas relinquished by DIAMANG whose rights originally granted in 1921 expired May 14, 1971.[8] The Angolan Government will gain financially from the new contracts.

Australia.—A major emerald deposit was opened near Poona, 430 miles northeast of Perth. One emerald from the deposit weighed 138 carats and measured 1.8 inches by 0.8 inch.[9] At Glengarry, an oval shaped black opal, valued at $168,000, measuring 2.25 inches by 1.5 inches was found and named the Orient Queen.[10]

Botswana.—The Orapa diamond mine began operations in July 1971 on a scheduled treating of 8,000 tons of diamond-bearing ore per day.[11] Gem diamond recovery was indicated to be only 10 percent of the estimated annual yield of 2 million carats.[12]

Burma.—The Mineral Development Corp., the Burmese state-owned mining concern, sent an exploration team to the Shan State following reported diamond finds in Mongmit township.[13] Jade was predominant in sales at Burma's Seventh Annual Gem, Jade, and Pearl Emporium accounting for $1.96 million of the total of $2.60 million. Pearl sales amounted to $480,000. All other gem sales amounted to $154,000. Jade sales, accounting for 76 percent of the total sales, set a new record owing to strong demand from Hong Kong. No single large stones were sold.[14]

Brazil.—A new diamond rush started in Minas Gerais State when diamond stones were found weighing 75, 44, and 24 carats.[15]

Ceylon.—The Government set up the State Gem Corporation which sponsored a gem auction. To protect consumers, the State Gem Corporation initiated a procedure to issue a certificate of authenticity for each gem stone giving its specific gravity, refractive index, hardness, weight, volume, color, and luster, together with a true-to-scale contact print.[16]

India.—The National Mineral Development Corporation (NMDC) started operations in the Majhgawan diamond pipe of 21 surface acres at Panna.[17] Ore reserves down to 1,000 feet was estimated to be 55 million tons. Although the grade is low, 10 carats per 100 tons, the venture is profitable because of the high ratio of gem diamond to industrial diamond, about 4 to 1. Other areas investigated by NMDC were at Golconda and Kurnool in Andhra Pradesh. NMDC imports gem diamond from Ghana for cutting and reexport.[18]

Ivory Coast.—Société Anonyme de Recherches et d'Exploitation Minières en Côte d'Ivoire (SAREMCI) at Tortiya south of Korogho, accounted for 91 percent and Société Diamantifere de Côte d'Ivoire (SODIAMCI) accounted for 8 percent of diamond production reported in 1970. New equipment installed by each was expected to maintain the ratio in 1971.[19]

Malagasy Republic.—Garnets were the most important gem stones produced and were marketed for jewelry, bearings, and abrasives.[20] De Beers Consolidated Mines Ltd. of South Africa concluded an agreement with the Government for prospecting for diamond. Under the agreement De Beers would analyze 20,000 samples of ore concentrate from the Malagasy Republic. The contract included Government sharing in any subsequent corporation.[21]

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[8] Bureau of Mines. Mineral Trade Notes. Diamond, Angola. V. 68, No. 12, December 1971, pp. 11–12.

[9] Journal of Mines, Metals & Fuels (India). Notes and News, Emerald Mine in Western Australia. V. 19, No. 12, December 1971, p. 372.

[10] The Evening Star, Washington, D.C. $168,000 Opal Found. V. 119, No. 190, July 9, 1971, p. D6.

[11] Holz P. Other African Countries. Botswana. Canadian Mining J., v. 93, No. 3, March 1972, p. 71.

[12] World Mining. De Beers Orapa Diamond Mine Starts Production in June 1971. V. 6, No. 13, December 1970, p. 50.

[13] Industrial Minerals (London). No. 46, July 1971, p. 45.

[14] Bureau of Mines. Mineral Trade Notes. Gem Stones, Burma. V. 68, No. 6, June 1971, p. 5.

[15] Jewelers' Circular-Keystone. Briefly. V. 142, No. 3, December 1971, p. 74.

[16] Staff, Modern Asia: Hong Kong. Gem Country. V. 5, No. 8, October 1971, pp. 24–27. Ceylon Government Gazette, No. 14, 989/8, Dec. 23, 1971, pp. 11A–16A.

[17] Staff, World Mining. Diamond Mining in India Today. V. 24, No. 6, June 1971, pp. 34–35.

[18] Journal of Mines, Metals & Fuels (India). Import of African Diamonds. V. 19, No. 1, January 1971, p. 25.

[19] Bureau of Mines. Mineral Trade Notes. Ivory Coast. V. 68, No. 8, August 1971, p. 11.

[20] Mining Annual Review. Malagasy. June 1971, p. 352.

[21] Bureau of Mines. Mineral Trade Notes. Malagasy Republic. V. 68, No. 7, July 1971, p. 17.

Table 3.—Diamond (natural): World production by country [1]

(Thousand carats)

Country	1969			1970			1971 p		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Africa:									
Angola	r 1,516	r 506	2,022	1,797	599	2,396	e 1,625	e 542	e 2,167
Botswana	NA	NA	NA	54	490	544	87	785	[2] 872
Central African Republic	r 348	r 187	535	r 313	r 169	482	304	163	467
Ghana	239	2,152	2,391	255	2,295	2,550	256	2,306	2,562
Guinea	22	50	72	22	52	[3] 74	e 22	e 52	e 74
Ivory Coast	81	121	202	85	128	213	e 88	e 132	e 220
Lesotho [4]	5	25	30	4	13	17	1	6	7
Liberia	[5] 562	[5] 184	[5] 746	[5] 577	[5] 235	[5] 812	525	214	739
Sierra Leone	736	1,253	1,989	723	1,232	1,955	715	1,220	1,935
South Africa:									
Premier	631	1,891	2,522	623	1,867	2,490	[6] 652	[6] 1,955	[6] 2,607
Other DeBeers Company [7]	2,457	2,010	4,467	2,615	2,140	4,755	2,267	1,855	e 4,122
Other	524	350	874	520	347	867	181	121	e 302
Total	3,612	4,251	7,863	3,758	4,354	8,112	3,100	3,931	7,031
South-West Africa, Territory of	1,923	101	2,024	1,772	93	1,865	e 1,800	e 100	e 1,900
Tanzania	394	383	777	359	349	708	404	404	[2] 808
Zaire (formerly Congo-Kinshasa)	r 1,802	r 11,621	r 13,423	1,649	12,438	14,087	e 1,700	e 12,000	e 13,700
Other Areas:									
Brazil e	160	160	320	160	160	320	160	160	320
Guyana	21	31	52	24	37	61	19	29	48
India	10	2	12	17	3	20	16	3	19
Indonesia e	14	6	20	14	6	20	14	6	20
U.S.S.R. e	1,500	6,000	7,500	1,600	6,250	7,850	1,800	7,000	8,800
Venezuela	118	76	194	129	371	500	e 130	e 370	e 500
World total	13,063	27,109	40,172	13,312	29,274	42,586	12,766	29,423	42,189

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

[1] Total (gem plus industrial) diamond output of 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 all cases except Angola (1969 only), Lesotho (all years), Liberia (1969 and 1970), Zaire (1969 only), and Venezuela (1969 and 1970), where sources give both total output and detail. The estimated distribution of the total in the case of a number of countries is conjectural, based on unofficial information of varying reliability.

[2] Exports.

[3] Official estimate by Government of Guinea.

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

[5] Exports for year ended August 31 of that stated.

[6] Total non-alluvial output of Transvaal, presumably includes a small share of total originating from non-De Beers-owned properties other than the Premier mine.

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

Nigeria.—The Government published Decree No. 55, Diamond Trading Decree 1971, in the Official Gazette No. 64, V. 58, Dec. 31, 1971.[22] The Federal Military Government issued the decree which contained 15 sections. Mining, selling, buying, importing, exporting, and cutting of diamond was to be licensed or authorized, and violators subject to arrest, forfeitures, and penalties.

Scotland.—A short paper described areas for collectors of minerals, precious stones, and semiprecious stones in Scotland.[23] A location map of the country was included.

Sierra Leone.—The third largest diamond ever found, 969.8 carats and valued at $11.7 million, was reported.[24] Sierra Leone diamond production has a high ratio of gem diamond. The Government and the economy are tied to diamond production to a remarkable degree as trade data for the last three years showed. Diamond exports were about two-thirds of the country's exports in value and were the source of 15 to 20 percent of the Government's revenue.

South Africa, Republic of.—Production of diamond decreased but value of sales increased. De Beers announced a 5 percent general increase in prices in terms of U.S. dollars on November 1, 1971; also, the South African exchange rate varied between August and December 1971.[25]

South West Africa.—Consolidated Diamond Mines of South-West Africa, Ltd. (CDM), a subsidiary of De Beers, closed the sea and foreshore operations in the areas leased to the Marine Diamond Corporation Ltd., a subsidiary of CDM.[26]

Tanzania.—Diamond was the most important mineral mined and exported. Diamond exports in 1971 were 808,000 carats. Gem zoisite (tanzanite) exports amounted to 79,000 carats and were 36 percent of the total value of exports of gem stones excluding the value of diamond. Ruby, sapphire, garnet, amethyst, and tourmaline were other gem stone types exported.

Venezuela.—A significant diamond discovery of gem quality on a 15,000 acre concession in the State of Bolivar was reported.[27] Diamond production increased 6 times in quantity and 4 times in value from 1965 to 1970 according to Government data in an article which also described mining methods and laws.[28]

TECHNOLOGY

A detailed description of synthetic gem stones and other synthetic materials was published.[29] Diamond imitations, their pretensions, and some trade names were also described.[30]

Personnel of the Hawaii Institute of Marine Biology tested a miniature submarine at Makapuu Point, Oahu, in a series of dives to harvest precious coral of which the varieties included gold, pink, bamboo, gold bamboo, and black. The submersible was equipped with an arm and claw and a large basket.[31] Union Carbide Corp.'s Crystal Products Department reported production of a giant synthetic white sapphire, 28,000 carats, 3.5 inches in diameter and 8 inches long, the largest manufactured sapphire crystal on record, using the Czochralski process.[32]

The damage caused by mechanically polishing sapphire and spinel wafers was minimized by chemical polishing.[33] Topaz was described in terms of geometrical and electrostatic interactions.[34] Tiny laser beams were used to burn out unsightly dark inclusions in diamond, a development for jewelers to be aware of.[35]

[22] Bureau of Mines. Mineral Trade Notes. Diamond, Nigeria. V. 69, No. 4, April 1972, pp. 5–12.
[23] Adamson, G. F. S. The Gemstones of Scotland. Mining and Minerals Engineering, v. 7, No. 6, June 1971, pp. 21–24.
[24] The Sunday Star, Washington, D.C. Third Largest Diamond Found on Conveyor in Mine Plant. V. 120, No. 107, Apr. 16, 1972, p. D7.
[25] Staff, Mining Journal, (London). Diamond Sales Improve. V. 278, No. 7117, Jan. 14, 1972, p. 33.
[26] Mining and Minerals Engineering (London). Marine Diamonds. V. 7, No. 6, June 1971, p. 25.
[27] The Wall Street Journal. Fairway Explorations Ltd. Reports Making Significant Diamond Find. V. 178, No. 8, July 13, 1971, p. 33.
[28] Fairbairn, W.C. Diamonds in Venezuela. Mining Magazine, v. 125, No. 4, October 1971, pp. 349–353.
[29] Webster, R. A. Comprehensive Compendium on Modern Synthetic Gem Stones, Part I. Lapidary J., v. 25, No. 1, April 1971, pp. 275–280; Part II, Lapidary J., v. 25, No. 2, May 1971, pp. 304–317.
[30] Sarett, M. R. The Facts About Diamond Imitations. Lapidary J. v. 25, No. 5, August 1971, pp. 714–715.
[31] Reported by Bureau of Mines State Liaison Officer for Hawaii.
[32] Iron Age. Gem of a Giant and Giant of a Gem, Techfront. V. 208, No. 15, Oct. 7, 1971, p. 31.
[33] Reisman, A., M. Berkenblit, J. Cuomo, and S. A. Chan. The Chemical Polishing of Sapphire and MgAl Spinel. J. Electrochemical Soc., v. 118, No. 10, October 1971, pp. 1653–1657.
[34] Ribbe, P. H., and G. V. Gibbs. The Crystal Structure of Topaz and Its Relation to Physical Properties. The American Mineralogist, v. 56, January–February 1971, pp. 24–30.
[35] Jewelers' Circular-Keystone. Something New to Look For in a Diamond. V. 61, No. 6, p. 114.

Gold

By J. M. West [1]

International monetary difficulties in 1971 led to suspension beginning August 15 of the exchange of gold for dollars in official transactions by the U.S. Government. In December, agreements were reached to increase the official price of gold to $38 per troy ounce but as of year-end there was no word as to when the Treasury would resume the exchange of gold in international settlements. Free market prices rose throughout the year in response to monetary and balance of payments problems coupled with reports that worldwide commercial demand for gold was nearly equal to or slightly in excess of world gold supplies. Prices twice reached a record U.S. high of $44.40 per ounce, Engelhard Industries selling price, the first time in August and the second in December. In London, the high for the year was $43.975, reached on December 6.

During 1971, U.S. official gold reserves declined 24.7 million ounces, while reserves of the International Monetary Fund (IMF) and estimated reserves of central banks and governments of the free world rose 11.2 and 11.6 million ounces, respectively.

Domestic production of gold declined to about 1.5 million ounces in 1971, nearly 15 percent below the 1970 output. Nearly 80 percent of the Nation's gold production came from four producers in 1971: Homestake Mining Co., Kennecott Copper Corp., Carlin Gold Mining Co., and Cortez Gold Mines. Consumption of gold rose 16 percent, led by a nearly one-third increase in consumption in jewelry and arts. Conversely, consumption in industrial products declined 5 percent. Net imports of in-

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient gold statistics

	1967	1968	1969	1970	1971
United States:					
Mine production ---- thousand troy ounces	1,584	1,478	1,733	1,743	1,495
Value ---- thousands	$55,447	$58,038	$71,944	$63,439	$61,673
Ore (dry and siliceous) produced:					
Gold ore ---- thousand short tons	3,076	2,780	3,393	3,692	3,472
Gold-silver ore ---- do	157	199	208	W	166
Silver ore ---- do	617	655	655	673	574
Percentage derived from:					
Dry and siliceous ores	69	63	59	60	60
Base-metal ores	27	34	40	38	39
Placers	4	3	1	2	1
Refinery production [1] ---- thousand troy ounces	1,526	1,539	1,717	NA	NA
Exports [2] ---- do	28,720	23,962	338	1,074	1,339
Imports, general [2] ---- do	930	5,944	5,861	6,652	7,201
Stocks Dec. 31:					
Monetary [3] ---- millions	$12,065	$10,892	$11,859	$11,072	$10,206
Industrial ---- thousand troy ounces	3,086	3,617	4,158	3,984	4,375
Consumption in industry and the arts thousand troy ounces	6,294	6,604	7,109	5,973	6,933
Price: [4] Average per troy ounce	$35.00	$39.26	$41.51	$36.41	$41.25
World:					
Production ---- thousand troy ounces	45,737	46,165	46,612	47,531	46,506
Official reserves [5] ---- millions	$41,600	$40,905	$41,010	[r] $41,275	$41,210

[r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data; included in gold and silver ores.
[1] From domestic ores—U.S. Bureau of the Mint.
[2] Excludes coinage.
[3] Includes gold in Exchange Stabilization Fund.
[4] U.S. Treasury price through Mar. 15, 1968, and Engelhard selling quotations Mar. 20, 1968, through 1971.
[5] Held by free-world central banks and governments.

dustrial gold rose 33 percent and industry stocks rose 10 percent during the year.

World gold output declined slightly in 1971, mostly because of a drop in the Republic of South African production. Republic of South Africa, with production valued at $1.29 billion, continued to supply the bulk of the world's gold, accounting for two-thirds of total new supplies. The U.S.S.R. ranked a distant second, with output estimated at 6.7 million ounces, slightly higher than in 1971. Canada and the United States were third and fourth, respectively, both with declining outputs.

Legislative and Government Programs.—Section 54.4 (a) (14) of the Gold Regulations was amended to authorize the Director of the Office of Domestic Gold and Silver Operations to license foreign subsidiaries of U.S. corporations to manufacture gold medals for sale to persons not subject to the jurisdiction of the United States. The express purpose was to assure a fair competitive position for these firms in the markets in which they operate.[2] As a result of the initiation of trading in gold coin futures on the West Coast Commodity Exchange in mid-1971, the U.S. Department of the Treasury issued a clarification of restrictions on holding or dealing in rare or unusual coins containing the following amendments: (1) The acquisition, holding, importation, and transportation of gold coin is limited to transactions for numismatic purposes and (2) the trading of gold in any form on any commodity exchange within the United States is prohibited. Furthermore, the overall intent of the Gold Regulations was made explicit by providing that trading in gold for speculative purposes is prohibited. Amendments were not to limit in any way the types of transactions currently engaged in by coin collectors or licensees under existing authority.[3] Trading of gold coin futures began July 20, and the Treasury order ended transactions on July 22 after 473 contracts of 200 troy ounces each had been traded.

As part of the President's New Economic Policies beginning August 15, 1971, the Treasury temporarily suspended the convertibility of dollars to gold. The official price of gold remained at $35 per ounce throughout the year despite the suspension, although an unofficial agreement was reached to increase the price to $38.

A number of bills were introduced in Congress relating to gold, generally for purposes of permitting American citizens to hold gold and to increase the domestic production of gold. None of the bills were passed. The Office of Minerals Exploration (OME) in the U.S. Geological Survey continued to offer participatory loans for exploration assistance up to 75 percent of permissible costs for gold exploration. However, OME activities in gold were at a relatively low level in 1971, with only a few active contracts or pending actions.

DOMESTIC PRODUCTION

A decline in domestic production in 1971 was partly the result of a copper strike which reduced byproduct gold output and interrupted smelter and refinery operations. Outputs in Alaska and California were lower in 1971 because of declining placer gold production. Colorado production increased owing to greater outputs from the Sunnyside and Idarado lode mines. A sharp drop in Nevada production was due mainly to lower output at the Cortez mine.

At the Homestake mine in South Dakota gold output dropped 11 percent, to 513,494 ounces valued at about $21 million. To produce this amount 1.8 million tons of ore was processed. Ore grade averaged 0.285 ounce of gold per ton compared with 0.296 ounce in 1970. Metallurgical recovery declined to 93 percent compared with 95 percent in 1970 because an amalgamation process used in milling had to be eliminated owing to new environmental regulations. The company sought a process to offset the losses and improve recoveries and after many trials found that a charcoal-in-pulp gold collection technique for cyanide solutions developed by the Bureau of Mines would be highly effective. Installation of an $850,000 plant based on this process was authorized and construction began early in 1972. In addition to gold,

[2] U.S. Department of the Treasury. Gold Regulations: Manufacture and Sale of Gold Medals. Federal Register, v. 36, No. 79, Apr. 23, 1971, p. 7659.

[3] U.S. Department of the Treasury. Gold Regulations: Clarification of Restrictions on Holding or Dealing in Rare or Unusual Coins. Federal Register, v. 36, No. 143, July 24, 1971, p. 13786.

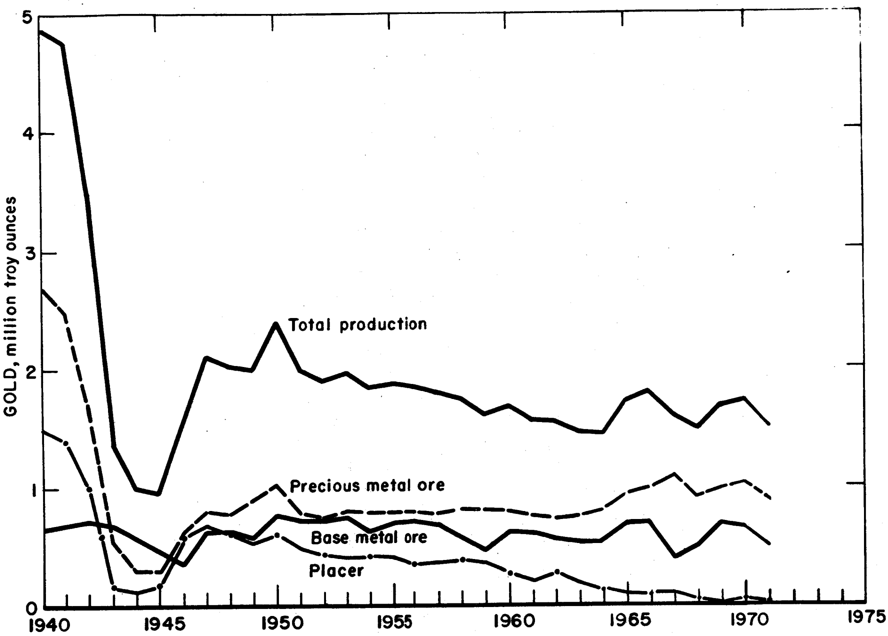

Figure 1.—Gold production in the United States.

the Homestake mine produced 116,680 ounces of byproduct silver in 1971. Measured ore reserves at yearend were 6.1 million tons averaging 0.328 ounce per ton, a decrease of 2.9 million tons from the end of 1970. Part of the decline was due to recalculations to reflect higher mining costs and a slight increase in the cutoff grade. In addition, there were 1.3 million tons of indicated reserves averaging 0.357 ounce per ton. Deep level development work continued with sinking of the No. 6 winze from the 6,800 to the 7,189 level. Major development work proceeded on an airway to the 5,900 level in the Nineteen Ledge. Potential new reserves between the 5,900 and 6,800 levels in the Nineteen and Twenty-one Ledges were estimated to total 3.7 million tons with 0.342 ounce of gold per ton, bringing total estimated reserves to 11 million tons averaging 0.336 ounce per ton.

Mill throughput at the Cortez mine in Nevada increased to an average 2,132 tons per day, from 2,000 in 1970. However, gold production dropped to 120,251 ounces from the 209,000 ounces produced in 1970. Production included 218 ounces recovered by cyanide leaching of low-grade mine waste, which began in December. By early 1972 a waste leach dump of about 0.5 million tons was expected to be emplaced for this low-cost extraction technique. Solutions drained to a sump and were pumped to the mill for gold extraction. Average grade of ore milled in 1971 declined to 0.176 ounce per ton; 778,018 tons were treated during the year. Mill recovery was 87.4 percent of the gold in the ore. Proven ore reserves at yearend were 887,000 tons, averaging 0.227 ounce per ton. Operations at Cortez were expected to end early in 1973 because of depleted reserves.

The Carlin gold mine, also in Nevada, produced 199,000 ounces of gold compared with 201,000 ounces in 1970; sales in 1971 were valued at $8.3 million. A pretreatment plant, utilizing a new chlorine gas process to oxidize carbonaceous gold ores prior to cyanidation, treated 143,400 tons of such ores after startup in January. Some of the Carlin production resulted from heap-leaching of low-grade ores, spread out on four asphalt pads near the plant and sprinkled with cyanide solutions for periods of about 1 week to each 1,000 tons.

An estimated 65 percent of the contained gold in the heap-leached ores was extracted by this means. Carlin Gold Mining Co. continued investigations at its Bootstrap and Blue Star deposits near the Carlin operations and made plans to begin mining. Based on current planning and known reserves, production at Carlin was expected to continue through 1976.

During the year the Bureau of Mines placed experimental charcoal gold extraction columns in cyanide recovery plants at the Homestake, Carlin, and Cortez mines. Test results were promising with the columns, which were designed to replace existing zinc dust precipitation circuits for extraction of gold from cyanide solutions; further studies were expected to result in several permanent installations of process-scale equipment. The columns permit efficient extraction from very dilute gold solutions.

Utah Copper Division, Kennecott Copper Corp., with its open pit mine at Bingham, Utah, remained second only to Homestake in gold production, virtually all as a byproduct of copper refining. Kennecott reported gold production of 340,600 ounces in 1971. Most of this came from the 35 million tons of low-grade porphyry copper ores mined by the Utah Copper Division.

The Mayflower mine, operated by Hecla Mining Co. in the Park City district, Utah, produced about 124,400 tons of ore, averaging 0.51 ounce of gold per ton. Gold was accompanied by other metals including lead, zinc, copper, and silver, and tonnage mined was up from 116,000 tons averaging 0.48 ounce per ton in 1970. Ore reserves at the Mayflower were estimated at 183,000 tons at yearend, down from 240,000 tons at the end of 1970. Development work was curtailed after discouraging results on the 2,600- and 2,800- foot levels, and production was expected to decline in 1972.

At the Knob Hill mine, Republic district, Washington, ore reserves approached exhaustion and were reported sufficient for only about 2 more years of operation. Day Mines, Inc., shared in production with Knob Hill Mines, Inc., from the Gold Dollar and Knob Hill properties and reported its shares as 11,061 tons of ore, grading 1.0 ounce per ton of gold from the Gold Dollar, and 14,787 tons, grading 0.5 ounce per ton from the Knob Hill.

CONSUMPTION AND USES

Domestic consumption of gold, as indicated by sales to fabricators of industrial and other products, rose 16 percent, to 6.93 million ounces in 1971 compared with 5.97 million ounces in 1970, when consumption was down because of slack industrial activity. The Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury, reported net industrial use of gold during 1971 for jewelry and arts, 62 percent; for industrial uses, including space and defense, 27 percent; and for dental use, 11 percent. A drop in the percentage for industrial uses was attributed to a decline in use of gold in electronics, due in part to the trend to microminiaturization and partly because of the development of new techniques for selective plating only of areas where gold is needed. Consumption in electronics was estimated to have declined about 4 percent, to 1.38 million ounces in 1971. An approximate one-fourth increase in the use of gold for jewelry was partly due to higher personal income levels during 1971 and consequent greater expenditure on quality luxury items containing gold. Greater use of gold in dentistry in 1971 was also attributed to an increase of disposable incomes.

According to a new study of world gold consumption patterns,[4] non-communist countries used an estimated 45.4 million ounces for fabrication in 1971, of which 35.1 percent went into jewelry in advanced nations, 39.8 percent into jewelry in developing nations, 5.4 percent into dentistry, 6.5 percent into electronics, 7.9 percent into coins, medals, and medallions, and 5.3 percent into other industrial and decorative products.

Traditional domestic uses of gold remained centered in jewelry and arts primarily, although the U.S. pattern in recent years has moved generally toward greater industrial use, particularly with special demands for space and defense applications. Substantial amounts of gold were used in the electroplating of jewelry and ornamental products (possibly 2 million ounces)

[4] Fells, Peter D. Gold 1972. Consolidated Gold Fields Ltd., 49 Moorgate, London, E.C.2, 46 pp.

and as rolled gold plate and gold fill. Brazing alloys containing gold were important in both jewelry and industrial brazing where special qualities of strength and durability were required. Dental alloys of gold were used in orthodontistry and for inlays, crowns, and bridges. Probably the most important industrial use of gold was in electronics where it was applied chiefly by electroplating or in the form of fine wires for connecting circuits. Semiconductors, connectors, printed circuits, electron tube parts, switch contacts, and wave guide surfaces were among the wide variety of components using gold plate. Usually, the application was very thin, however, and is becoming thinner as plating technology advances. Jet engine and spacecraft manufacturers made use of gold for coating space guidance and attitude motors and nozzles, jet exit cones, and engine housing shrouds for heat reflective surfaces. Engelhard Industries introduced a new cyanide-free gold-plating process capable of producing ductile deposits of 99.99 percent gold on complex shapes in thicknesses exceeding 0.01 inch.[5] Higher plating speed for wire and strip were claimed for another new Engelhard process. The firm also produced precision gold wire in sizes down to 0.009 inch in diameter to meet requirements for integrated circuits and semiconductors. Sel-Rex Corp. developed a selective spot-plating system enabling an electronics manufacturer to plate a 0.0001 inch thickness of gold at a rate of 1,500 feet of strip per hour. The company also developed a process for low-karat gold alloy electroplating whereby required qualities were obtained with 40 percent less gold used.

STOCKS

Monetary.—Official U.S. gold stocks, including those in the Exchange Stabilization Fund, were valued at $10,206 million at the end of 1971 compared with $11,072 million at the end of 1970 for a drop of $866 million during the year. In comparison, during 1970 the decline was $787 million. Stocks dropped sharply during the year until convertibility of gold for U.S. dollars was suspended in mid-August when stocks stood at $10,209 million. Stocks declined slowly thereafter as previous commitments were satisfied. Stocks at yearend were equivalent to 291.6 million ounces of gold.

Gold stocks of national monetary authorities and international institutions (excluding Communist countries) decreased slightly in value during 1971 to $41,210 million from $41,275 million at the end of 1970 and were approximately equal to 1.18 billion ounces at $35 per ounce. About 45 percent of this gold was held by 11 industrial European countries and 25 percent by the United States. IMF stocks accounted for 15 percent of the total. Principle European holders, with reserves in million ounces, were: West Germany, 116.5; France, 100.7; Switzerland, 83.1; Italy, 82.4; Netherlands, 54.5; and Belgium, 44.1. Net monetary sales by the U.S. in 1971 were as follows, in million ounces: France, 13.5; Switzerland, 5.0; Belgium, 3.1; Netherlands, 0.7; and others. 1.8. The IMF received about 0.6 million ounces of U.S. gold.

IMF gold stocks rose 11.24 million ounces during the year. The IMF gold holdings were reported at a value of $5.14 billion (based on $38 gold), or 4.73 billion in equivalent special drawing rights (SDR), at the end of 1971. This compared with $4.34 billion ($35 gold) and the same in SDR at the end of 1970 (the SDR is defined as the equivalent of 0.888671 gram of fine gold). At the end of 1971 the U.S. SDR holdings were 1.1 billion compared with 0.85 billion at the end of 1970 and against a quota of 6.7 billion SDR available to the U.S. at the end of 1971. The total SDR holdings of all industrial countries at yearend were reported about 4.59 billion out of 9.3 billion allocated. As in 1970 when the Republic of South Africa sold about 18.3 million ounces of gold to the IMF in accordance with agreements of December 30, 1969, Republic of South Africa continued to supply the IMF with gold amounting to about 3.9 million ounces during the first half of 1971. Agreements essentially had provided that Republic of South Africa would sell all of its production on the free market, less an amount equivalent to its payments surplus, unless the country

[5] Glogau, R. C. New Gold Plating Methods Flood the Market. Am. Metal Market, July 28, 1971, p. 2A.

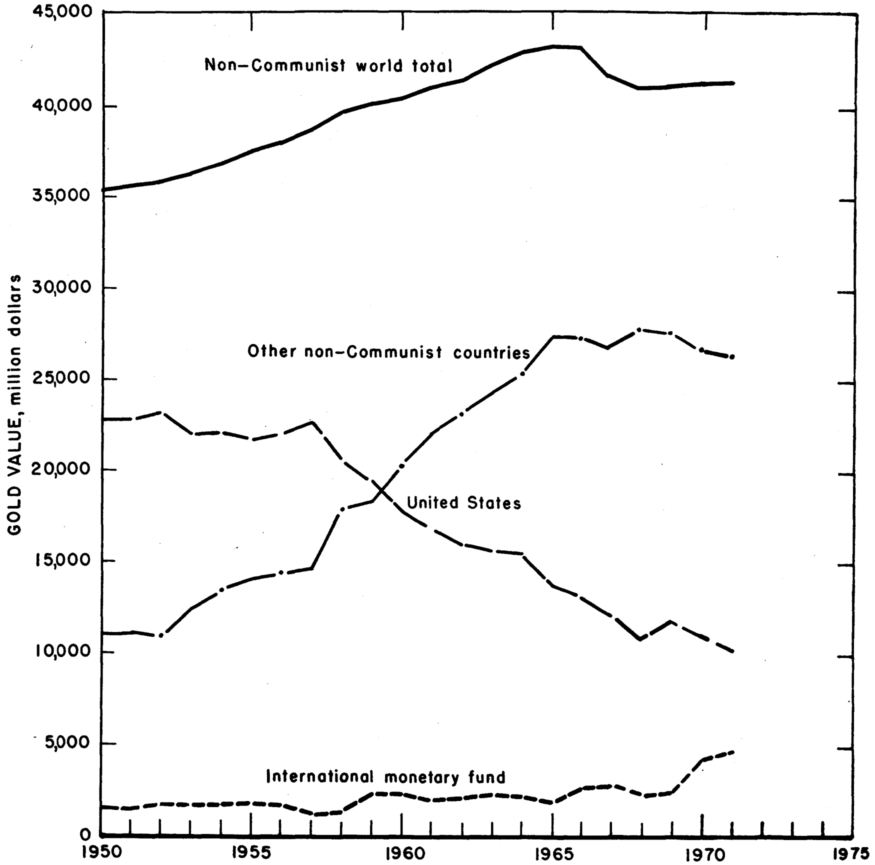

Figure 2.—Gold reserves of free world central banks and governments.

was suffering from a deficit or if the price fell below the official level. Republic of South Africa's official stocks of gold at the end of 1971 were down to 11.71 million ounces, a drop of 7.32 million ounces from stocks at yearend 1970.

At yearend, the U.S. balance of payments measured on a liquidity basis (excluding allocations of SDR's) showed a deficit of $22.7 billion (preliminary figure) compared with a $4.7 billion deficit at the end of 1970. Balances on an official reserve transactions basis showed a deficit of $30.5 billion compared with $10.7 billion at the end of 1970. Short-term liabilities to foreigners, reported by banks in the United States (exclusive of dollar holdings by the IMF) were $55.4 billion at the end of 1971 compared with $41.8 billion at the end of 1970. Liabilities at the end of 1971, potentially payable in gold, were accountable to the following principle countries, in billion dollars: Japan, 14.3; United Kingdom, 7.4; West Germany, 6.6; Canada, 3.4; Switzerland, 3.2; and France, 3.1.

Industrial.—Inventories of gold in hands of domestic refiners and fabricators rose 10 percent during the year, to 4,375,000 ounces according to data provided by the Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury. The net stock increase followed a decline of 168,000 ounces in the first half of the year.

PRICES

Gold prices on the free market rose throughout the year, remaining well above the official monetary price of $35 per ounce. The low for the year was $37.85 (prices, Engelhard selling) in January and the high of $44.40 was reached in both August and December. Monthly averages ranged from $38.32 in January to $43.93 in December, and the average for the year was $41.25 compared with $36.41 for 1970. The Engelhard selling price at yearend 1971 was $44.00 compared with $37.80 a year earlier. Price increases were attributed to a variety of factors, including international monetary uncertainties, war in Southeast Asia, and balance of payments problems.

The "closing of the gold window" on August 15 by the U.S. Government thus denying convertibility of U.S. dollars to gold by foreign banks, had little effect on the free market price, which varies according to supply and demand. The existing two-tier system, established in 1968, recognizes two kinds of markets; the official monetary market of central banks and governments, and the free market of commercial and industrial users. Following closure of the gold window in August 1971, discussions were held by representatives of a group of 10 industrialized nations and it was announced on December 18, 1971, that agreement had been reached to increase the official price of gold to $38 per ounce. During the period that led up to the suspension of convertibility, the price of gold on the free market rose sharply to the year's high of $44.40 on August 9, then declined to $43.45 on August 13, a Friday. Trading of gold on the New York market was suspended on August 16, the Monday following the announcement, and when trading was resumed on August 17, the price was quoted at $43.65. Part of the August 15 announcement concerned price controls and it was unclear at first whether the free market price of gold would be limited by price ceilings. In addition to other uncertainties of trading, this also had a dampening effect on prices. It was not until January 1972 that the U.S. Department of the Treasury ruled that domestic gold producers, dealers, and refiners would not be subject to Price Commission guidelines, which had restricted price increases to 2.5 percent. However, any increases were still to be limited by world prices. The ruling did not apply to prices of finished gold products, which remained subject to guideline limitations, except with a later provision that increased costs of gold could be passed on to the consumer. U.S. enactment of a bill (P.L. 92–267) authorizing a $3 increase in the official price of gold to $38 was not completed until March 31, 1972. The change in terms of gold from the equivalent of 0.888671 to 0.818513 grams per dollar was the first U.S. devaluation since the Gold Reserve Act of 1934, passed on January 30, 1934, established the $35 level.

Table 2.—U.S. monthly gold selling prices, per ounce

(Engelhard Industries)

Month	1971		
	Average	Low	High
January	$38.32	$37.85	$38.60
February	39.18	38.60	39.40
March	39.32	39.15	39.50
April	39.46	39.35	40.15
May	40.97	39.90	41.65
June	40.55	40.00	41.30
July	41.43	40.70	42.85
August	43.13	41.10	44.40
September	42.48	41.55	43.60
October	42.96	42.80	43.15
November	43.27	42.60	44.10
December	43.93	43.15	44.40
Year	41.25	37.85	44.40

FOREIGN TRADE

Exports totaled 1.34 million ounces, valued at $51.2 million, and consisted 57 percent of bullion and the balance mainly scrap. About 75 percent of the bullion went to India; the majority of the scrap went to the United Kingdom, Belgium-Luxembourg, and West Germany.

Imports of gold in 1971 totaled 7.2 million ounces valued at $283.9 million, mostly in the form of refined bullion. Principle sources, with quantities in million ounces, were Canada, 2.7; Switzerland, 2.2; and Burma, 1.8. About 75 percent of the gold was imported for industrial use.

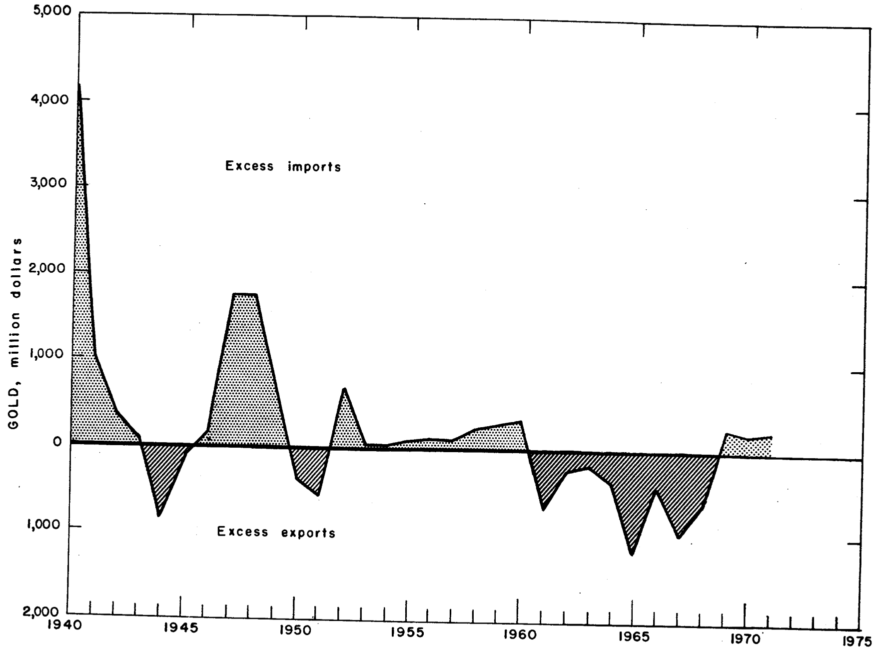

Figure 3.—Net exports or imports of gold.

WORLD REVIEW

World production of gold in 1971 declined from the record level of 47.5 million ounces in 1970, mainly because of a drop in production in the Republic of South Africa. Outputs also declined significantly in the United States and Canada but rose in the U.S.S.R. and in Australia. According to well-known gold dealer, Samuel Montagu & Co. Ltd., world consumption was about 46.5 million ounces in 1971, including an estimated 6 million ounces that was believed to have gone into private holdings.[6] The increase in private holdings was in contrast to 8 million ounces estimated to have been sold from investor and speculator stocks in 1970. Gold expert, D. O. Lloyd-Jacob (Consolidated Gold Fields Ltd.), has estimated the 1972 world demand for gold in fabrication in the range of 42.5 to 45 million ounces. By 1980, demand was expected to reach about 63 million ounces, assuming a rise in personal income, averaging 5 percent per year. From 1972 to 1980 net supply of gold was expected to decline from about 41 to 38 million ounces. Supply estimates assumed a 1.3-million-ounce decline in Republic of South African production, a 2.2-million-ounce decline from other free world gold mines, a 0.3-million-ounce expansion of byproduct gold supply, and a constant 1.6-million-ounce-per-year sale of gold to the free world by the U.S.S.R.

Australia.—Gold mines continued to operate under the Federal subsidy begun in 1954. An increase to $12 an ounce in maximum subsidized payments was under consideration early in the year. Western Mining Corp. announced intention to close its Central Norseman Gold Corp. N.L. and Gold Mines of Kalgoorlie (Aust.) Ltd. mines by about the end of 1972 if a higher subsidy were not provided. The mines accounted for about one-fourth of Australian gold output and employed about 850 of the total of 1,000 men in gold mining in Western Australia.

Bolivia.—Production was down because of litigation over operations of South American Placers, Inc., holding concessions

[6] Samuel Montagu & Co. Ltd. (London). Annual Bullion Review 1971, pp. 6, 7.

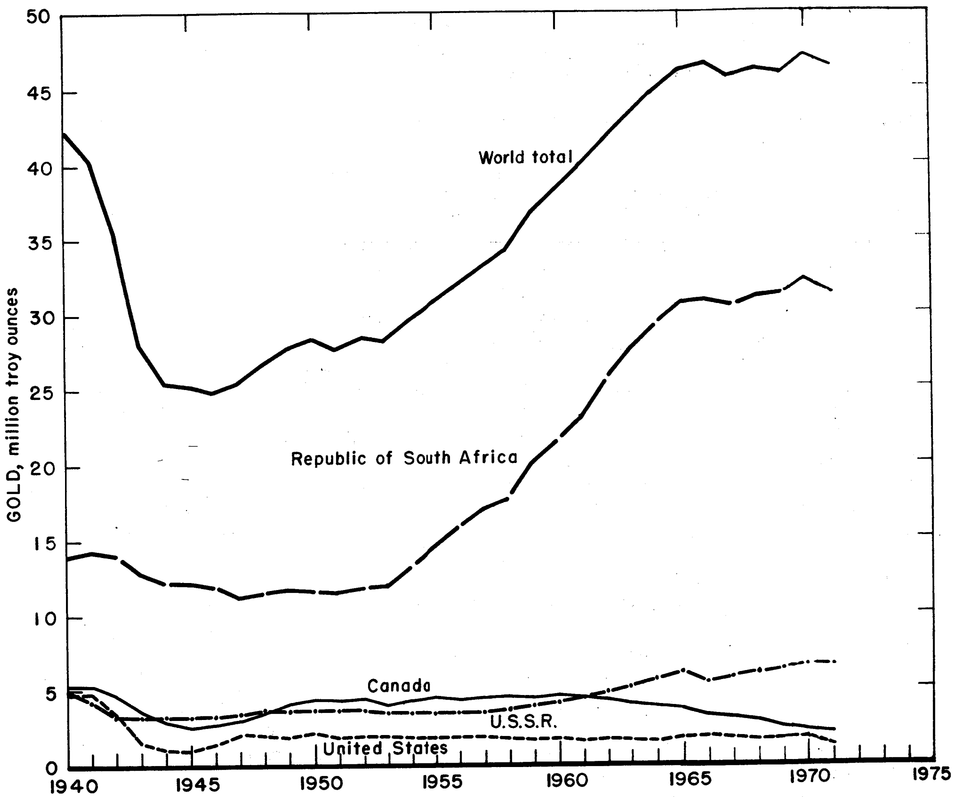

Figure 4.—World production of gold.

on the Kaka, Mapiri, and Tipuani Rivers near Teoponte and Guanay.

Brazil.—One large lode mine and two dragline-floating washing plants produced the bulk of the recorded gold output. Over 90 percent of production came from the Morro Velho group of mines operated by Mineração Morro Velho, S.A. A diamond dredge in Minas Gerais produced byproduct gold.

Canada.—Gold production in Canada declined 7 percent in 1971 continuing a 10-year downtrend. Gold quartz mines and placers contributed 79 percent of the total and base metal mines the balance. Ontario was the leading Province for gold, providing 50 percent of the total; Quebec, Northwest Territories, and British Columbia supplied 29, 14, and 4 percent, respectively; and the balance came from the Yukon (0.5 percent) and other Provinces.

Canada continued its program to subsidize gold mining, supporting about 30 producers employing an estimated 1,300 people with subsidies totaling about $12 million. Subsidized production accounted for all but 18 percent of the output from gold mines (1970). Maximum subsidy payments were $10.27 per ounce. Production and assistance data by individual mine were published by the Canadian Government.[7] Campbell Red Lake Mines Ltd., in the Red Lake district of Ontario, remained the only lode gold producer not requiring assistance under the subsidy program. Production at Campbell Red Lake was 196,237 ounces from 303,045 tons of ore milled in 1971. Output was 10 percent higher but average grade 5 percent lower than in 1970. Reserves totaled 1.38 million tons, averaging 0.67 ounce per ton.

In British Columbia, Bralorne Can-Fer Resources Ltd. announced plans to close its Bralorne and Pioneer mines in the latter half of the year because of high oper-

[7] Department of Energy, Mines and Resources (Ontario, Canada). Report on the Administration of the Emergency Gold Mining Assistance Act for the fiscal year ended March 31, 1971. 97 pp.

ating costs. In Quebec, the East Malartic mine was expected to suspend operations in 1971. During 1970, the MacLeod Mosher mine in the Thunder Bay district and Renabie Mines Ltd. in the Sudbury district of Ontario were reported to have ceased operations.

A new property in the Red Lake area adjoining the Dickenson mine was brought into production by Robin Red Lake Mines Ltd., subsidiary of Dickenson Mines Ltd. Output in 1971 was 21,320 ounces from 26,289 tons of ore milled. Ore reserves were 82,000 tons, averaging 0.79 ounce per ton at yearend, and a drilling program was planned. Drilling progressed at the Lac Du Rocher gold property of Sturdy Mines Ltd. and Talisman Mines Ltd. in the Northwest Territories, where veins up to 6 feet wide were explored. Goldex Mines Ltd. planned additional drilling of its properties in the Val d'Or-Malartic area, northwestern Quebec, where underground and possible open pit mining of ores, grading 0.1 to 0.25 ounce of gold per ton, was under consideration.

Colombia.—Ore reserves at the El Silencio mine of Frontino Gold Mines Ltd. were exhausted and operations were cut back.

Fiji.—Emperor Gold Mining Co. received Government assistance amounting to $0.5 million for development work at its Vatukuola mines.

Honduras.—A production tax of 4 percent was levied on gold late in 1970. Promising gold values were reported in drilling by United Siscoe Mines (U.S.) at Clavo Rico.

India.—The Kolar Champion Reef mine continued operating at depths exceeding 10,000 feet as ore grades continued to decline.[8] In March 1971 John Taylor and Sons of London ended its role as consulting engineers to the Indian Government for operation of the Hutti and Kolar gold mines, Mysore State. Average grades at the mines declined further (0.26 and 0.17 ounce per ton, respectively, in 1970). Total ore reserves were down to about 0.5 million tons. The Kolar mines accounted for about 60 percent of production. Statistics released by the All-India Goldsmith Federation indicated that $333 million in gold was being smuggled into India annually and of this about $67 million was converted into jewelry while the balance was hoarded. At the beginning of 1971 the total value of all unofficial Indian gold holdings was estimated by the same source at $6.05 billion.

Mexico.—Mexican gold production, down from that in 1970, remained almost entirely a byproduct of other base metal output with over half produced by Industrias Peñoles, S. A., and affiliates. Three major gold refiners were provided rebates of a 15-percent sales tax; a 50-percent reduction in the gold production tax was continued in 1971.

Nicaragua.—Neptune Gold Mining Co., subsidiary of American Smelting and Refining Company (ASARCO), continued milling about 300 tons of gold ore per day and opened the new Vesubio lead-zinc mine and flotation mill, all in the Bonanza area of Nicaragua. Gold content of Vesubio ore averaged 0.09 ounce per ton, mill capacity was rated at 500 tons per day, and reserves were estimated at 1.2 million tons.

Papua-New Guinea, Territory of.—Bougainville Copper Pty. Ltd. was scheduled to begin copper (with byproduct gold) production in mid-1972 at its Bougainville Island operation. Gold content of the approximate 900-million-ton ore reserve was estimated to average 0.018 ounce per ton, and output was expected at about 50,000 ounces per year.

Philippines.—On August 5, 1971, the Philippine Government raised gold subsidy price ceilings to P310 ($48) per ounce for firms producing in excess of 100,000 ounces per year and P350 ($54) for smaller producers.[9] The larger producers were to receive a subsidy of P50 ($7.75) per ounce plus 65 percent of the difference between production costs and the official gold price of P225 ($35) per ounce. The maximum bonus over production costs was placed at P30 ($4.70) per ounce. Somewhat higher allowances were specified for smaller producers. Other restrictions were placed on producers wanting the subsidy including the stipulation that all production be sold to the Central Bank at the Peso equivalent of the official gold price. Benguet Consolidated Inc. remained the country's leading gold producer and the only firm qualifying in the over-100,000-ounce category (248,348 ounces of gold produced in 1970).

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[8] U.S. Embassy, New Delhi, India. State Department Airgram A-281, June 25, 1971, pp. 37–38.

[9] U.S. Embassy, Manila, Philippines. State Department Airgram A-11, Jan. 13, 1972, 4 pp.

Rhodesia, Southern.—The bulk of Rhodesia's gold output continued to come from copper production. The Joyce gold-copper mine at Beatrice, long inactive, was reopened, and a promising gold discovery was made on the Ntabazinduna Tribal Trust Land. Two new mines, the Lion and Termite were being developed in the Silobela area, 55 miles west of Que Que. The search for gold in the area was unique in that it was facilitated by the careful analyses of sands brought to the surface by ants and termites. Rhodesia's Gold Mining (Financial Assistance) Act, providing support for about seven gold mines, was extended to August 31, 1973.

South Africa, Republic of.—The production of gold declined in 1971, partly because lower grade ore was mined and also because of technical operating problems. During 1971 the Republic of South Africa continued to sell all of its newly mined gold on the free market to offset trade deficits, according to terms of an agreement with the IMF, and in addition sold 7.31 million ounces from official reserves. At the end of 1971, Republic of South Africa reserves in gold coin and bullion were down to 11.72 million ounces. Devaluation late in 1971 raised the Rand value of gold from R24.80 to R28.30 per ounce. Higher world prices for gold during 1971 increased the premiums paid by the Government to gold producers, although company profits from uranium, an important byproduct of some mines, were down owing to slack world demand.

Production of the Consolidated Gold Fields Ltd. group of mines was a record 6.3 million ounces, with the West Driefontein mine, world's largest gold producer, increasing output 8 percent to 2.9 million ounces in 1971. Water was still being pumped out of the mine from flooding in 1968 and it was expected that hoisting could begin at the No. 4 shaft early in 1972. The No. 4 had been expected to serve development work at the East Driefontein mine. At the East Driefontein, shaft development continued, although other work was delayed by dewatering; by yearend the No. 1 shaft was complete and equipped to its final 5,030-foot depth. East Driefontein was expected to begin producing early in 1973 and to reach a planned milling rate of 181,000 tons per month by 1976. The Kloof mine increased output 11 percent, to 1.1 million ounces, despite a serious underground fire which was sealed off and allowed to burn itself out. Gold Fields' drilling was completed at Deelkraal and the possibility for establishing a new mine was deliberated. In mid-1971 shareholders of West Witwatersrand Areas Ltd. were invited to merge with Gold Fields of South Africa, wholly owned subsidiary of Consolidated Gold Fields Ltd. Under terms of the merger, West Witwatersrand would take over responsibility for management of the Gold Fields group of companies in South Africa. However, the surviving firm would be Gold Fields of South Africa. The survivor would no longer be considered a subsidiary of Consolidated Gold Fields. Completion of the merger was expected late in 1971.

Benefiting from a low-interest Government loan, Randfontein Estates Ltd., controlled by Johannesburg Consolidated Investment Co., continued initial development of its new mine in the West Rand area. Production was expected to start in 1974 and reach a milling rate of 100,000 tons per month about the end of 1975. Reserves are estimated at 30 million tons and the ore contains both gold and uranium.

Western Deep Levels Ltd., of the Anglo American Corp. group, conducted a further deep development program to open up stoping areas below 10,000 feet. Development was mainly directed to the Carbon Leader Reef, which averages nearly one ounce of gold per ton and is expected to greatly increase the life of the mine. A subvertical ore shaft and three 22-degree-inclined shafts were to be sunk from the 10,000-foot level to a depth of 12,448 feet, and stoping between the 120 and 109 levels was scheduled to begin in 1974.

Union Corp. Ltd. reported gold production of 3.71 million ounces in 1971. Outputs increased at its St. Helena mine, Orange Free State, and Bracken, Kinross, and Windelhaak mines, all in the Evander area. At its East Rand properties, the East Geduld mine produced 34,000 ounces in cleanup operations following closure in 1970. Operations at Grootvley; were expected to continue only about 2 more years and at Marievale about 4 more years.

The Buffelsfontein mine of General Mining & Finance Corp. Ltd. encountered severe faulting in new areas of the Vaal Reefs, under development in 1971 which will cause ore dilution and consequent decline in grade. Buffelsfontein remained the Republic of South Africa's leading uranium producer as well as an important gold producer.

East Daggafontein Mines Ltd.. which produced about 296,000 ounces of gold in 1971, planned to close in the second half of 1972 because of depleted reserves. Ore grade averaged about 0.18 ounce per ton in 1971. With cessation of this and other operations in the area and reduced pumping, the rising water table will cause further mine flooding. The Rand Leases gold mine, near Roodeport, was reported about to close because of ore depletion.

Estimates of Republic of South Africa ore reserves, fully developed or blocked out, reported by members of the Chamber of Mines of South Africa, were on the order of 150 million metric tons averaging about 0.55 ounce of gold per ton. Estimates were based on stoping widths ranging from a minimum of 2.6 feet to a maximum of 5.5 feet. Average cost of production for all mines was estimated at R7.80 ($11.00) per ton of ore milled in 1971. Average mining grades were close to 0.4 ounce per ton. Because of increasing costs, efforts have been expanded to reduce ore dilution during mining. Rock cutting experiments using specially designed continuous mining machines for narrow veins were conducted during the year at the Doornfontein and Stilfontein gold mines and resulted in one-third less dilution.[10] This and other technical improvements were expected to lead to more efficient gold mining in Republic of South Africa.

United Kingdom.—Early in 1971 the Government dropped restrictions on holding or trading of gold coins by residents of the United Kingdom.

U.S.S.R.—The Soviet Union continued to restrict information on gold but it was reported that a large new gold mine, the Muruntau, had been opened on the south side of Mt. Muruntau, in the Kyzyl-Kum desert of West-central Uzbekestan.[11] Initially the mine was being worked by open pit to be followed by underground development. The first ingot was reportedly poured in July 1969. The cyanide processing plant was said to incorporate a unique ion extraction process, presumably using a resin to collect the gold after solution with cyanide. Soviet gold sales to the free market were reported early in 1971 and estimates indicated possible movement of 2 million to 3 million ounces out of the U.S.S.R. and East Europe early in 1971.[12]

Venezuela.—A $6.6 million project was under consideration for modernizing the El Callao gold mine, owned by Compañia Nacional de Mineria.

TECHNOLOGY

Further progress was made during 1971 in chemical treatment of gold ores. Two processes for recovery of gold from leached plant slurries, developed by Bureau of Mines metallurgists at the Salt Lake City Metallurgy Research Center, were tested by commercial gold producers. One process utilized multiple compartment columns for treatment of clear or slime-bearing solutions; the other was a carbon-in-pulp process for extracting gold from pulps or slimes alone. Small pilot plants were installed at the Carlin, Nev., property of the Carlin Gold Mining Co. and the Lead, S. Dak., property of the Homestake Mining Co. Both used granular activated carbon to extract gold from the pulps, and the gold-loaded carbon from either was then stripped of gold using a novel high-pressure process also invented by the Bureau. The latter pressure stripping produced concentrated gold solutions containing up to 1,000 times as much gold per unit volume as the pregnant solutions contain in normal operations. The new processes were expected to be more efficient and less costly to install and operate than existing conventional processes.

Bureau studies also concluded that it was technically feasible to leach gold insitu from placer gold deposits using cyanidation where gravels were too deeply buried or too low in tenor to be mined by other methods.[13] The researchers envi-

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[10] U.S. Embassy, Johannesburg, Republic of South Africa. State Department Airgram A–88, Dec. 3, 1971, 4 pp.

[11] World Mining. Muruntau-Uzbekstan's Golden Mountain Is Important Soviet Mine. V. 7, No. 12, November 1971, pp. 56–57.

[12] American Metal Market. Soviet Gold Sales Seen by London Bullion Sources. V. 78, No. 84, May 3, 1971, p. 32.

[13] Nichols, I. L., H. B. Salisbury, and B. K. Shibler. Laboratory Evaluation of Some Factors in Cyaniding Gold Placers. BuMines RI 7559, 1971, 12 pp.

sioned the extraction of gold from deep deposits by injection and retrieval of solutions through wells and from shallow deposits using trenches, thereby greatly reducing the need for excavation and land surface damage.

Preparation of reports continued on Bureau studies of Tertiary channels ("fossil river beds") containing placer gold in Nevada County, Calif. The studies, conducted under the Heavy Metals Program, which ended in mid-1970, included investigations of exploration techniques, environmental control requirements, and various features of extractive technology. Approximately 15 reports were in various stages of completion.

Encouraging results were reported on a test of heap-leaching of low-grade gold-bearing waste rock at the Carlin mine in Nevada. The process, developed by the Bureau of Mines, extracted 67 to 95 percent of the gold from ores analyzing on the order of 0.02 ounce per ton in the laboratory and in the field test, extraction of 53 percent was achieved from similar material. In the process, mine-run or coarsely graded rock is heaped on an impervious base or pad and is sprinkled with a cyanide leach liquor. Solutions collected below may then be treated as usual for recovery of the gold by zinc precipitation. Heap-leaching of gold was also about to begin at the Cortez mine in Nevada where a large dump of uncrushed submarginal ore was spread on a base of compacted tailings in preparation for leach application. Solutions were to be collected in a pond below the dump and returned to the existing mill circuits.

Recent Bureau research on oxidation processes applicable to extraction of gold from carbonaceous ores was reviewed and a unique electrolytic recovery process using common salt (NaCl) was described.[14]

In a statistical study, frequency distributions of gold assay data from some major mines were compared, and it was determined that use of a lognormal distribution in estimating average grades introduced undesirable bias.[15] Another statistical study showed that at the Homestake gold mine in S. Dak., sampling at 5-foot intervals provided nearly as good results as sampling at shorter intervals, suggesting fewer samples might be taken.[16] The relationship of beach and stream placer gold deposits to gold-bearing schists 50 miles east of Nome, Alaska, was investigated, and it was concluded that similar schists probably supplied most of the placer gold elsewhere in the southern Seward Peninsula.[17] A report was issued supplying the basic information needed for a novice placer gold prospector or miner beginning a small-scale placer operation.[18]

A number of reports described gold occurrences or deposits, including those in the Klamath Mountains, northern California and southwestern Oregon,[19] in north-central Nevada and southwestern Idaho,[20] the Southern Cortez Mountains, Nevada,[21] in South Carolina,[22] and in Alaska.[23] An annotated bibliography on reports dealing with gold geochemistry was issued.[24] Two deep holes drilled by the U.S. Geological Survey to explore potential gold-bearing strata in the vicinity of the Roberts Mountains thrust fault, north-central Nevada, intercepted anomalous gold values associated with base-metal sulfide veins along fractures.[25] Geochemical prospecting for

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[14] Scheiner, B. J., R. E. Lindstrom, and T. A. Henrie. Oxidation Process for Improving Gold Recovery From Carbon-Bearing Gold Ores. BuMines RI 7573, 1971, 14 pp.

[15] Link, Richard F., George S. Koch, Jr., and John H. Schuenemeyer. Statistical Analysis of Gold Assay and Other Trace-Element Data. BuMines RI 7495, 1971, 127 pp.

[16] Koch, George S., Jr., and Richard F. Link. Sampling Gold Ore by Diamond-Drilling in the Homestake Mine, Lead, S. Dak. BuMines RI 7508, 1971, 35 pp.

[17] Mulligan, John J. Sampling Gold Lode Deposits, Bluff, Seward Peninsula, Alaska. BuMines RI 7555, 1971, 40 pp.

[18] West, J. M. How to Mine and Prospect for Placer Gold. BuMines IC 8517, 1971, 43 pp.

[19] Hotz, Preston E. Geology of Lode Gold Districts in the Klamath Mountains, California and Oregon. U.S. Geol. Survey Bull. 1290, 1971, 91 pp.

[20] Roberts, Ralph J., Arthur S. Radtke, and R. R. Coats. Gold-Bearing Deposits in North-Central Nevada and Southwestern Idaho. Econ. Geol., v. 66, No. 1, January–February 1971, pp. 14–33.

[21] Wells, J. D., and J. E. Elliott. Geochemical Reconnaissance of the Cortez-Buckhorn Area, Southern Cortez Mountains, Nev. U.S. Geol. Survey Bull. 1312–P, 1971, pp. P1–P18.

[22] Minard, J. P. Gold Occurrences near Jefferson, S.C. U.S. Geol. Survey Bull. 1334, 1971, 20 pp.

[23] Reed, B. L., and R. L. Miller. Orientation Geochemical Soil Survey at the Nixon Fork Mines, Medfra Quadrangle, Alaska. U.S. Geol. Survey Bull. 1312–K, 1971, pp. K1–K21.

Clark, S. H. B., and H. L. Foster. Geochemical and Geological Reconnaissance in the Seventy-Mile River Area Alaska. U.S. Survey Geol. Survey Bull. 1315, 1971, 21 pp.

[24] Cooper, Margaret. Selected Annotated Bibliography on the Geochemistry of Gold. U.S. Geol. Survey Bull. 1337, 1971, 63 pp.

[25] Theodore, Ted G., and Ralph J. Roberts. Geochemistry and Geology of Deep Drill Holes at Iron Canyon, Lander County, Nevada. U.S. Geol. Survey Bull. 1318, 1971, 32 pp.

gold in surface waters using neutron activation was considered unpromising in a study that took place in Colorado's Front Range.[26] Descriptions of foreign gold deposits and their parageneses were published, including Japanese deposits.[27] and the Salsigne gold mine in France; [28] several general discussions were also published on paragenesis related to temperature, depth, and structures.[29] Various morphologic forms of gold were described and photographed; [30] it was found that all crystals and grains of gold exhibited mosaic structures.

Exoelectron emission tests were made on gold-bearing drill cores by the Mine Systems Engineering Group at the Bureau of Mines, Denver, Colo., research center. The purpose was to determine whether the technique would help differentiate hydrothermal from sedimentary quartz as a guide to delineating gold ore bodies. The method proved better than one using high temperature thermoluminescence and a report was in preparation at yearend.

Several large gold dredge operations of recent years were described, including those at Bear Valley, Idaho; Goodnews Bay, Alaska (mainly platinum); Marysville, Calif; Folsom, Calif.; and in the Yukon Territory Canada.[31] The Bureau of Mines found that gold-bearing Tertiary gravels in California could be satisfactorily supported in underground openings with standard rock bolts using an epoxy resin grout or with the newly designed explosive anchor bolts.[32] Research was completed on feasibility of developing the Golden Sunbeam gold property in Custer County, Idaho, where resources were estimated to amount to 82 million tons averaging a little over $1 per ton in gold and silver.[33] The feasibility of mining gold from frozen gravel placers in Alaska was studied by the Bureau of Mines and conditions were determined for maintaining an opening without artificial supports.[34] D.D.V. Oxford patented a diamond chain sawing method for mining thin bodies of gold ore.[35] Feasibility of using such rock cutters for selective gold mining was being investigated in South Africa.[36]

Processing of gold and silver was described at the Rand Refinery in South Africa, which treats all South African gold production.[37] The plant was rededicated in January 1971 after undergoing modernization. Treatment of recycled electrical and electronic scrap took into account aluminum removal in the recovery of precious metals.[38]

Research at the University of Melbourne, Australia, showed that gold could be extracted from solutions using raw brown coal as a medium for adsorption.[39] Ozone was used to counteract cyanide absorbing effects of carbonaceous impurities in certain refractory gold ores after lowering the pH of an ore slurry to about 1.0–2.0[40] Iodine was used in an aqueous alcoholic solution [41] and with a ketonic

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[41] Jacobs, A. L. Gold Recovery Process. U.S. Pat. 3,625,674, Dec. 7, 1971.

solvent[42] in new gold extraction processes.

The Chamber of Mines of South Africa continued to publish its excellent quarterly series of reports called Gold Bulletin, containing articles on new uses for gold and abstracts on new technology.[43] The April issue featured an article on use of gold in industry reviewing data compiled by D. O. Lloyd-Jacob and P. D. Fells in studies for Consolidated Gold Fields.

New specifications for refined gold were proposed by the American Society for Testing and Materials for 99.95 and 99.99 percent grades. Precise control of color and of thickness up to 40 microns was claimed for a new gold plating process called Endura Glo.[44] A cyanide-free gold plating process, ECF-60, using an alkaline electrolyte was developed; also, an improved spot-plating process called Auro Spot HS was marketed.[45] A more efficient spectrographic technique was developed for determining the elements present in gold plating solutions.[46] A process for plating gold from a gel electrolyte was investigated and was believed worthy of further study despite a problem with hydrogen gas bubbles that made a porous gold deposit.[47] Use of a pulsed electric current for gold electroplating appeared to lower plating rates, although permissible instantaneous current was much higher as compared with direct current plating methods.[48]

Specular reflecting and electrically continuous gold films were formed by a minor addition of rhodium which inhibited grain growth when an organometallic coating was fired.[49] Tensile strength and hardness of gold and platinum alloys were improved with additions of thorium dioxide and alumina and dispersion hardening.[50] Artificial gold-selenide minerals were produced and studied,[51] and the solubilities of rare earths and gold were investigated.[52] Basic research was done by the Bureau of Mines on volatization of gold chlorides and it was found that iron and aluminum compounds especially increased the amount of gold vapor transported at temperatures near 250° C through complexes formed with metal chlorides.[53] Another Bureau study examined valences of gold compounds of chlorine and bromine.[54]

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Table 3.—Mine production of recoverable gold in the United States, by State

(Troy ounces)

State	1967	1968	1969	1970	1971
Alaska	22,948	21,262	21,227	34,776	13,012
Arizona	80,844	95,999	110,878	109,853	94,038
California	40,570	15,682	7,904	4,999	2,966
Colorado	21,181	22,638	25,777	37,114	42,031
Idaho	4,838	3,227	3,403	3,128	3,596
Montana	9,786	13,385	24,189	22,456	15,613
Nevada	434,993	317,382	456,294	480,144	374,878
New Mexico	5,188	6,630	8,952	8,719	10,681
Oregon	186	23	875	256	244
Pennsylvania [1]	73,337	54,453	47,020	55,008	55,434
South Dakota	601,785	593,052	593,146	578,716	513,427
Tennessee	181	140	126	124	192
Utah	288,350	334,419	433,385	408,029	368,996
Total	1,584,187	1,478,292	1,733,176	1,743,322	1,495,108

[1] Production of Pennsylvania, Washington, Wyoming (1969), and North Carolina (1971) combined to avoid disclosing individual company confidential data.

Table 4.—Mine production of recoverable gold in the United States, by month

(Troy ounces)

Month	1970	1971
January	146,274	133,085
February	135,329	120,977
March	148,173	136,566
April	138,898	127,545
May	147,338	132,514
June	147,955	137,552
July	139,139	84,046
August	150,685	130,127
September	147,062	124,533
October	143,382	122,979
November	151,698	126,218
December	147,389	118,966
Total	1,743,322	1,495,108

Table 5.—Twenty-five leading gold-producing mines in the United States in 1971, 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-silver ores.
3	Carlin	Eureka, Nev	Carlin Gold Mining Co	Gold ore.
4	Cortez	Lander, Nev	Cortez Gold Mines	Do.
5	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
6	Knob Hill and Gold Dollar	Ferry, Wash	Knob Hill Mines, Inc	Gold ore.
7	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Copper ore.
8	Tripp-Veteran Pit	White Pine, Nev	Kennecott Copper Corp	Do.
9	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Do.
10	Copper Canyon	Lander, Nev	Duval Corp	Do.
11	San Manuel	Pinal, Ariz	Magma Copper Co	Do.
12	Ruth Pit	White Pine, Nev	Kennecott Copper Corp	Do.
13	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
14	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
15	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
16	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
17	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
18	Leadville	Lake, Colo	American Smelting & Refining Co	Lead-zinc ore.
19	Continental	Grant, N. Mex	United States Smelting Refining and Mining Co	Copper ore.
20	Hogatza River	Yukon River Region, Alaska	do	Placer.
21	U.S. and Lark	Salt Lake, Utah	do	Lead-zinc ore.
22	Christmas	Gila, Ariz	Inspiration Consolidated Copper Co	Copper ore.
23	Lucky Friday	Shoshone, Idaho	Hecla Mining Co	Lead ore.
24	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Copper ore.
25	Copper Cities	Gila, Ariz	Cities Service Co	Do.

Table 6.—Production of gold in the United States in 1971 by State, types of mine, and class of ore, yielding gold, in terms of recoverable metal

State	Placer (troy ounces of gold)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	12,327	230	685	--	--	--	--
Arizona	--	[1] 58	[1] 10	--	--	W	W
California	2,307	[1] 715	[1] 152	W	W	--	--
Colorado	1,623	--	--	--	--	785	64
Idaho	--	--	--	--	--	557,257	805
Montana	52	739	183	13,765	1,337	15,471	139
Nevada	6	1,599,018	319,036	315	97	155	6
New Mexico	--	--	--	--	--	--	--
South Dakota	--	1,799,678	513,427	--	--	--	--
Utah	--	--	--	152,117	1,282	--	--
Other States [2]	36	71,581	54,253	--	--	360	12
Total	16,351	3,472,019	887,746	166,197	2,716	574,028	1,026
Percent of total gold	1	--	60	--	(3)	--	(3)

State	Lode					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	--	--	--	--	--	--
Arizona	135,301,327	93,617	3,250	5	--	--
California	--	--	W	W	--	--
Colorado	[4] 322,392	[4] 1,322	W	W	W	W
Idaho	26,492	555	274,716	1,659	--	--
Montana	13,493,157	13,730	313	52	4,027	6
Nevada	8,392,460	55,593	197	134	--	--
New Mexico	17,228,961	10,562	--	--	--	--
South Dakota	--	--	--	--	--	--
Utah	35,008,400	303,544	--	--	--	--
Other States [2]	2,000	9	621	6	--	--
Total	209,775,189	478,932	279,097	1,856	4,027	6
Percent of total gold	--	32	--	(3)	--	(3)

State	Lode					
	Copper-lead, lead-zinc copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	--	--	--	--	230	13,012
Arizona	95,034	20	77,166	386	135,476,835	94,038
California	[4] 87,540	[4] 381	--	[5] 126	88,255	2,966
Colorado	816,951	39,009	--	[5] 13	1,140,128	42,031
Idaho	780,602	577	--	--	1,639,067	3,596
Montana	30	3	17,218	111	13,544,720	15,613
Nevada	532	6	--	--	9,992,677	374,876
New Mexico	119,021	119	--	--	17,347,982	10,688
South Dakota	--	--	--	--	1,799,678	513,421
Utah	472,082	64,154	159	16	35,632,758	368,997
Other States [2]	1,956,067	297	--	[5] 1,257	2,030,629	55,870
Total	4,327,859	104,566	94,543	1,909	218,692,959	1,495,108
Percent of total gold	--	7	--	(3)	--	100

W Withheld to avoid disclosing individual company confidential data.
[1] Combined with other dry and siliceous ores to avoid disclosing individual company confidential data.
[2] Includes North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.
[3] Less than ½ unit.
[4] Combined with other base-metal ores to avoid disclosing individual company confidential data.
[5] Includes byproduct gold recovered from tungsten ore in California and North Carolina; from fluorspar ore in Colorado; and from magnetite-pyrite ore in Pennsylvania.

Table 7.—Gold produced in the United States from ore, old tailings, etc., in 1971, by State and methods 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)	685
Arizona	149,480	148,999	--	--	2,983,955	90,980	481	3,058
California	89	89	--	--	12,097	621	(3)	38
Colorado	1,239	1,238	3,071	--	779,629	37,294	1	43
Idaho	1,647	1,646	--	--	198,374	3,581	1	15
Montana	13,551	13,504	--	--	284,493	13,832	47	1,729
Nevada	18,659	18,658	--	319,036	355,344	55,712	1	124
New Mexico	18,520	18,463	--	--	659,893	10,677	57	4
South Dakota	1,800	1,800	--	513,427	--	--	--	--
Utah	36,247	36,080	--	--	905,113	367,691	167	1,305
Other States [4]	2,659	2,656	--	--	377,772	55,611	3	223
Total	243,891	243,133	3,071	832,463	6,556,670	635,999	758	7,224

[1] Includes some nongold-bearing ores not separable.
[2] Excludes tonnages of fluorspar, magnetite-pyrite, and tungsten ores from which gold was recovered as a byproduct.
[3] Less than ½ unit.
[4] Includes North Carolina, Oregon, Pennsylvania, 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
1967	400,836	609,714	25.3	38.5	32.1	4.1
1968	394,051	482,616	26.7	32.6	38.2	2.5
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

[1] Crude ores and concentrates.

Table 9.—Gold production at placer mines in the United States, by methods 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:						
1969	4	4	814	13	$547	$0.672
1970	1	1	709	29	1,055	1.488
1971	2	3	[1] 740	[2] 7	301	[3] .149
Dragline dredging:						
1969	2	2	[1] 2	([2]) ([4])	17	[3] .934
1970	1	3	[1] 2	([2]) ([4])	20	[3] 10.000
1971	--	--	--	--	--	--
Hydraulicking:						
1969	4	--	3	([4])	3	1.245
1970	8	4	17	1	20	1.176
1971	5	5	32	1	30	.938
Nonfloating washing plants:						
1969	30	42	[1] 347	[2] 9	365	[3] .727
1970	19	37	[1] 275	[2] 8	291	[3] 1.058
1971	21	38	[1] 289	[2] 8	333	[3] 1.152
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1969	26	4	112	3	123	1.100
1970	9	2	[1] 4	[2] 1	23	[3] 5.750
1971	12	4	6	--	10	1.667
Total placers:						
1969	66	52	[1] 1,278	[2] 25	1,055	[3] .726
1970	38	47	[1] 1,007	[2] 39	1,409	[3] 1.399
1971	40	50	[1] 1,067	[2] 16	674	[3] .287

[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	1967	1968	1969	1970	1971
Jewelry and arts	3,840	3,908	3,839	3,340	4,299
Dental	566	771	710	658	750
Industrial, including space and defense	1,888	1,925	2,560	1,975	1,884
Total	6,294	6,604	7,109	5,973	6,933

[e] Estimated by Office of Domestic Gold and Silver Operations, U.S. Treasury Department.

Table 11.—U.S. exports of gold in 1971, by country

Destination	Ore, base bullion and scrap: Troy ounces	Ore, base bullion and scrap: Value (thousands)	Refined bullion: Troy ounces	Refined bullion: Value (thousands)
Belgium-Luxembourg	201,480	$8,155	--	--
Brazil	--	--	320	$12
Canada	182	6	25,147	1,049
Germany, West	53,358	2,153	--	--
India	--	--	571,424	20,000
Italy	60	2	--	--
Mexico	1,246	45	--	--
Sweden	2,806	100	--	--
Switzerland	--	--	160,389	6,576
United Kingdom	318,370	13,009	--	--
Venezuela	--	--	4,022	142
Total	577,502	23,470	761,302	27,779

Table 12.—U.S. imports of gold in 1971, by country

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Australia	25,672	$902	350	$14
Austria	--	--	48	2
Belgium-Luxembourg	--	--	6,497	235
Burma	--	--	1,792,003	62,720
Canada	30,851	1,188	2,686,047	109,176
Chile	2,983	104	--	--
Colombia	394	16	--	--
El Salvador	221	8	48	2
France	--	--	39,142	1,654
Germany, West	309	10	38,472	1,610
Honduras	2,593	56	--	--
Hong Kong	550	19	--	--
Korea, Republic of (South)	536	18	--	--
Mexico	4,936	187	--	--
Nicaragua	28,751	1,160	--	--
Norway	368	13	--	--
Panama	100	4	60	2
Peru	20,984	749	--	--
Philippines	67,542	2,688	--	--
Portugal	287	10	--	--
Singapore	1,656	67	--	--
South Africa, Republic of	734	26	25,650	1,030
Switzerland	--	--	2,170,843	89,688
Taiwan	16	(1)	--	--
U.S.S.R.	--	--	16,240	634
United Kingdom	100	2	233,841	9,916
Venezuela	1,887	37	--	--
Total	191,470	7,264	7,009,241	276,683

[1] Less than ½ unit.

Table 13.—Value of gold imported into and exported from the United States

(Thousand dollars)

Year	Exports	Imports
1969	$12,287	$236,906
1970	37,790	237,464
1971	51,249	283,947

Table 14.—Gold: World production, by country

(Troy ounces)

Country [1]	1969	1970	1971 p
North America:			
Canada	2,545,109	2,408,574	2,243,000
Costa Rica e	500	500	500
El Salvador	--	2,301	3,503
Haiti e	3,000	3,000	3,000
Honduras	6,223	3,333	3,503
Mexico	r 180,623	198,241	150,915
Nicaragua	120,011	115,173	121,134
United States [2]	1,733,176	1,743,322	1,495,108
South America:			
Argentina	16	--	NA
Bolivia	49,854	30,603	22,179
Brazil	176,938	180,076	157,378
Chile	59,102	50,718	64,417
Colombia	218,872	217,965	188,842
Ecuador	7,287	e 7,300	e 7,300
French Guiana	3,590	2,347	e 2,300
Guyana	2,102	4,433	e 4,400
Peru	131,641	104,258	98,928
Surinam	2,389	1,137	e 1,100
Venezuela	19,385	21,862	19,162
Europe:			
Finland	18,872	20,319	17,489
France	54,946	62,726	e 65,000
Germany, West e	1,000	1,000	1,700
Portugal (mine output)	16,333	11,992	14,721
Romania e	60,000	60,000	60,000
Sweden (mine output)	45,011	44,345	e 44,000
U.S.S.R. e [3]	6,250,000	6,500,000	6,700,000
Yugoslavia	84,074	97,384	115,743
Africa:			
Cameroon	r 193	235	96
Congo (Brazzaville)	3,922	2,636	e 2,600
Ethiopia	42,400	27,282	21,226
Gabon	14,243	16,108	13,728
Ghana	706,621	703,858	697,517
Guinea	3,922	e 4,000	e 4,000
Kenya	17,903	--	--
Liberia [4]	1,136	e 1,100	e 1,100
Mali	32	e 30	e 30
Malagasy Republic	r 646	514	412
Mozambique	21	35	e 35
Niger	161	235	e 235
Nigeria	298	123	36
Rhodesia, Southern e	480,000	500,000	500,000
South Africa, Republic of	31,275,882	32,164,107	31,388,632
Tanzania	16,016	7,859	167
Zaire (formerly Congo Kinshasa)	175,804	177,128	179,079
Zambia	e 5,000	e 5,000	9,866
Asia:			
Burma e	150	150	150
China, People's Republic of e	50,000	50,000	50,000
India	109,473	104,200	118,572
Indonesia	r 7,928	7,608	10,578
Japan [5]	246,492	255,759	254,890
Khmer e	4,000	4,000	4,000
Korea:			
North e	160,000	160,000	160,000
South [2]	50,734	51,409	28,807
Malaysia:			
Malaya	3,153	3,912	5,671 (Malaya and Sarawak)
Sarawak	2,271	1,265	
Philippines	571,145	602,715	637,048
Taiwan	21,486	22,602	19,496
Oceania:			
Australia	r 721,894	624,985	670,136
British Solomon Islands Protectorate	413	291	444
Fiji	91,572	103,785	89,129
New Zealand	10,717	11,283	9,418
Papua and New Guinea	25,857	[6] 23,798	23,389
Total	r 46,611,539	47,530,921	46,505,809

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

[1] Gold is also produced in Bulgaria, Czechoslovakia, Spain, and small quantities probably in East Germany, Hungary, Thailand, and several other countries. Data for these are not available. Data are also lacking on clandestine activities.

[2] Mine production.

[3] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Purchases by Bank of Monrovia.

[5] Refinery production for Japan was as follows: 1969—677,476 ounces; 1970—NA; and 1971—772,646 ounces.

[6] New Guinea only.

Graphite

By David G. Willard [1]

Supplies of natural graphite, particularly the higher grades, remained tight in 1971. Although the growth of foreign demand eased, mostly as a result of the slowdown in Japanese industrial activity, production problems in Ceylon and the Malagasy Republic—the principal supply areas of high quality graphite—prevented any significant rise in world output. Importers in the United States were hampered both by slow deliveries and by delays resulting from domestic dock strikes. Consumption in the United States is estimated to have risen slightly but remained below the level reached in 1969. Domestic production and imported supplies, supplemented by larger-than-usual releases of surplus graphite from the strategic stockpile, were sufficient to meet the demand in 1971, but the future supply-demand balance continued to concern the industry.

Legislation and Government Programs.—Defense material inventories as of December 31, 1971 showed that the stockpile contained a total of 36,685 tons of strategic-grade graphite. This amount represented a reduction of 4,908 tons from the yearend 1970 inventory and was the result of disposals of 3,976 tons of Malagasy crystalline graphite and 933 tons of crystalline graphite other than Ceylon and Malagasy, plus a 1-ton upward adjustment in the Ceylon amorphous lump stock total.

Disposals were larger than in previous years in response to requests from domestic importers who were having difficulty in obtaining supplies from their regular foreign sources. The annual release of Malagasy crystalline flake graphite was raised, in agreement with domestic suppliers and the Malagasy Government, from 500 to 1,500 tons. A further increase to 2,500 tons has been proposed for fiscal year 1973.

[1] Economist, Division of Nonmetallic Minerals.

DOMESTIC PRODUCTION

Southwestern Graphite Co. of Burnet, Tex., remained the only domestic producer of natural graphite in 1971. Data on its output are confidential, but it can be stated that there was a continuation of the declining trend of the last few years.

The tabulated output of manufactured graphite dropped slightly in 1971, breaking the rapidly rising trend of recent years. Production of 256,137 tons was 7 percent below the 274,076 tons produced in 1970. Total value fell only 1 percent, to $157.3 million from the $158.5 million of the year before.

Although consumption of electrodes continued to grow, markets for other manufactured graphite products were depressed by the continued slackness in industrial

Table 1.—Salient natural graphite statistics

	1967	1968	1969	1970	1971
United States:					
Consumption [1] [2] short tons	38,316	38,507	r 37,164	32,908	39,172
Value thousands	$5,700	$5,904	r 6,354	$5,866	$7,610
Exports short tons	3,569	4,169	5,655	5,783	5,733
Value thousands	$460	$509	r $782	$701	$680
Imports for consumption [1] short tons	56,675	67,922	58,459	66,449	57,755
Value thousands	$2,348	$2,494	$2,419	$3,027	$2,727
World: Production short tons	394,817	481,793	414,194	426,412	429,084

r Revised.
[1] Includes some manufactured graphite.
[2] Data for 1971 not comparable with data for previous years because of additional respondents not previously included in survey.

activity. Cost consciousness on the part of industrial consumers created resistance to the introduction of some of the newer types of specialty products. Considerable research and development effort was directed toward the discovery of new forms and uses of manufactured graphite, some of the results of which are noted in the section on technology.

Seven companies, operating 12 plants, reported their 1971 output of manufactured graphite to the Bureau of Mines. One company, Becker Brothers Carbon Co. of Cicero, Ill., suspended production during the year. The reporting companies and their plant locations are listed below.

Company	Location
Air Reduction Co., Inc.:	
Airco Speer Electrode Division	Niagara Falls, N.Y.
Airco Speer Carbon Products Division	St. Marys, Pa.
Carborundum Co.:	
Graphite Plant	Hickman, Ky.
Graphite Products Division	Sanborn, N.Y.
Great Lakes Carbon Corp.:	
Antelope Valley Plant	Rosamond, Calif.
Graphite Products Division	Niagara Falls, N.Y.
Morganton Plant	Morganton, N.C.
The Ohio Carbon Co.	Cleveland, Ohio
Charles Pfizer & Co., Inc.	Easton, Pa.
Stackpole Carbon Co.	St. Marys, Pa.
Union Carbide Corp.:	
Niagara Falls Plant	Niagara Falls, N.Y.
Tennessee Plant	Columbia, Tenn.

Manufactured graphite was produced at other plants in the United States, but their output could not be included in the foregoing tabulation. Most of these plants produced specialty products, which were small in total tonnage, although their unit values were relatively high.

CONSUMPTION AND USES

Consumption data reported in table 3 are not comparable with similar data published in earlier years because a large number of firms was added to the survey for this year. Graphite consumption by these firms had not been included in previous tabulations.

Total natural graphite consumption is estimated to have risen about 5 to 10 percent in 1971 from its depressed level in 1970. This relatively small rise means that total consumption had not returned to its pre-recession level of 1969.

Improved graphite markets occurred mainly in the motor vehicle industry and in miscellaneous uses. The upturn in domestic automobile sales that occurred in 1971 boosted graphite consumption in the manufacture of brake and clutch linings, rubber goods, and in lubricants and packings. Among the smaller, miscellaneous uses showing strong gains were powdered metal manufactures and products made from graphite-plastic composite materials (the latter group includes seals and similar products but not graphite fiber composites,

Table 2.—Government yearend stocks of natural graphite
(Short tons)

Type of graphite	National stockpile	Supplemental stockpile	Total all Stockpiles
Malagasy crystalline flake:			
Objective	10,800	--	10,800
Uncommitted excess: Stockpile grade	10,446	--	10,446
Total	21,246	--	21,246
Malagasy crystalline fines: Objective	5,230	[1] 1,910	7,140
Ceylon amorphous lump: Objective	[2] 4,295	1,204	5,499
Other than Ceylon and Malagasy, crystalline: Objective	[3] 2,800	--	2,800

[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: Office of Emergency Preparedness. Stockpile Report to the Congress July–December 1971.

for which no large market has yet developed).

The market for graphite in the primary metals industries was slower to recover, and the consumption of graphite in crucibles, foundry facings, and steel recarburizing was lower in 1971 than in 1970.

Changing technology is affecting the demand for natural graphite over the longer term. Crucible manufacturers are now able to use small flake graphite, which costs less than the large flake graphite formerly considered necessary. Demand for graphite as a carbon raiser in steelmaking has been boosted in some areas by the increased use of electric furnaces because of the absence of coal as a source of carbon.

Table 3.—Consumption [1] of natural graphite in the United States in 1971, by uses [2]

(Short tons)

Use	Crystalline		Amorphous [3]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Bearings	76	$38,706	W	W	W	W
Brake linings	650	295,925	663	$256,108	1,313	$552,033
Carbon brushes	206	143,008	174	118,114	380	261,122
Crucibles, retorts, stoppers, sleeves, nozzles	3,435	598,426	311	72,814	3,746	671,240
Foundry facings	1,164	312,897	5,353	615,337	6,517	928,234
Lubricants	743	316,350	2,100	469,653	2,843	786,003
Packings	199	121,135	171	56,081	370	177,216
Paints and polishes	58	80,188	133	54,555	191	134,743
Pencils	1,164	455,506	584	140,615	1,748	596,121
Refractories	W	W	7,973	779,060	W	W
Rubber	197	96,310	171	47,717	368	144,027
Steelmaking	652	102,544	3,706	437,254	4,358	539,798
Other [4]	6,667	1,235,885	2,622	765,964	[5] 17,338	[5] 2,819,615
Total	15,211	3,796,880	23,961	3,813,272	39,172	7,610,152

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

[1] Consumption data incomplete. Excludes small consuming firms.

[2] Data for 1971 not comparable with data for previous years because of additional respondents not previously included in survey.

[3] Includes mixtures of natural and manufactured graphite.

[4] Includes adhesives, ammunition, antiknock compounds, batteries, carbon products, chemical and plastics, electronic products, gray iron castings, insulation, magnetic tape, powdered metal parts, sealing compound, small packages, and uses indicated by symbol W.

[5] Numbers in "Other" line do not add to "Other" totals because those totals include all data, published and withheld, not shown in totals of individual line items.

PRICES

Quoted domestic prices of natural graphite remained unchanged in 1971. The price freeze during the latter part of the year undoubtedly contributed to the stability, as did the relatively slight increase in consumption. Prices of imported graphite were generally higher, which indicated that importers were, for the time being, absorbing the cost increases and not passing them on to their customers.

Nevertheless, published prices for natural graphic merely represent the range of prices. Actual prices are negotiated between buyer and seller on the basis of a wide range of specifications. A better guide to price trends is the average value per ton, which can be determined from table 5, although it should be kept in mind that these prices are largely for shipments of unprocessed graphite. The average values for each of the three major categories of imported graphite in 1971 were as follows:

Crystalline flake	$141 per ton
Crystalline lump, chip, or dust	$288 per ton
Other natural, crude and refined	$37 per ton

The Oil, Paint and Drug Reporter quotes prices on an ex-warehouse basis. December 27, 1971 quotations follow:

	Per pound
No. 1 flake graphite, 90 to 95 percent carbon	$0.32–$0.42
No. 2 flake graphite, 90 to 95 percent carbon	.239–.32
Powdered crystalline graphite:	
88 to 90 percent carbon	.184–.27
90 to 92 percent carbon	.255–.275
95 to 96 percent carbon	.29–.399
Powdered amorphous graphite	.0626–.195
Powdered amorphous or crystalline graphite, minimum of 97 percent carbon	.28–.36

Yearend prices, f.o.b. sources, were quoted in the Engineering and Mining Journal for two major classifications of graphite imported by the United States as follows (after conversion from metric tons):

	Per short ton	
	1970	1971
Flake and crystalline graphite, bags:		
Ceylon	$91–$172	$133–$241
Germany, West	123–777	143–855
Malagasy Republic	86–281	86–281
Norway	77–121	83–132
Amorphous, nonflake, cryptocrystalline graphite (80 to 85 percent carbon):		
Mexico (bulk)	19	22
South Korea (bags)	22	22
Hong Kong (bags)	24	24

FOREIGN TRADE

Exports of natural graphite declined 1 percent from the record 1970 level, to 5,733 tons. Smaller sales to Europe and Asia offset gains in other parts of the world, notably Canada.

Imports for consumption dropped 13 percent from the high level of the previous year. All three types of imported natural graphite shared in the decrease, indicating that the high 1970 imports combined with lower consumption had resulted in some excess stocks. The largest tonnage declines occurred in purchases from some of the leading supply sources including Norway, −36 percent; the Malagasy Republic, −24 percent; Ceylon, −9 percent; and Mexico, −8 percent.

Table 4.—U.S. exports of natural graphite, by countries

Destination	Amorphous, crystalline flake, lump, or chip, and natural, n.e.c. [1]			
	1970		1971	
	Short tons	Value	Short tons	Value
Argentina	53	$7,682	28	$3,444
Australia	211	15,998	201	17,952
Bahamas	--	--	69	15,522
Belgium-Luxembourg	278	23,760	70	9,649
Brazil	76	7,343	135	11,218
Canada	1,586	179,338	1,902	221,768
Chile	34	4,499	15	1,913
Colombia	168	14,564	61	5,591
Denmark	22	2,810	--	--
France	645	94,778	202	23,758
Germany, West	234	28,211	256	28,773
India	55	3,732	4	550
Italy	300	34,547	389	39,707
Japan	309	40,547	249	31,705
Mexico	586	75,036	634	80,926
Netherlands	177	15,316	18	2,340
New Zealand	4	252	50	3,180
Norway	27	2,909	--	--
Panama	35	2,638	--	--
Peru	68	9,424	133	18,963
Philippines	69	5,364	85	13,126
Singapore	--	--	50	6,144
Spain	--	--	206	16,940
Sweden	6	652	58	4,976
Switzerland [2]	99	12,662	3	675
Taiwan	40	4,785	--	--
United Kingdom	553	89,447	641	77,914
Venezuela	79	15,307	211	37,346
Other countries	69	8,995	63	5,557
Total	5,783	700,596	5,733	679,637

[1] Not elsewhere classified.
[2] Revised: 1969 Switzerland should read 4,418 tons ($101,384); total all countries should read 10,064 tons ($782,038).

Table 5.—U.S. imports for consumption of natural and artificial graphite, by countries

Year and country	Natural						Artificial		Total	
	Crystalline flake		Crystalline lump, chip, or dust		Other natural, crude and refined					
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	4,872	$523	210	$45	53,357	$1,838	20	$13	58,459	$2,419
1970:										
Austria	--	--	--	--	281	23	--	--	281	23
Canada	--	--	--	--	35	3	67	6	102	9
Ceylon	--	--	--	--	2,506	379	--	--	2,506	379
France	3	(1)	--	--	(1)	(1)	--	--	3	(1)
Germany, West	1,068	241	62	20	1,198	185	26	8	2,354	454
Italy	--	--	13	7	--	--	11	8	24	15
Japan	33	14	--	--	1	(1)	--	--	34	14
Korea, Republic of	--	--	--	--	723	24	--	--	723	24
Malagasy Republic	4,609	515	--	--	1,097	117	--	--	5,706	632
Mexico	--	--	--	--	50,307	1,032	--	--	50,307	1,032
Netherlands	--	--	1	1	--	--	--	--	1	1
Norway	--	--	--	--	4,403	434	--	--	4,403	434
Switzerland	--	--	--	--	--	--	5	2	5	2
United Kingdom	--	--	--	--	--	--	(1)	8	(1)	8
Total	5,713	770	76	28	60,551	2,197	109	32	66,449	3,027
1971:										
Canada	--	--	--	--	3	1	277	19	280	20
Ceylon	60	11	56	13	2,159	448	--	--	2,275	472
France	--	--	--	--	28	16	(1)	(1)	28	16
Germany, West	759	228	15	5	823	171	4	3	1,601	407
Italy	--	--	--	--	--	--	27	25	27	25
Japan	--	--	2	3	1	1	2	2	5	6
Korea, Republic of	--	--	--	--	116	6	--	--	116	6
Malagasy Republic	4,063	458	--	--	302	41	--	--	4,365	499
Mexico	50	1	--	--	46,132	961	--	--	46,182	962
Norway	--	--	--	--	2,830	304	--	--	2,830	304
South Africa, Republic of	--	--	--	--	28	3	--	--	28	3
Switzerland	--	--	--	--	--	--	15	7	15	7
U.S.S.R.	--	--	--	--	3	(1)	--	--	3	(1)
United Kingdom	--	--	--	--	(1)	(1)	--	--	(1)	(1)
Total	4,932	698	73	21	52,425	1,952	325	56	57,755	2,727

[1] Less than ½ unit.

WORLD REVIEW

Output of graphite in the world is estimated to have increased slightly in 1971, but at a far slower rate than in the year before. Demand eased during the year, chiefly as a result of the industrial slowdown in Japan, which relieved some of the pressure on world supplies. However, production of premium-quality graphite was curtailed by problems arising from civil strife and nationalization of the mines in Ceylon and damage caused by severe storms in the Malagasy Republic. As a result, the world supply and demand situation, especially for the higher grades of graphite, remained relatively tight at the end of 1971.

Brazil.—Cia. Nacional de Grafita Ltda., the country's principal graphite producer, expanded its processing and beneficiation plant from 200 to 300 tons per month, effective late in 1970. An exploration program reportedly increased the company's reserves to 880,000 short tons of ore, with an average grade of 18-percent carbon.

The expansion program is in anticipation of higher domestic demand, since no Brazilian graphite is exported.[2]

Ceylon.—The government nationalized Ceylon's three graphite mines in 1971. Expectation of nationalization, along with price increases, led importers in the United States and Japan to conclude bulk-buying agreements with Ceylonese producers in late 1970 and early 1971, which caused a temporary shortage in other world markets.[3] Insurrection in the country during the first part of 1971 suspended production for a time, further aggravating the supply problem. As a result, some consumers turned to other sources, particularly in China and Norway.[4] A further potential impact on the supply situation was an offer by India of a purchase contract for a large portion of the Ceylonese production.[5]

India.—Indian scientists experimented with a chemical treatment process for beneficiating the country's low-grade graphite deposits. High yields were obtained, but costs were not given.[6]

[2] Industrial Minerals. World of Minerals. No. 50, Nov. 1971, p. 23.
[3] Industrial Minerals. Ceylon: Graphite Industry Faces Biggest Crisis. No. 46, July 1971, p. 37.
[4] Industrial Minerals. Graphite Demand Benefits China and Norway. No. 45, June 1971, pp. 32, 33.
[5] Mining Journal. Graphite Problems. V. 277, No. 7096, Aug. 20, 1971, p. 153.
[6] Mining Journal. Indian Graphite Process. V. 277, No. 7094, Aug. 6, 1971, p. 122.

Table 6.—Graphite: World production, by countries

(Short tons)

Country [1]	1969	1970	1971 [p]
Argentina	268	84	[e] 90
Austria	28,467	30,570	23,581
Brazil [e]	[r] 2,480	2,800	2,800
Burma	112	86	168
Ceylon [2]	12,586	10,788	8,548
China, Peoples Republic of [e]	33,000	33,000	33,000
Germany, West	14,369	18,084	[e] 19,000
Hong Kong	219	--	--
Italy	1,895	2,302	701
Japan	1,903	1,615	1,600
Korea, North [e]	83,000	83,000	83,000
Korea, Republic of	81,939	65,621	79,934
Malagasy Republic	[r] 18,865	21,903	22,103
Mexico	47,311	61,341	56,125
Norway	10,274	11,447	9,172
South Africa, Republic of	506	771	1,262
U.S.S.R. [e]	77,000	83,000	88,000
United States	W	W	W
Total	414,194	426,412	429,084

[e] Estimate. [p] Preliminary. [r] Revised.
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] Exports.

Table 7.—Graphite: Exports from the Malagasy Republic, by countries

(Short tons)

Country	1969	1970
Australia	166	249
Canada	44	22
France	3,865	4,142
Germany, West	3,135	3,720
India	124	195
Italy	994	595
Japan	1,969	1,907
Netherlands	44	44
Poland	116	132
Spain	340	315
United Kingdom	5,086	4,448
United States	4,375	6,215
Other countries	150	401
Total	20,408	22,385

Source: Official trade returns of the Malagasy Republic.

TECHNOLOGY

Research efforts on graphite during 1971 were directed largely toward developing new forms and uses for manufactured graphite and studying the properties of composite materials made with graphite fibers. However, some developments also affected the long-established uses of natural graphite.

Morganite Crucible, Ltd., introduced a line of clay-graphite crucibles employing a new formula, which, it was claimed, would give up to 50 percent longer life.[7]

The demand for large, long-life batteries for automobiles and other uses stimulated considerable research on battery-making techniques employing lithium and several other new materials. Graphite was included in some of these new batteries, while its use as a polar element was eliminated in others. The market potential is large, and the success of one or more of these types could have considerable impact, both positive and negative, on requirements for battery materials.[8]

A recently introduced product makes use of the lubricating property of graphite. Nickel-coated graphite is injected into a molten aluminum alloy to prevent the finished product from galling.[9]

Increasing use is being made of electrically conductive coatings in the manufacture of electrical and electronic products. Graphite is one of the most widely used coating materials because of its versatility and relatively low cost.[10]

In the constantly growing field of powder metallurgy, graphite has found a place as one of the principal sources of carbon. Powdered graphite is mixed with iron powder and alloys to produce various types of steel products. The inclusion of graphite in a mix also aids in heat treatment.[11]

A number of articles described research into the properties of composite materials made with graphite fibers. No commercial applications were mentioned outside the aerospace field because the high cost of such materials remains a deterrent to their widespread use. Research effort has resulted in the development of a metal-fiber composite mating aluminum and graphite, a type of combination that has been unsuccessful in the past.[12] Some of the more interesting applications of graphite fiber composites that were under consideration included pressure-resistant hulls and structures for deep sea projects,[13] structural members of experimental safety vehicles and mobile homes,[14] parts of a space shuttle,[15] various types of high-value recreation equipment, and high-quality bearings and gears.[16]

Patents were issued for 15 processes that involved the use of graphite during the year, the applications of which represented nearly the full spectrum of graphite uses. Four were coating compositions, two involved lubricating properties, two were for refractory uses, and two for pencil leads; and one patent each incorporated graphite in bearings, batteries, brake and clutch linings, pigments, and an alloy-coated graphite that could have various uses.

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[7] Industrial Minerals. Company News & Mineral Notes. No. 46, July 1971, p. 45.

[8] American Metal Market. Lithium Batteries May Help Cut Peak Load Power Costs. V. 79, No. 25, Feb. 7, 1972, p. 1.

[9] Burke, Keith E., and C. H. Albright. Determination of Graphite in Graphite Aluminum Alloys. Metallurgia, v. 83, No. 499, May 1971, p. 163.

[10] Materials Engineering. Conductive Coatings Cut Costs, Simplify Electrical Designs. V. 74, No. 6, November 1971, p. 48.

[11] ———. What's New in Powder Metallurgy. V. 74, No. 3, September 1971, p. 22.

[12] Hanby, K. R. Fiber-Reinforced Metals. Defense Metals Information Center Review of Recent Developments. Apr. 28, 1971, p. 1.

[13] Conway, Joseph C., and Amos J. Shaler. Development and Analysis of Modified Graphites for Deep Sea Submergence. Am. Ceram. Soc. Bull., v. 50, No. 8, August 1971, p. 656.

[14] Materials Engineering. Nonmetallics Outlook. V. 75, No. 3, March 1972, p. 37.

[15] Industrial Research. Aerospace. V. 14, No. 4, April 1972, p. 27.

[16] Rauch, H. W., Sr. Graphite Fiber: Another Wonder Material. Ceram. Age, v. 87, No. 5, May 1971, p. 24.

Gypsum

By Avery H. Reed [1]

The gypsum industry recovered from the low activity of 1970 and set new production records. Total value of crude gypsum mined increased 11 percent, and total value of calcined gypsum produced increased 15 percent. The value of products sold increased 23 percent. The expansion was due to increased domestic production, since imports were about the same.

University of Nebraska geologists discovered a 118-acre deposit of commercially pure gypsum in Nemaha County, southeastern Nebraska, while drilling test holes for ground water. The deposit ranges from 90 to 350 feet deep, and is the first gypsum source with economic potential to be found within the state.

Plans were announced for the construction of a $5 million gypsum mining and processing operation near Thermopolis, Wyo.

Kaiser Gypsum Co., Inc., of Oakland, Calif., and Republic Housing Corp. of Dallas, Tex., have reached an agreement for Republic to lease the Kaiser Gypsum wallboard plant at Rosario, N.M.

Groundbreaking ceremonies were held for a new $4.5-million gypsum wallboard manufacturing plant in West Memphis, Ark., the 265,000-sq-ft plant will be known as Temple Gypsum. The facility will be operated by a new corporation that has been formed as a subsidiary of Temple Industries, Diboll, Tex.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Active mines and plants [1]	113	115	114	108	107
Crude: [2]					
Mined	9,393	10,018	9,905	9,436	10,418
Value	$34,383	$36,775	$38,354	$35,132	$39,057
Imports for consumption	4,563	5,474	5,858	6,128	6,094
Calcined:					
Produced	7,879	8,844	9,324	8,449	9,526
Value	$115,467	$133,239	$143,466	$132,047	$151,991
Products sold (value)	$362,268	$404,739	$414,880	$353,474	$435,257
Exports (value)	$2,918	$3,556	$3,446	$3,475	$4,214
Imports for consumption (value)	$11,353	$13,058	$14,602	$16,581	$16,332
World: Production	50,879	54,486	57,581	57,244	58,564

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.

DOMESTIC PRODUCTION

Forty two companies produced crude gypsum at 67 mines in 21 States. Of these mines, 13 were underground and 54 were open pit. Output increased 10 percent and was only 4 percent below the 1959 record. Leading states were Michigan, California, Texas, Iowa, and Oklahoma. These five states, with 32 mines, accounted for 60 percent of the total crude gypsum produced. Leading companies were United States Gypsum Co. with 13 mines; National Gypsum Co. with 7 mines; Georgia-Pacific Corp. with 7 mines; The Flintkote Co. with 4 mines; and The Celotex Corp. with 3 mines. These five companies, operating 34 mines, produced 68 percent of the total crude gypsum.

Thirteen companies calcined gypsum at 74 plants in 30 states. Output increased 13 percent and established a new record, 1 percent above the 1964 record. Leading states were Texas, New York, California, Iowa, and Georgia. These five states, with 28 plants, accounted for 34 percent of the total calcined gypsum. Leading companies were United States Gypsum Co. with 21 plants; National Gypsum Co. with 18 plants; Georgia-Pacific Corp. with 10 plants; The Flintkote Co. with five plants; and Kaiser Gypsum Co. Inc. with five plants. These five companies, operating 59 plants, produced 80 percent of the total calcined gypsum.

Table 2.—Crude gypsum mined in the United States, by State

(Thousand short tons and thousand dollars)

State	1970			1971		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arizona	4	98	$358	4	W	W
California	7	1,132	3,271	7	1,352	$3,884
Iowa	5	1,136	4,223	5	1,154	4,460
Michigan	5	1,312	5,061	5	1,433	5,585
Nevada	3	451	1,457	3	695	2,372
New York	3	425	2,737	3	415	2,376
Oklahoma	7	874	2,616	8	1,022	3,073
South Dakota	1	15	61	1	21	83
Texas	8	1,220	4,252	7	1,303	4,806
Wyoming	4	216	868	4	232	918
Other States [1]	22	2,557	10,228	20	2,791	11,500
Total	69	9,436	35,132	67	10,418	39,057

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

[1] Includes the following States to avoid disclosing individual company confidential data: Louisiana, Montana, Virginia and Washington (1971), 1 mine each; Arkansas, Indiana, Kansas (1971), New Mexico (1971), Ohio, and Utah, 2 mines each; Kansas, 3 mines (1970); Colorado, and New Mexico (1970) 4 mines.

Table 3.—Calcined gypsum produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1970					1971				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	7	822	$10,403	16	4	6	881	$10,838	18	5
Florida	3	438	5,194	9	2	3	518	5,769	9	2
Georgia	3	538	9,432	15	--	3	616	11,058	15	--
Iowa	5	713	12,301	22	4	5	796	13,704	22	4
Michigan	4	325	6,130	9	1	4	373	7,263	9	1
Nevada	3	240	3,425	12	6	3	330	4,851	12	6
New Jersey	4	334	4,785	9	4	4	452	7,369	9	4
New York	7	874	13,551	21	8	7	922	15,688	21	8
Ohio	3	321	4,984	9	1	3	358	5,790	9	1
Texas	7	870	14,273	28	3	7	1,035	17,074	30	1
Other States [2]	30	2,974	47,569	79	38	29	3,245	52,587	77	37
Total	76	8,449	132,047	229	71	74	9,526	151,991	231	69

[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.

[2] Comprises States and number of plants as follows: Arizona, Arkansas, Colorado, Connecticut, Delaware, Illinois, Massachusetts, Montana, New Hampshire, New Mexico (1971), Pennsylvania, and Washington, 1 plant each; Kansas, Louisiana, Maryland, New Mexico (1970), Oklahoma, Utah, Virginia and Wyoming, 2 plants each; and Indiana, 3 plants.

CONSUMPTION AND USES

Apparent consumption of gypsum, as measured by production plus imports minus exports, was 16.5 million tons, an increase of 6 percent. Imports were 37 percent of the total, compared with 39 percent in 1970.

Of the total gypsum supply, 4.6 million, or 28 percent, was sold or used uncalcined, compared with 27 percent in 1970. Of the total uncalcined gypsum, 74 percent was used for portland cement retarder, 24 percent for agriculture, and 2 percent for other uses, compared with 79 percent, 19 percent, and 2 percent, respectively, in 1970.

Six percent of calcined gypsum was sold or used for plaster, and 94 percent was for prefabricated products, compared with 23 percent and 77 percent, respectively, in 1970. Of the prefabricated products, 75 percent was used for regular wallboard, 16 percent for type-X wallboard, 3 percent for lath, and 6 percent for other uses. In 1970, 91 percent was used for regular wallboard, 7 percent for lath, and 2 percent for other uses.

PRICES

The value of crude gypsum increased from \$3.72 per ton in 1970 to \$3.75 per ton. The value of calcined gypsum increased from \$15.63 per ton in 1970 to \$15.96 per ton.

The average value of gypsum products increased from \$25.38 per ton in 1970 to \$26.14 per ton. Plasters were valued at \$28.23 per ton and prefabricated products were valued at \$34.12 per ton.

Quoted prices for gypsum are published monthly in Engineering News-Record. Prices quoted December 23, 1971, showed a wide range, based on delivered prices. Prices for ½-inch regular wallboard ranged from \$40 per thousand square feet at Dallas to \$85 at Chicago. Prices for plaster ranged from \$31 per ton at Dallas to \$56 per ton in Minneapolis.

Table 4.—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	1970		1971	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland cement retarder	3,358	\$15,933	3,386	\$16,173
Agricultural gypsum	804	4,238	1,124	5,386
Fillers and unclassified	96	1,123	113	1,328
Total [1]	4,258	21,294	4,624	22,888
Calcined:				
Industrial	284	9,058	263	8,843
Building:				
Regular base coat	411	8,708	381	8,086
Mill-mixed base coat	206	6,130	188	5,639
Veneer plaster	48	2,715	90	5,034
Roof-deck concrete	240	4,534	W	W
Other [2]	95	3,383	257	5,679
Total	1,000	25,470	916	24,438
Prefabricated products [3]	[4] 8,669	[4] 297,652	11,112	379,088
Total	--	323,122	--	403,526
Grand total, Value	--	353,474	--	435,257

W Withheld to avoid disclosing individual company confidential data; included with "Other".
[1] Data may not add to totals shown because of independent rounding.
[2] Includes gauging, molding, and Keene's cement, prepared finishes (1970), mixing plants (1970), and items indicated by symbol W.
[3] Includes weight of paper, metal, or other materials.
[4] Excludes tile.

Table 5.—Prefabricated products sold or used in the United States, by product

Product	1970 Thousand square feet	1970 Thousand short tons [1]	1970 Value (thousands)	1971 Thousand square feet	1971 Thousand short tons [1]	1971 Value (thousands)
Lath:						
⅜ inch	501,684	395	$13,059	361,312	279	$9,286
½ inch	208,574	198	6,801	111,918	102	3,314
Other	[2] 15,498	[2] 18	[2] 613	W	W	W
Total [3]	725,756	611	20,473	473,231	381	12,600
Regular gypsum wallboard:						
¼ inch	105,164	66	2,344	105,698	59	2,708
⅜ inch	1,188,863	914	33,052	1,200,682	851	35,659
½ inch	6,070,972	5,483	179,416	6,858,222	6,207	189,692
⅝ inch	1,220,309	1,336	51,162	916,469	1,078	34,342
1 inch [4]	29,555	43	2,844	27,336	48	2,016
Total [3]	8,614,863	7,842	268,818	9,108,408	8,244	264,417
Sheathing	184,784	178	6,059	274,212	260	8,215
Type-X gypsum wallboard	--	--	--	1,616,790	1,826	67,226
Predecorated wallboard	--	--	--	123,048	120	17,660
Veneer base	--	--	--	291,754	278	8,858
Other [5]	37,552	38	2,302	2,480	3	112
Grand total [3]	9,562,956	8,669	297,652	11,889,927	11,112	379,088

W Withheld to avoid disclosing individual company confidential data; included with ½-inch lath.
[1] Includes weight of paper, metal, or other materials.
[2] Includes a small quantity of ¼-inch and 1-inch lath.
[3] Data may not add to totals shown because of independent rounding.
[4] Includes a small quantity of 5/16-inch, 7/16-inch, ¾-inch, 1⅝-inch, and 3¾-inch gypsum wallboard.
[5] Includes laminated board (1970), formboard (1970), and unspecified board (1971).

FOREIGN TRADE

Imports of crude gypsum were 6.1 million tons, of which 77 percent came from Canada, 15 percent from Mexico, and 5 percent from Jamaica. Exports of crude gypsum were only 41,000 tons.

WORLD REVIEW

Brazil.—Large deposits of gypsum are known to occur in the Northeast, but until recently utilization was limited to production for use in cement manufacture. In 1969 a new company, Gypsum do Nordesta S.A. Indústria e Comércio de Gesso (subsidiary of Sudeste S.A. Industria e Comércio of São Paulo) was formed for the purpose of producing gypsumboard, a new development. Located on the margin of the Rio São Francisco in Petrolina, the plant is well placed near the deposits, will utilize electric power from Paulo Afonso, and have the benefit of relatively cheap transportation—by river to Minas Gerais and then by rail to the south-central markets. The enterprise is scheduled for a production rate in 1972 of 2 million square meters annually.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed or calcined: Quantity	Crude, crushed or calcined: Value	Other manufactures n.e.c., value	Total value
1969	40	$2,003	$1,443	$3,446
1970	41	1,915	1,560	3,475
1971	41	2,318	1,896	4,214

Canada.—Alscope Consolidated announced the discovery of commercial gypsum deposits in British Columbia, near Skookumchuck. Canada was the second largest gypsum producer, with shipments of more than 6 million tons. Of the total production, 4.7 million tons were exported to the United States, and the balance was consumed in Canada.

France.—France was the third largest gypsum producer, with shipments of nearly 6 million tons. Of the total production, about one-half was exported to Belgium-Luxembourg, one-fourth to Sweden and

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude (including anhydrite)		Ground or calcined		Alabaster manufactures [1] value	Other manufactures n.e.c., value	Total value
	Quantity	Value	Quantity	Value			
1969	5,858	$12,394	2	$87	$1,242	$879	$14,602
1970	6,128	r 13,791	2	106	1,559	1,125	r 16,581
1971	6,094	13,447	2	105	1,545	1,235	16,332

r Revised.
[1] Includes imports of jet manufactures, which are believed to be negligible.

Table 8.—U.S. imports for consumption of crude gypsum (including anhydrite), by country

(Thousand short tons and thousand dollars)

Country	1970		1971	
	Quantity	Value	Quantity	Value
Canada	4,730	$10,859	4,681	$10,155
Dominican Republic	90	287	161	476
Italy	(1)	3	(1)	6
Jamaica	267	731	309	913
Mexico	980	r 1,835	943	1,897
Taiwan	58	44	--	--
Other countries	3	32	(1)	(1)
Total	6,128	r 13,791	6,094	13,447

r Revised.
[1] Less than ½ unit.

the Netherlands, and the balance was consumed in France.

Spain.—Spain was the fifth leading gypsum producer, with shipments of nearly 5 million tons. Most of the material was exported.

U.S.S.R.—The U.S.S.R. ranked fourth in gypsum production, with shipments of more than 5 million tons. Small quantities were exported to Finland, but most of the gypsum was consumed locally.

United Kingdom.—The United Kingdom was the sixth leading gypsum producer, with shipments of nearly 5 million tons. British Gypsum Ltd. accounted for most of the production. None of the material was exported.

TECHNOLOGY

There have been many attempts to make profitable use of the gypsum obtained as a byproduct in many industrial processes. Large quantities of this gypsum are produced in the manufacture of phosphoric acid fertilizer. This waste gypsum has to be either stockpiled at the factory site or discharged into rivers or the sea. In the United States, experiments aiming at the use of waste gypsum have not succeeded owing to the low quality of the finished product. Also, production on an industrial scale seems to have encountered difficulties. The quality of the manufactured hemihydrate gypsum, in some instances, reached the lower limits of the quality standards. Customers refused the use of essentially lower quality gypsum. It thus appears that the use of byproduct gypsum is feasible only in those areas where no natural gypsum supplies are available.

Sabina Industries has announced that preliminary talks with two American corporations have taken place recently regarding the sublicensing of the U.S. rights to the process for production of high-quality gypsum from waste byproduct of phosphate fertilizer manufacture. Further discussions are planned in the coming weeks, these directed toward a possible agreement with one or other of these companies. Sabina has held the Canadian rights to the process from Giulini GmbH of Frankfurt, West Germany, for several months and re-

Table 9.—Gypsum: World production, by country

(Short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada (shipments) [2]	6,373,648	6,318,523	6,800,000
United States	9,905,000	9,436,000	10,418,000
Central America:			
Dominican Republic [e]	110,000	110,000	110,000
El Salvador	--	6,120	[e] 6,600
Guatemala	8,514	8,499	[e] 8,800
Honduras	8,443	10,146	[e] 10,000
Jamaica	281,120	311,780	340,888
Mexico	1,343,818	1,422,927	1,431,071
Nicaragua [2]	33,600	[e] 33,000	27,789
Trinidad and Tobago	4,480	[e] 4,500	[e] 4,500
South America:			
Argentina	590,073	464,693	[e] 460,000
Brazil	314,868	[e] 320,000	[e] 320,000
Chile	137,831	140,288	168,018
Colombia	166,449	188,495	[e] 200,600
Paraguay	3,858	6,614	13,228
Peru	49,630	99,142	[e] 99,000
Venezuela [e]	90,400	110,200	110,200
Europe:			
Austria [2]	745,206	694,270	654,462
Belgium	87,052	96,962	106,296
Bulgaria	187,393	186,290	[e] 187,400
Czechoslovakia	485,000	536,800	[e] 551,000
France [2]	6,568,886	6,711,084	5,634,458
Germany, East [3]	310,850	318,570	319,000
Germany, West (marketable)	2,013,084	1,623,661	1,756,355
Greece	[r] 299,447	340,121	363,762
Ireland	319,200	324,800	[e] 330,700
Italy	[e] 3,306,900	3,637,623	[e] 3,860,000
Luxembourg	10,129	5,580	5,889
Poland [e]	893,000	937,000	937,000
Portugal	104,868	126,815	195,684
Spain	[r] 4,346,384	4,660,610	[e] 4,630,000
Switzerland [e]	110,000	110,000	110,000
U.S.S.R.	5,032,045	[e] 5,200,000	[e] 5,200,000
United Kingdom [2]	[r] 5,065,760	4,712,960	4,599,840
Yugoslavia	255,547	276,260	[e] 303,100
Africa:			
Algeria [e]	193,000	193,000	193,000
Angola	18,075	20,062	21,818
Arab Republic of Egypt (formerly United Arab Republic)	517,975	[e] 551,200	[e] 551,200
Ethiopia	5,722	5,126	3,948
Kenya [2]	68,172	66,223	101,271
Libya	[r] 3,340	4,189	[e] 4,400
Niger [e]	2,200	2,200	2,200
South Africa, Republic of	396,193	452,058	450,003
Sudan [2]	[e] 5,500	1,804	[e] 2,200
Tanzania	12,161	22,838	18,892
Asia:			
Burma	3,857	5,880	13,440
China, People's Republic of [e]	606,300	606,300	606,300
Cyprus	[r] 17,950	31,791	16,162
India	1,531,676	1,014,716	1,179,495
Iran [4]	[r] 2,138,481	2,314,851	[e] 2,480,200
Israel [5]	[r] 77,828	77,162	88,185
Japan	683,427	593,895	590,729
Jordan	[e] 38,600	28,660	26,455
Lebanon	33,069	38,581	40,785
Mongolia [e]	27,600	27,600	27,600
Pakistan	[r] 149,540	184,661	147,172
Philippines	[r] 34,190	19,244	98,955
Saudi Arabia [6]	[e] 16,500	18,994	39,602
Syrian Arab Republic [e]	16,500	16,500	16,500
Taiwan	5,647	12,484	18,010
Thailand	101,449	159,008	185,081
Turkey [e]	308,600	352,700	352,700
Oceania: Australia	[r] 1,005,430	931,940	[e] 1,013,900
Total	[r] 57,581,465	57,244,000	58,563,843

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Gypsum is also produced in Cuba and Romania, but production data are not available. Production in Bolivia and Ecuador is negligible.

[2] Includes anhydrite.

[3] Crude production estimates based on calcined figures.

[4] Year ended March 20 of year following that stated.

[5] Year ended March 31 of year following that stated.

[6] Data presented are for Hejira calendar years as follows: 1969—Hejira year 1389 (March 19, 1969—March 8, 1970); 1970—Hejira year 1390 (March 9, 1970—February 28, 1971); 1971—Hejira year 1391 (February 27, 1971—February 16, 1972).

cently acquired exclusive right to the process within the United States.[2]

A new hemihydrate process for making sulfuric acid is said to be especially suitable to locations near a good supply of natural gypsum. Lummus Co. and Nippon Kokan of Japan, have developed two processes based upon Nippon's existing commercial acid process. Europe is expected to react with enthusiasm to this improved technology, and a Swedish firm already has opened communications about it.[3]

Oesterreichische Stickstoffwerke AG, of Linz, Austria, are currently cooperating with Krupp Chemieanlagenbau, of Essen, to improve the OSW gypsum-sulfuric acid process. The improvement, it is stated, will concern the heat economy of the process, this to be considerably improved by a sinking of specific heat requirements. The Austrian process, usable with natural anhydrite or phosphoric acid byproduct gypsum, is subject to worldwide interest, it is stated in Linz.[4]

To comply with state laws regulating toxic sulfur emissions and other stack gases, The Anaconda Company is installing smelter emission controls which essentially remove the sulfur content of the gases. Present Montana State laws limit emissions to 43 tons per day, but Anaconda currently releases tonnages greatly in excess of this amount. As part of a long-term plan the company intends spending some $26 million to cure the problem and at the same time increase the capacity of the smelter. The first phase of the expansion plan will take two years. An interesting byproduct of the proposed installations will be gypsum. First the SO_2 driven off in the gases is converted to sulfuric acid (the plant, which is similar to most other smelters in the U.S., will have a daily capacity of 600 tons); indigenous supplies of limestone will then be brought in, calcined, and reacted with the sulfuric acid to give easily stored calcium sulfate. However, Montana is already well supplied with gypsum by producers of the naturally occurring mineral, and Anaconda will have to look farther afield for markets.[5]

[2] The Northern Miner. V. 57, No. 49, Feb. 24, 1972, p. 18.
[3] Chemical & Engineering News. Sept. 13, 1971, p. 48.
[4] Chemical Age. V. 103, No. 2719, Aug. 27, 1971, p. 6.
[5] Industrial Minerals. V. 45, June 1971, p. 35.

Helium

By Gordon W. Koelling[1]

Sales of high purity helium (99.995 percent purity)[2] in the United States continued to decline in 1971, falling 18 percent to a total of 447 million cubic feet.[3] Approximately 39 percent of this total was sold by the Bureau of Mines and 61 percent was accounted for by private industry plant sales. Exports of high purity helium, all by private industry, totaled 130 million cubic feet in 1971. The f.o.b. Bureau of Mines 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.

On January 26, 1971, following careful and intensive review of the helium conservation program over a period of 3 years, the Department of the Interior invoked the termination provisions of the four contracts under which the Bureau of Mines purchased helium for long-term conservation storage. Under the termination notices the United States was to cease the purchase of helium at 8:00 a.m., March 28, 1971. However, on March 27 the U.S. District Court for the District of Kansas, in an action brought by three of the contractors, issued an order which, in effect, required the United States to continue the purchase of helium from the three contractors pending further order of the Court. The order was affirmed on appeal on the ground that the requirements of the National Environmental Policy Act had not been complied with. As of yearend 1971, the Department was in the process of formulating an environmental impact statement in furtherance of an evaluation of the environmental consequences of termination of the contracts.

The fourth contractor, who was not a party to the suit in Kansas, filed a suit in the Court of Claims contending that the failure of the Government to make payments under its contract for an extended period of time constituted a material breach of the contract excusing the contractor from performance. A decision by the Court of Claims held that the Government's failure to pay constituted a material breach, justifying the contractor in regarding the contract at an end. The issue as to damages is yet to be litigated. Pursuant to an interim storage contract, the Bureau of Mines is accepting for storage helium delivered by this contractor.

PRODUCTION

As of yearend 1971, there were 12 helium extraction plants operating in the United States. Of these, two were owned by the Federal Government and operated by the Bureau of Mines, five were private industry plants extracting helium primarily for long-term conservation storage, and five were private industry plants producing helium for independent sale to commercial (non-Federal) customers.

Total helium extracted from natural gas during 1971 declined approximately 1 percent to 4,565,103,000 cubic feet. Approximately 87 percent of this total was crude helium[4] and only 13 percent was high purity helium produced for sale. About 87 percent of crude helium production was

[1] Geographer, Division of Fossil Fuels.
[2] Referred to as grade A helium in previous Minerals Yearbook chapters.
[3] 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.
[4] Helium mixed with various quantities of other light gases, mostly nitrogen.

Table 1.—Ownership and location of helium extraction plants in the United States, 1971

Category and owner or operator	Location	Type of production
Government owned:		
Bureau of Mines	Exell, Tex	Crude and high purity helium.
Do	Keyes, Okla	High-purity helium.
Private industry, conservation:		
Cities Service Helex, Inc	Ulysses, Kans	Crude helium.[1]
National Helium Corp	Liberal, Kans	Do.
Northern Helex Co	Bushton, Kans	Do.
Phillips Petroleum Co	Dumas, Tex	Do.
Do	Hansford County, Tex	Do.
Private industry, other:		
Alamo Chemical-Gardner Cryogenics	Elkhart, Kans	High purity helium.
Cities Service Cryogenics, Inc	Scott City, Kans	Crude helium.[2]
Kansas Refined Helium Co	Otis, Kans	High purity helium.
Kerr-McGee, Corp	Navajo, Ariz	Do.
Linde Division, Union Carbide Corp.[3]	Shiprock, N.Mex	Crude helium.

[1] Also purifies crude helium piped from Cities Service Cryogenics, Inc., plant at Scott City, Kans.
[2] Crude helium is piped to Cities Service Helex, Inc., plant at Ulysses, Kans. for purification.
[3] Former Bureau of Mines plant, now owned by the Navajo Indian Tribe and operated under lease as a pilot-plant operation.

Table 2.—Helium extracted from natural gas in the United States

(Thousand cubic feet)

	1967	1968	1969	1970	1971
Crude helium:					
Extracted at Bureau of Mines plants	107,800	199,300	306,200	429,400	504,406
Extracted at private industry plants	3,676,400	3,591,700	3,596,300	3,523,800	3,483,919
Total	3,784,200	3,791,000	3,902,500	3,953,200	3,988,325
High purity helium:[1]					
Extracted at Bureau of Mines plants	607,000	478,400	360,700	230,700	173,626
Extracted at private industry plants	300,200	388,700	398,800	416,500	403,152
Total	907,200	867,100	759,500	647,200	576,778
Grand Total	r 4,691,400	r 4,658,100	r 4,662,000	r 4,600,400	4,565,103

r Revised.
[1] Includes only those quantities produced for sale; quantities entering conservation storage system after purification are included under crude helium.

from private industry conservation plants and 70 percent of high purity output was from private industry plants producing for sale to commercial customers. The remaining 13 percent of crude and 30 percent of high purity helium produced was extracted by Bureau of Mines plants.

Of the 678,032,000 cubic feet of helium produced by the Keyes and Exell plants of the Bureau of Mines in 1971, almost 92 percent was extracted from natural gas supplied by a private natural gas pipeline company on a gas-processing contract basis. The remaining 8 percent was extracted from natural gas which was produced from the Bureau of Mines Cliffside gasfield primarily to create additional reservoir space for helium conservation storage. All helium extraction from Cliffside natural gas occurred at the Exell plant.

An extensive modernization program at the Exell plant was behind schedule at yearend because of delays caused by technical problems. The new facilities included in this modernization program are for consolidating operations, improving efficiency, and facilitating underground helium storage operations.

Table 3.—Summary of Bureau of Mines helium plant and Amarillo shipping terminal operations, 1971

(Thousand cubic feet)

Supply:	
Inventory at beginning of period [1]	13,557
Helium extracted: [2]	
Exell plant:	
Crude	234,119
High purity [3]	50,304
Subtotal	284,423
Keyes plant:	
Crude	270,287
High purity [3]	123,322
Subtotal	393,609
Total extracted	678,032
Helium returned in containers (net)	244
Total supply	691,833
Disposal:	
Sales of high purity helium [3]	173,626
Net deliveries to helium conservation system [4]	506,733
Inventory at end of period [1]	11,474
Total disposal	691,833

[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

The declining trend in domestic helium demand, which began in 1967, continued during 1971 as sales of high purity helium fell to their lowest level since 1959. Much of this decline is attributable to the overall reduction in the level of the national space program, and the shift from an emphasis on research and development to an operational phase within the program, especially where large boosters (rockets) are concerned. An overall slowdown in the Nation's economy has also been a contributing factor.

The share of the domestic helium market accounted for by Bureau of Mines sales has declined rapidly during recent years, dropping from 54 percent in 1969 to 39 percent in 1971. This resulted because of a decreasing demand for helium on the part of Federal agencies, which are required by law to purchase all of their direct major requirements from the Department of the Interior. The f.o.b. Bureau of Mines 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 1970 and 1971 average f.o.b. private plant price of $21 per thousand cubic feet. Much of the decline in sales for Federal agencies was accounted for by reduced shipments to the Bureau's principal customers, the Department of Defense and the National Aeronautics and Space Administration.

Approximately 20 percent of Bureau sales in 1971 were through purchases by Federal agencies from private distributors under General Services Administration contracts. These contracts made relatively small quantities of helium readily available to Federal installations and reduced freight charges for small purchases.

Domestic consumption of helium during 1971 was primarily for purging and pressurizing rockets and spacecraft, for maintenance of controlled atmospheres, and for research, welding, lifting gas, and leak detection. 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 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
1967	e 867
1968	e 802
1969	e 670
1970	e 542
1971	447

e Estimate.

Table 5.—Bureau of Mines sales of high purity helium, by recipient, 1971

(Thousand cubic feet)

Federal agencies:	
Atomic Energy Commission	19,175
Department of Defense	82,355
National Aeronautics and Space Administration	32,905
National Weather Service	3,066
Other [1]	1,062
Subtotal	138,563
Non-Federal customers [2]	35,063
Total	173,626

[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 in compliance with a court order obtained by Cities Service Helex, Inc., National Helium Corp., and Phillips Petroleum Co. following issuance in January 1971 by the Department of the Interior of notices of termination effective on March 28, 1971. The Bureau also continued, since March 28, 1971 to accept helium from the contractor not involved in that litigation, Northern Helex Co., for storage to that company's account under an interim storage agreement.

Helium held in the Bureau of Mines conservation storage system, which includes the conservation pipeline system and the partially depleted Cliffside gasfield near Amarillo, Texas, increased 14 percent during 1971 to a yearend total of 32,167,743,000 cubic feet. Of this total, 98 percent was stored under the Bureau's conservation program, and the remaining 2 percent was stored under contract for private producers' own accounts. Approximately 13 percent of the net addition to the helium conservation system in 1971 was accounted for by deliveries from Bureau plants, 75 percent was acquired from private industry conservation plants and 12 percent was added to storage under contract for private producers' own accounts. Most of the latter was accounted for by quantities stored under an interim agreement for the account of Northern Helex Co. since March 28, 1971.

Table 6.—Summary of Bureau of Mines Helium conservation system [1] operations, 1971

(Thousand cubic feet)

Helium in conservation storage system at beginning of period:	
Stored under Bureau of Mines conservation program	28,118,119
Stored under contract for private producers' own accounts	58,972
Total	28,177,091
Input to system:	
Net deliveries from Bureau of Mines plants [2]	506,733
Acquired from private industry conservation plants	3,011,085
Stored under contract for private producers' own accounts	537,671
Total	4,055,489
Redelivery of helium stored under contract for private producers' own accounts	−64,837
Net addition to system	3,990,652
Helium in conservation storage system at end of period:	
Stored under Bureau of Mines conservation program	31,635,937
Stored under contract for private producers' own accounts	531,806
Total	32,167,743

[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.

Table 7.—Helium purchased by Bureau of Mines for conservation storage, 1971

(Thousand cubic feet)

Company	Helium delivered
Cities Service Helex, Inc	[1] 741,902
National Helium Corp	[1] 1,165,251
Northern Helex Co	[2] 147,463
Phillips Petroleum Co	[1] 956,469
Total	3,011,085

[1] Deliveries accepted in compliance with order of the Federal District Court for the State of Kansas after 8:00 a.m., March 28, 1971 when termination provisions of these companies' helium conservation contracts were to have taken effect.
[2] This company ceased delivery of helium for Bureau of Mines conservation program as of 8:00 a.m., March 28, 1971.

Table 8.—Summary of private industry helium conservation plants, 1971

(Thousand cubic feet)

Owner	Location	Delivered for Bureau of Mines conservation storage	Stored for companies' own accounts in Bureau of Mines conservation system			Total extracted
			Delivered	Withdrawn	Net	
Cities Service Helex, Inc	Ulysses, Kans	741,902	[1] 35,458	[1] 40,488	−5,030	736,872
National Helium Corp	Liberal, Kans	1,165,251	23,580	21,961	1,619	1,166,870
Northern Helex Co	Bushton, Kans	147,463	461,538	2,388	459,150	606,613
Phillips Petroleum Co	Dumas, Tex	535,512	17,095	--	17,095	973.564
Do	Hansford County, Tex	420,957				
Total		3,011,085	537,671	64,837	472,834	3,483,919

[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

As of December 31, 1971, proved and probable helium reserves (in natural gas with a minimum helium content of 0.3 percent) in the United States were estimated at 129 and 15 billion cubic feet, respectively, exclusive of those quantities in conservation storage at the Cliffside field. The total 144 billion cubic feet of proved and probable reserves available at yearend was 6 percent less than at the beginning of the year.

Although proved and probable helium reserves were contained in the natural gas reservoirs of over 100 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 83 percent of proved and probable reserves were in fields being produced at yearend 1971. Approximately 55 percent of the helium-rich (0.3 percent helium content) natural gas produced was being processed for helium extraction, and helium contained in the remaining 45 percent of helium rich natural gas output was being wasted incident to the consumption of the gas.

Efforts to locate helium resources in the United States continued during the year. A total of 511 natural gas samples from 17 States were collected and analyzed for helium content. None of these samples indicated the occurrence of significant helium discoveries.

FOREIGN TRADE

Exports of high purity helium in 1971 increased 24 percent and comprised 23 percent of the U.S. helium industry's total high purity sales as compared to 16 percent during 1970. All exports were from private industry extraction plants which depended on foreign markets for 32 percent of their total high purity sales in 1971. Most shipments were to Western Europe and Japan.

Authority to grant export licenses for helium was transferred from the Department of State to the Department of Commerce in March 1971.

Table 9.—Exports of high-purity helium from the United States

(Million cubic feet)

Year	Quantity
1967	e 40
1968	e 65
1969	e 90
1970	e 105
1971	130

e Estimate.

WORLD REVIEW

An estimated 112 million cubic feet of helium was produced outside the United States during 1971. 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 70 million cubic feet during the year.

During the latter part of 1971, Petrocarbon Developments, Ltd., of the United Kingdom signed a contract to construct a plant in Poland for the separation of helium and nitrogen from natural gas which has about a 45-percent nitrogen content. A helium purification and liquefaction unit to be integrated with the nitrogen removal process is to have a high-purity helium output capacity of 150 million cubic feet per year. Completion of this project was scheduled for mid-1974.

Iron Ore

By F. L. Klinger [1] and H. J. Polta [2]

A recessional trend in the iron and steel industry in the United States and most other countries in 1971 led to cutbacks in production and shipments of iron ore by most of the world's major suppliers. World production of iron ore appeared to increase slightly in 1971, but the volume of trade appeared to be 5 to 10 percent less. Production or shipments declined 10 percent or more in the United States, Canada, Sweden, Liberia, Venezuela, Chile, and Peru. Output increased about 2 percent in France, and about 4 percent in India and the Soviet Union. Only Australia and Brazil appeared to register strong gains in both production and exports in 1971, but the activity of the iron ore industry in these and other exporting countries appeared weakened at yearend because of the low level of demand from Japan and other importing countries. Australia continued to lead the world in iron ore exports, and in 1971 it became the world's third largest producer. Japanese imports of iron ore again reached the 100-million-ton level but were expected to drop in 1972.

Iron ore prices were higher in 1971, partly due to contracts negotiated in late 1970 and partly due to increases announced during 1971. U.S. prices for Lake Superior iron ores rose 3 to 5 percent. The average value of U.S. imports of iron ore in 1971 was $11.23 per ton, 5 percent more than in 1970. For iron ore importers, increases in ore prices were offset to some extent by reductions in ocean freight rates, which in some cases in late 1971 were one-half to one-third the rates in effect 9 months or 1 year earlier. Another development affecting iron ore prices in 1971 was the revaluation of several world currencies and the devaluation of the U.S. dollar. This was significant in Japanese purchase contracts with Australian producers, where the price of iron ore is fixed in U.S. currency.

The demand for ores with high iron content, beneficiated to strict physical and chemical specifications, continued. Rising labor, transportation, and handling charges in the United States made it increasingly difficult for some U.S. producers to compete with foreign ores, and several more mines with high production costs and/or marginal-grade ores were closed. At the same time, improvements in flotation technology led a Michigan producer to announce the first U.S. project to produce high-grade iron ore from fine-grained hematite ore of the taconite type.

The trend toward increasing production of pelletized iron ore also continued. World production of pellets was estimated at 121 million long tons in 1971; the United States accounted for about 44 percent. Prereduction of iron ore also increased; 1.8 million tons of new plant capacity was completed in 1971.

In transportation, offshore loading of slurried iron ore by submarine pipeline was begun in New Zealand. The size of ore-carrying vessels continued to increase; the largest cargo loaded in 1971 was 150,000 tons, but larger carriers were in service. A dozen foreign ports were in various stages of planning or development designed to accommodate carriers of up to 250,000 deadweight tons (d.w.t.), and more than 40 vessels of this size were on order.

[1] Physical scientist, Division of Ferrous Metals.
[2] Mining engineer, Division of Ferrous Metals.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Iron ore (usable;[1] less than 5 percent Mn):					
Production [2]	84,179	85,865	88,328	89,760	80,762
Shipments [3]	82,415	81,934	89,854	87,176	77,106
Value [3]	$817,511	$836,433	$929,293	$941,738	$891,001
Average value at mines per ton	$9.92	$10.21	$10.34	$10.80	$11.55
Exports	5,906	5,884	5,160	5,492	3,061
Value	$71,585	$70,835	$62,310	$67,898	$38,147
Imports for consumption	44,611	43,941	40,732	44,891	40,124
Value	$443,918	$453,753	$402,178	$479,518	$450,644
Consumption	127,424	131,753	140,235	r 131,571	116,196
Stocks Dec. 31:					
At mines	12,959	16,041	13,566	15,316	17,653
At consuming plants	55,121	53,232	50,935	52,781	57,738
At U.S. docks	2,987	2,797	2,648	3,403	3,424
Manganiferous iron ore (5 to 35 percent Mn):					
Shipments	289	245	385	329	177
World: Production	612,820	668,142	701,495	754,484	773,376

r Revised.
[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct ore (mostly pyrites cinder and agglomerates).
[2] Includes byproduct ore.
[3] Excludes byproduct ore.

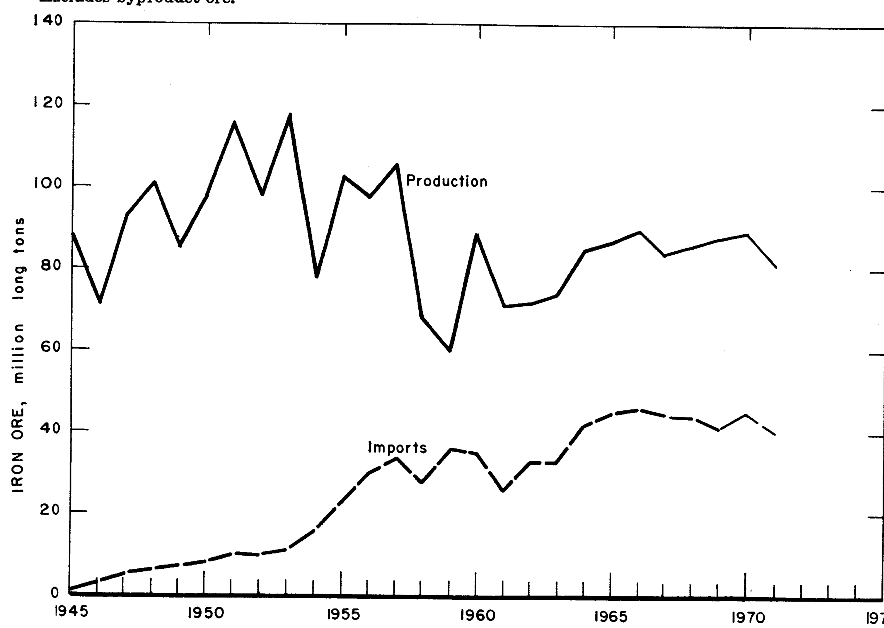

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

According to preliminary data, the average number of men employed at U.S. iron ore mines and beneficiating plants in 1971 was approximately 15,900, a decline of 6 percent compared with the previous year. This was accompanied by declines of 8 percent in production of crude ore and 10 percent in output of usable ore compared with 1970. The main reductions in employment occurred in Minnesota, Alabama, New York, and Michigan, where several mines were closed between late 1970 and the fall of 1971.

Total hours worked and the number of man-shifts were 9.6 percent less than in 1970, but productivity continued to rise.

Nationwide, the average output of crude ore was approximately 40 tons per man-shift, about 2 percent more than in 1970. Output of usable ore declined slightly, to 16.3 tons per man-shift, but this was compensated by the rise in quality of product so that in terms of iron contained in usable ore, productivity increased by 1 percent. As in 1970, productivity in the Lake Superior district was about 15 percent higher than the national average. In 1971, this district accounted for 69 percent of total employment and about 79 percent of U.S. production.

Employment and productivity data for 1971 are summarized in table 2. As in previous years, this data does not include office workers at mines and associated beneficiating plants.

DOMESTIC PRODUCTION

Mainly because of a recession in the iron and steel industry, domestic production of usable iron ore in 1971 was 10 percent less than in 1970, and mine shipments declined by 11.7 percent. Relatively high levels of output and shipments were maintained during the first half of the year, owing to the possibility of an industry-wide strike on July 31 when most labor contracts expired. Although a major strike was averted, production fell off sharply during the last 6 months. Local strikes affecting some railroads, ports, and mines contributed to the decline by disrupting production and shipments during the summer and fall. The most prolonged of these was a dock strike at West Coast ports that began June 15 and lasted well into October, cutting off exports of iron ore to Japan.

Despite the decline in production, the same trends evident in the iron mining industry in previous years, such as the decline of underground mining, increasing production by open pit methods, increasing beneficiation of ores before shipment, and improvement in quality of products, were continued in 1971. The progression of some of these trends during the last 20 years is indicated by the data in the accompanying tabulation (data is approximate, based on nationwide averages):

	1951	1961	1971
Tons crude ore mined per ton usable product [1]	1.3	1.93	2.45
Crude ore mined in open pits, as percent of total crude output	79	88	92
Direct-shipping ore,[2] as percent of total usable ore output [1]	74	27	7
Number of operating underground mines [3]	30	14	6
Average iron content (natural) of crude ore mined, percent	NA	NA	34
Average iron content (natural) of usable ore produced,[1] percent	51	54	60
Pellets, as percentage of usable ore produced	--	21	66
Average value of ore shipped, f.o.b. mine	$5.46	$8.99	$11.55
Average employment [4]	34,300	22,700	15,900
Productivity: Tons Fe contained in usable ore produced, per man-shift	6.3	7.2	9.8

NA Not available.
[1] Excluding byproduct ore.
[2] Including ore crushed and sized but not further treated.
[3] Includes only mines that produced more than 500,000 tons of crude ore. Six of these were combined underground-open pit operations in 1951; none in 1961 or 1971.
[4] Production workers only, at mines and mine concentrators, as reported to the Bureau of Mines.

The trend toward use of larger mining equipment also continued. A typical taconite mining operation in 1971 used 100-ton trucks, shovels with 12-cubic-yard buckets, and jet-piercing or rotary drills for making blast holes 9 to 12 inches in diameter. Experimentation on the Mesabi range in 1971 included the use of a 200-ton truck and shovels with bucket capacities of up to 15 cubic yards.

The Lake Superior district produced 79 percent of the Nation's output of usable iron ore in 1971. Minnesota accounted for 63 percent of the national output; Michigan, 15 percent; and Wisconsin, 1 percent. The remainder was produced in 16 other States, led by California, Missouri, Wyoming, Utah, Pennsylvania, and New York. Production came from 74 mines, the same number as in 1970, but by the end of the year at least five mines, including two underground mines, were closed.

In Minnesota, the Danube mine on the western Mesabi range was closed by Pickands Mather & Co. on May 1, 1971. The reason given was the availability and more favorable economics of higher grade ore from other sources. Ore shipments from the Danube and adjacent properties totaled about 22 million tons since 1919. Late in the year, the Snyder Mining Co. announced permanent closure of the Whiteside, Wanless, and Woodbridge mines due to exhaustion of ore reserves. Shipments from these properties had totaled about 11 million tons. Meanwhile, stripping operations continued at the Donora property near Aurora, owned by U.S. Steel Corp., and at the Rana mine near Kinney, operated by Rhude & Fryberger, Inc. In taconite operations, U.S. Steel continued construction of new mine and plant facilities designed to increase production of pelletized concentrate at Minntac to 12 million tons per year. The expansion was scheduled to be completed in 1972. The Minntac expansion, together with improvements being made by other companies at the five other taconite plants in the State, is expected to raise productive capacity of Minnesota plants to 40 million tons of pellets per year. A request by Pickands Mather & Co. to the Minnesota Pollution Control Agency for a permit to construct and operate a waste disposal system for a proposed taconite operation near Hibbing indicated that the company was still considering construction of the taconite plant for which feasibility studies had been announced in 1970. Production capacity of the plant would be 4 million tons of pellets per year. Elsewhere, the controversy concerning alleged pollution of Lake Superior by Reserve Mining Co.'s taconite processing plant at Silver Bay continued throughout the year. Resolution of the dispute was expected to be difficult because of the complexity of the technical and economic problems involved.

In Michigan, a most significant development was the announcement by Cleveland-Cliffs Iron Co. (CCI) of plans to build a major taconite processing complex at its Tilden property by mid-1974. This venture will be the first to produce iron ore on a commercial scale from low-grade, nonmagnetic deposits of the taconite type, of which large resources exist in Michigan and elsewhere in the Lake Superior district. Concentration of the material will be based on the selective flocculation-desliming and flotation process (see Technology section) developed and patented by the Bureau of Mines in cooperation with CCI. The plans involve annual production of 4 million tons of pelletized concentrate, from 10 million tons of crude ore averaging 36 percent Fe. Cost of the project was estimated at $150 million.

In other Michigan developments, the Tracy underground mine, which opened in 1955, was closed January 13, 1971, by Jones & Laughlin Steel Corp. High costs of mining were cited as a principal reason. Only two underground mines are now operating in Michigan: the Mather mine at Negaunee, operated by CCI; and the Sherwood mine on the Menominee range, operated by Inland Steel Co. Closing of the Tracy mine led to the termination of iron ore shipments from the Marquette docks of the Soo Line railroad on July 15.

In California, production of magnetite concentrate was begun in November at the Beck mine in San Bernardino County. The mine, operated by Standard Slag Co., is scheduled to produce 500,000 tons of concentrate per year for export to Japan. The first cargo was shipped from Los Angeles on December 5. Later in December, Kaiser Steel Corp. announced the cessation of exports of iron ore and pellets to Japan. Expiration of the company's long-term contracts with Japanese buyers was originally scheduled to end in March 1972. The bulk of production from the Eagle Mountain mine was expected to be shipped to the Kaiser steelworks at Fontana.

In Nevada, the Minnesota mine operated by Standard Slag Co. since 1951, was closed in mid-1971 due to exhaustion of ore reserves. Stockpile shipments were expected to continue until early 1972.

In New York, Republic Steel Corp. closed the Old Bed-Harmony underground mine near Port Henry in mid-1971, owing to high production costs.

CONSUMPTION

Total consumption of iron ore and agglomerates in 1971 was 11.7 percent less than in 1970. This was compared with a decline of 10.9 percent registered in production of pig iron. The weight ratio of iron ore and agglomerates consumed to hot metal produced remained at approximately 1.54 to 1. Consumption of iron ore and agglomerates in steelmaking furnaces, however, was 37 percent less than in 1970 and reflected a continuing decline in the number of operating open-hearth furnaces.

The share of pellets in total consumption continued to increase. Domestically produced pellets comprised 41 percent of total iron ore and agglomerates consumed at iron- and steel-making plants in 1971, compared with 38 percent in 1970 and 34 percent in 1969. Pellets from both domestic and foreign sources made up at least 48 percent of total consumption in 1971.

The method of reporting iron ore consumption adopted in 1963 was continued in 1971 (*see* table 11 and 13). Concentrate used for agglomerate produced at mine sites was not reported as iron ore consumed; its consumption was reported when the agglomerate was shipped to the furnace site and used (table 11). However, concentrate and fines used for production of agglomerate (mainly sinter) at blast furnaces and steel plants was reported as iron ore consumed (table 13), and consumption of agglomerates from this source is included in table 11.

Iron ore consumed in making agglomerates at iron and steel plants (table 13) includes foreign and domestic direct-shipping ores, concentrates, and fines generated in shipping. It does not include other materials such as limestone, flue dust, mill scale, and coke breeze used in making agglomerates. The increase in weight due to such additives is included, however, under the "agglomerate" columns of tables 11 and 13.

Consumption of agglomerates in 1971 as reported in table 11, includes pellets produced at domestic mines. This material was previously included with iron ore. The "agglomerates" columns now include pellets produced at both domestic and foreign mines, other agglomerates of foreign origin, and agglomerates produced at domestic iron and steel plants. With reference to footnote 2 in table 11, consumption data for 1966 through 1970 are as follows, in thousand long tons:

	1966	1967	1968	1969	1970
Pellets produced at domestic mines	31,018	33,180	40,995	48,323	r 50,190
Foreign pellets and other agglomerates	7,888	8,993	10,051	9,053	9,977

r Revised.

STOCKS

Stocks of iron ore at U.S. mines, docks, and consuming plants totaled 78.8 million tons on December 31, 1971. The total was 10 percent more than 1 year earlier. Mine stocks, at 17.6 million tons, appeared to be a record high for this date, and the 57.7 million tons reported at consuming plants was the highest yearend total since 1962. The unusually large inventories reflected the decline in demand, particularly during the last half of the year, and they accumulated during a period of sharply reduced production, shipments, and foreign trade. The total quantity of stocks at yearend represented about an 8.5-month supply at the average rate of domestic consumption in 1971.

PRICES

Base prices for Lake Superior natural iron ores and iron ore pellets were increased in 1971. Compared with 1970, the increases amounted to about 3.4 percent for natural ores and 5.2 percent for pellets. Published prices for natural ores, basis 51.5 percent iron, per long ton, rail of vessel at lower lake ports, were 37 cents higher than in 1970 and were as follows: Mesabi non-Bessemer, $11.17; Mesabi Bessemer, $11.32; Old Range non-Bessemer, $11.42; and Old Range Bessemer, $11.57. The price of iron ore pellets, per long ton unit of contained iron, was 28 cents in 1971, compared with 26.6 cents in 1970. These prices were in effect January 1, 1971, and any increase in transportation or handling costs was to be borne by the buyer. Shortly thereafter, the basic lake freight rate for iron ore shipped from the head of the lakes to lower lake ports was raised by 10 cents per gross ton, to $2.25. Compared with rates in effect on April 15, 1970, lake freight rates in effect April 15, 1971, showed an increase of 9.7 percent, and dock handling charges were up 23 percent. No further increases were apparent during the remainder of 1971.

The average value of usable iron ore shipped from domestic mines in 1971 (excluding byproduct ore) was $11.55 per long ton f.o.b. mine, compared with $10.80 in 1970 and $10.34 in 1969. These data were calculated from producers' statements and approximated the commercial selling price less the cost of mine-to-market transportation.

The rising average value reflected higher market prices as well as the increasing proportion of pellets in domestic iron ore shipments. Pellets made up 66.4 percent of domestic shipments in 1971, compared with 61.7 percent in 1970 and 59.5 percent in 1969.

Published prices for foreign iron ores were scarce in 1971. Nominal prices published by American Metal Market during the year were as follows: Swedish iron ore pellets, 68 percent Fe minimum, Atlantic shipping ports, $14.25 per ton; Brazilian iron ore, 68–69 percent Fe, Atlantic port, $10.00 per long ton.[3] Prices indicated by import contracts for three Spanish steel companies, as authorized by the Spanish Ministry of Trade during the first 5 months of 1971, f.o.b., per long ton, were approximately $9.43 to $11.18 for Mauretanian ore (lots of 9,000 to 103,000 tons); $8.41 to $13.80 for Brazilian ore (lots of 24,000 to 101,000 tons); and $14.90 to $17.70 for Canadian pellets (lots of 59,000 to 118,000 tons).[4]

Elsewhere, prices indicated for Brazilian iron ore, f.o.b. Tubarão/Vitoria, per long ton, basis 64 percent Fe natural, ranged from approximately $6.72 to $7.50 for fines and $9.50 to $9.80 for lump grades. Prices paid for Swedish ore by major buyers, f.o.b. Narvik, per long ton, were approximately $10.00 for Kiruna B fines (64.6 percent Fe natural) and $15.85 for Kiruna pellets (65.5 percent Fe natural). The average price of Swedish iron ore sold by Granges AB to European buyers in 1971, though not quoted, was stated to be about 9 percent higher than in 1970.

TRANSPORTATION

Most U.S. ores were shipped from Lake Superior district mines to smelters via the rail-vessel transportation system used since the beginning of the century. However, increasing competition from foreign ores was necessitating innovations directed toward reducing iron ore transportation costs. With transportation accounting for 25 percent or more of the cost of domestic iron ore delivered to the blast furnace, reductions in this cost could have considerable favorable impact on domestic ore production.

Completion of the Poe Lock at Sault St. Marie in 1968 made possible the use of larger vessels on the Great Lakes. The large vessels built to take advantage of the enlarged facility, for Bethlehem Steel Corp. (52,400 gross tons) and U.S. Steel Corp. (45,000 gross tons), are expected to be in operation in 1972.

Another cost-reducing effort, extension of the shipping season on the Great Lakes, continued. Closing dates for the shipping season at Two Harbors, Minn., for the last 5 years were as follows: Dec. 28, 1967; Jan. 3, 1969; Jan. 10, 1970; Jan. 27. 1971, and Jan. 30, 1972.

To help extend the shipping season, Congress authorized $9.5 million to the U.S. Army Corps of Engineers for making a 3-year study and demonstration program of an air bubbling system for keeping open shipping channels. This followed a $50,000 experiment in which compressed air forced through perforated pipe at the bottom of the main shipping channel in the Duluth-Superior port successfully produced up to 30 feet of open water in the winter of 1970–71.

[3] American Metal Market. V. 78, No. 183, Sept. 22, 1971, p. 16.
[4] Metal Bulletin (London). No. 5621, Aug. 3, 1971, p. 33.

The two new self-unloading vessels under construction and designed specifically for transporting iron ore to upriver terminals will reduce handling charges.[5] Both will be used to haul iron from Lake Superior and Lake Michigan ports to the Cleveland, Ohio, works of Jones & Laughlin Steel Corp. These 15,500-ton vessels are scheduled for completion in 1973 and 1974.

Plans for another innovation in lake transportation were announced by Litton Industries in mid-year.[6] The plans are to produce and operate a new tug-barge system for transporting bulk materials on the Great Lakes. The unique self-unloading, 52,000-long-ton system will be the largest of its kind. It will be used to carry iron ore and pellets, coal, limestone, and grain between Great Lakes ports in the United States and Canada.

Other ways to reduce transportation costs continued to receive consideration. These included expansion of the unit-train concept and pipelining taconite concentrate fines as an ore-water or ore-crude oil slurry.

The need for critical review and study of ways to reduce transportation costs of domestic iron ores was obvious considering worldwide developments in ocean transportation of bulk commodities. Published transportation rates (as of Apr. 15, 1971) for the bulk of U.S. ores from mine to Lower Lake ports totaled $4.64; rail, Mesabi to Duluth $1.83; dock handling $0.26; vessel, Lake Superior to Lower Lake ports $2.25; hold of vessel to rail of vessel $0.30. These rates did not change during the remainder of 1971, but they were 9 to 20 percent higher than rates in effect Apr. 15, 1970. Further upward pressure on rail rates was generated by a series of local strikes in mid-year and new labor contracts in August.

More than 200 ships of 100,000-d.w.t. and greater were included in the world fleet in 1971. More and larger ships were being built and still more were being planned. The largest ore/oil (o/o) carrier in existence was about 245,000-tons d.w.t., the largest ore/bulk/oil (o/b/o) carrier was about 170,000-tons d.w.t.[7] More than 40 o/o and o/b/o vessels in the 250,000-d.w.t. class were on order at yearend. In Japan a 162,400-d.w.t. iron ore carrier was delivered to a Tokyo firm on September 14. It will be used to carry ore from Chile for Nippon Steel Corp.

To accommodate the large vessels built in recent years and the even larger ones planned or under construction, docking facilities were being modernized throughout the world. At least 12 facilities for 250,000-d.w.t. bulk carriers were in the planning, engineering, or construction stage.[8]

In South America a $60 million expansion of the ore port at Tubarão, Brazil, was underway.[9] The expansion will allow the port to accommodate 250,000-ton iron ore carriers. The master plan for the port calls for facilities that will eventually handle 400,000-ton carriers. In Peru, dredging of the harbor at San Nicolas was completed by Marcona Mining Co., to permit berthing of ore carriers of up to 175,000 d.w.t.

The facilities at the port of Dampier in western Australia, built in 1966 to handle 65,000-d.w.t. carriers, have been enlarged so that the port now regularly handles 100,000-ton vessels.[10] The work in progress at East Intercourse Island will make facilities for accommodating 150,000-ton carriers.

The Waipipi project of the Marcona Corp., on the west coast of New Zealand's North Island, inaugurated use of an offshore pipeline terminal for loading a bulk commodity onto a carrier.[11] Slurry containing 42,000 tons of iron ore was pumped via submarine pipeline to the S.S. San Juan Traveler, which was moored to a single point buoy located 1.5 miles offshore. About 350,000 tons of ore was shipped by yearend.

In the United States, the Maritime Administration awarded Soros Associates, New York City, a contract to study the feasibility of multipurpose offshore terminals. The new large vessels operating in world trade are barred from using most U.S. ports because of channel depth limitations.

With new large carriers using modernized port facilities, record loadings of iron ore were reported throughout the world.

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[5] Skillings' Mining Review. V. 60, No. 9, Feb. 27, 1971, p. 22.
[6] American Metal Market. V. 78, No. 143, July 28, 1971, p. 13.
[7] Industrial Minerals. V. 1, No. 51, December 1971, pp. 51–53.
[8] Sugin, L. Deepwater Terminals-Dredging vs Offshore. Skillings' Mining Review, v. 61, no. 30, July 22, 1972, pp. 10–16.
[9] Engineering News Record. V. 186, No. 21, May 27, 1971, p. 30.
[10] Skillings' Mining Review. V. 60, No. 38, Sept. 18, 1971, p. 30.
[11] Mining Magazine. V. 125, No. 3, September 1971, p. 225.

In Canada, a record cargo of 135,070 long tons of concentrate was loaded on a German ore carrier at Port Cartier, Quebec, on August 17. The shipment to Rotterdam was the largest dry bulk cargo to be loaded at a North American port. On September 21–22, a vessel was loaded with 136,805 long tons at Sept-Iles, Quebec. On October 9–11, 150,192 long tons were loaded at Porto Salazar, Angola.[12] In some cases, maximum loading of vessels was not possible because of inadequate facilities at loading or receiving ports.

The use of the large vessels, together with the decreased demand for cargo space resulting from the worldwide recession in the steel industry, greatly reduced ocean shipping rates. In June, Metal Bulletin reported "charterers have been able to secure tonnage for Chile to Japan at $4.50."[13] The rate 1 year earlier was $10.30 per ton. The midyear rate for a 50,000-ton shipment from Tubarão, Brazil, to the Netherlands was $3.00 per ton; the rate 12 months earlier was $6.00 per ton. In Europe, the Granges Co. reported that dry cargo rates in the last half of 1971 were 75 percent less than those prevailing 1 year earlier. In April a 50,000-ton vessel reportedly contracted two consecutive trips from Port Elizabeth, Republic of South Africa, to Japan at $2.025 per ton.[14] A cargo from Port Hedland, Australia, to Japan was reported at $1.895 per ton.

In October, Metal Bulletin reported rates of $2.99 for Peru to Japan; Dampier to Japan at $1.20; and Dampier to Rotterdam at $2.60.[15] Time-charter fixtures reported included the following, in dollars per deadweight ton: A 63,000-ton vessel for 12 months at $1.53; a 73,800-ton vessel for 4 to 5 months at $1.35; and a 67,000-ton vessel for two round trips Japan-Lourenço Marques at $1.10. The Wall Street Journal in July reported "the rate for moving iron ore from a St. Lawrence River port in Canada to Rotterdam has sunk to $1.27 a ton from $5.75 a year ago."[16]

The 57-day longshoreman's strike (October 1–November 26) at East Coast and Gulf Coast ports did not materially affect U.S. imports of iron ores. The major importers ship iron ore in their own boats manned with their own seamen, and therefore were not struck. The dock strike at West Coast ports, however, stopped all exports of iron ore to Japan from mid-June to October.

Data on iron ore trade, transportation patterns, and shipping facilities in the U.S. Gulf Coast area were published by the Bureau of Mines. The study includes forecasts of commodity movements in 1980.[17] The Bureau also published an economic study of California-Nevada iron ore resources and markets, which compares transportation costs in this area with those of foreign suppliers.[18]

FOREIGN TRADE

Exports of iron ore in 1971 dropped to less than 60 percent of the quantity exported in 1970. The decline was partly due to strikes during the summer, which affected some U.S. railroads supplying West Coast and Lake Superior ports, and partly to reduced demand from foreign consumers, but it was mainly due to the dock strike at West Coast ports, which lasted from the end of June well into October. Kaiser Steel Corp., the principal West Coast exporter, announced on December 20 that exports of iron ore to Japan had been stopped. Originally, the company's contract for exports to Japan was to have expired in March 1972.

U.S. imports of iron ore for consumption in 1971 were 10.6 percent less than in 1970. Imports during the first half of the year were about 5 percent more than in the comparable period of 1970, apparently due to stockpiling of ore by consumers in anticipation of a possible strike in the domestic steel industry. However, no strike occurred, and imports declined during the last 6 months owing to the low level of iron and steel demand. The principal decline was in imports from Canada, which

[12] Industrial Minerals. No. 51, December 1971, pp. 51–53.
[13] Metal Bulletin. No. 5604, June 4, 1971, p. 42.
[14] Metal Bulletin. No. 5596, May 4, 1971, p. 27.
[15] Metal Bulletin. No. 5643, Oct. 22, 1971, p. 49.
[16] Wall Street Journal. V. 178, No. 5, July 8, 1971, p. 8.
[17] Fulkerson, F. B. Gulf Coast Export-Import of Mineral Commodities. Bu Mines I.C. 8508, 1971, 90 pp.
[18] Moore, Lyman. Economic Evaluation of California-Nevada Iron Resources and Iron Ore Markets. Bu Mines I.C. 8511, 1971, 207 pp.

totaled 3.6 million tons less than in 1970. Imports from Chile, where the mines owned by Bethlehem Steel Corp. were taken over by the Chilean Government early in 1971, fell to very low levels after May. Imports from Australia, however, exceeded 1 million tons for the first time.

In 1971 the average value of iron ore exports was $12.46 per long ton, up 10 cents compared with 1970. The average value of imports in 1971 was $11.23, 5 percent more than in 1970.

WORLD REVIEW

Argentina.—The Argentine Government was planning to establish an iron ore mine and pelletizing plant in Patagonia. The pellet plant was to have a production capacity of 2 million tons per year; completion is planned for 1974. Ore reserves at the mine site were reported to be 85 million tons averaging 54.8 percent iron and about 1.4 percent phosphorus. Concentration by magnetic separation and flotation was proposed, to yield a concentrate containing about 68 percent iron and less than 0.15 percent phosphorus. An additional 115 million tons of ore reserves were reported in the area.[19]

Australia.—Production and exports of iron ore continued to grow at a rapid rate in 1971. With output of more than 60 million tons, Australia ranked third among world producers in 1971. Exports increased to 45 million tons, most of which went to Japan. The rate of growth was expected to slow in 1972 owing to cutbacks in Japanese production of iron and steel.

Despite uncertainties concerning 1972 shipments, construction proceeded on three projects designed to increase productive capacity by a total of 30 million tons per year by 1973. An ore-crushing and train-loading complex was completed at Mt. Whaleback in October 1971. This will increase ore handling capacity of the Mt. Newman project by 10 million tons annually. Hamersley Iron Pty. Ltd. expected to complete its Paraburdoo complex and a second ore terminal at East Intercourse Island in 1972. Construction on the Robe River project, of Cliffs Western Australia Mining Co. Pty. Ltd., was half completed by yearend and all engineering work was reportedly completed. Mine production was scheduled to begin in mid-1972, and pelletizing operations at Cape Lambert were to be underway by early 1973.

Large new reserves of iron ore were reportedly proven in the Pilbara region by the Hamersley, Broken Hill Pty. Co. Ltd., and Mt. Goldsworthy Mining Ltd., companies.

Canada.—Production and exports of iron ore in 1971 declined by 7 percent and 13 percent, respectively, compared with 1970 levels. Decreased demand from the United States was mainly responsible. U.S. imports from Canada in 1971 were 3.6 million tons less than in 1970.

Progress continued on the major expansion projects underway at Sept-Iles (see Technology section) and Labrador City by the Iron Ore Co. of Canada (IOC), and at Mt. Wright by Quebec Cartier Mining Co. (QCM). These projects will increase production capacity of IOC by 16 million tons of pellets and concentrates in 1973, and of QCM by 16 million tons of concentrates in 1974.

In other developments, Jones & Laughlin Steel Corp. sold its interest in the Adams mine and pelletizing plant to Dominion Foundries and Steel Ltd. on July 30, 1971. The Adams operation produces about 1 million tons of pellets per year. At Contrecour, Quebec, the Midland-Ross Corp. was building a metallized-pellet plant for Sidbec. The product will be used in electric furnaces at Contrecour and Montreal. Production capacity will be 400,000 tons of metallized pellets per year, and completion was scheduled for November 1972.

A $100 million project to increase iron ore production at Wabush Mines was cancelled in 1971 for economic reasons.

Brazil.—Exports of iron ore increased to 30.4 million tons in 1971, 11 percent more than in 1970. Exports of iron ore pellets rose to 1.5 million tons, twice the quantity exported in 1970. At yearend, Cía. Vale do Rio Doce (CVRD) was building a second pelletizing plant at Tubarão. The new plant will have a production capacity of 3 million tons of pellets per year and is scheduled for completion in 1973.

[19] Hadzeriga, P. The Iron Venture in Patagonia. Intermet Bulletin, v. 2, No. 1, July 1972, pp. 38–40.

Major investments were being made by CVRD with the objective of raising iron ore productive capacity to 45 or 50 million tons per year by 1975. A major facility being built under this program is the concentrator for itabirite at Cauê (see Technology section). In 1971, the company signed medium- and long-term contracts for delivery of more than 300 million tons of iron ore and pellets to Japanese, European, and U.S. buyers. Together with existing contracts, including those of its associated companies in Brazil, the required export volume could reach 50 million tons per year by 1975.

Construction of mine, rail, and port facilities proceeded as scheduled on the $150 million iron ore project of Minerações Brasileiras Reunidas S.A. (MBR). Shipments from the mine near Belo Horizonte were scheduled to begin in late 1973. Under long-term contracts signed in 1970 with Japanese, European, and Argentine steel companies, annual shipments of 9.3 million tons of high-grade ore will be required.

Chile.—On March 31, 1971, the Chilean Government, through Compañía de Acero del Pacífico S.A. (CAP), nationalized the properties of Bethlehem Chile Iron Mines Co. These properties included the El Tofo and El Romeral iron mines which Bethlehem had operated under a concession agreement with CAP since 1951. CAP reportedly contracted with Bethlehem to purchase the properties for "net book value" (estimated at $25 to $30 million) in 15 annual installments beginning in 1973.

CAP planned to complete the expansion of production facilities at the El Romeral mine, a project which Bethlehem had nearly completed prior to the Government's action. This project was scheduled to raise productive capacity at El Romeral to 4 million tons of iron ore products per year by the end of 1972.

In subsequent developments, CAP made the Rotterdam firm of Internatio-Müller exclusive agent for worldwide marketing of Chilean iron ores, and contracted with the Mitsubishi Corp. of Japan to supply 42 million tons of iron ore over a period of 12 years beginning in 1972. The latter contract reportedly specifies purchase prices (62 percent Fe basis) of $7.50 to $7.80 per long ton for lump ore and $5.45 to $5.90 per long ton for fines. Ore grades and prices are subject to renegotiation in 1975.

CAP plans to supply ore for the contract from the El Algarrobo and Boquerón Chañar deposits. The Algarrobo mine currently produces about 3.5 million tons per year. An underground mine is to be developed at Boquerón Chañar, to produce 3 million tons per year by 1976. The investment required to develop the Algarrobo-Boquerón Chañar project was estimated by CAP at $88 million. Shipping facilities at Puerto Guacolda are also to be expanded, to accommodate vessels of up to 250,000 d.w.t. The port was reportedly capable of handling vessels of 90,000 d.w.t. in 1971.

India.—Exports of iron ore in 1971 totaled 20.1 million long tons, the same quantity exported in 1970. Exports to Japan comprised 82 percent of the total. The levels of both production and exports in 1971 were well below those hoped for by the Government's Planning Commission. Inadequate transportation and port facilities were partly responsible, along with a decline in demand for iron ore by domestic steel producers.

Expansion of productive capacity at the Kiriburu mine in Bihar was continued in 1971, but the Kudremukh project in Mysore was awaiting final Government approval.

A $56 million project to improve port facilities at Mormugao was scheduled for completion in 1974. Berthing facilities are being expanded to accommodate 60,000-d.w.t. vessels initially, and 100,000-d.w.t. vessels by 1974. Capacity of loading facilities will be increased to 8,000 tons per hour. The project is expected to reduce iron ore freight rates from Mormugao to Japan from $5.60 to $2.80 per ton. About 10.5 million tons of iron ore was handled by the port in 1971.

Indonesia.—P.N. Aneka Tambang (PNAT), the State-owned mining company, began shipments of titaniferous magnetite concentrates in May 1971. The concentrates were produced from beach sand deposits near Tjilatjap on the south coast of Java. Total shipments in 1971 were about 237,000 long tons, all of which went to Japan. The company has a 10-year contract with Nippon Kokan Kabushi Kaisha calling for shipments of about 300,000 tons per year. Ore reserves at Tjilatjap were reported to be 6 million tons of concentrates containing approximately 55 percent iron and 8 to 9 percent TiO_2.

The port of Tjilatjap can accommodate ore carriers of up to 20,000 d.w.t. Further dredging was expected to raise this capacity to 30,000 d.w.t.

PNAT was considering production of similar concentrates from beach sand deposits near Jogjakarta where ore reserves are reportedly several times larger than at Tjilatjap. Transportation feasibility studies were being conducted by Sverdrup & Parcel & Associates, Inc., of St. Louis, Mo.

Ivory Coast.—Pickands Mather & Co. (PM) was completing an exploration and testing program in 1971 on extensive deposits of low-grade iron ore near Man in the west-central area of the country. A 10-million-ton-per-year pellet project was being considered. The company was joined in the investigation by the Japanese firms of Mitsubishi and Sumitomo in 1971. The latter firms are partners with PM in the Savage River project in Tasmania.

Liberia.—Shipments of iron ore products by Liberian producers in 1971 declined by 11 to 16 percent compared with the levels of 1970. Exports in 1971 totaled 20.9 million tons, 11 percent less than in 1970.

Bong Mining Co. completed construction of its pelletizing plant in early 1971. Production of pellets started in February and totaled 1.34 million tons by yearend. Nominal production capacity of the plant is 2 million metric tons per year. The company expected to complete two new production lines at its concentrator by mid-1972. At that time, production capacity (including pellets) will be about 6 million tons of ore products per year.

Liberian-American-Swedish Minerals Co. (LAMCO) produced 1.85 million tons of pellets in 1971, in addition to 8.4 million tons of washed lumpy ore and fines. The company decided to begin mining in the Tokadeh area (about 15 miles from Nimba) in early 1973. Mining will begin at a deposit containing proven reserves of about 50 million tons of concentrating-ore averaging 50 to 52 percent iron. Annual output from Tokadeh will be about 1 million tons of concentrate, obtained from 1.5 million tons of crude ore. Additional crude ore reserves of about 250 million tons are indicated in the area.

At Mano River, National Iron Ore Co. Ltd. (NIOC) continued work on its Mano II project, which was designed to increase production by 20 percent by early 1973 and to increase the life of the mine by 12 to 15 years. Capacity of the washing plant was being increased, with the flowsheet modified to include jigs and Humphreys spirals. When completed, the plant is expected to produce 5 million tons of concentrate from 8.5 to 9 million tons of crude ore per year. At that time the company will produce only one grade of product (sinter fines), averaging 58.5 percent iron, 4.5 percent each of silica and alumina, and 11 percent moisture. Present output of concentrates includes both lump and fine grades. In late 1971, NIOC contracted with the Royal Netherlands Blast Furnaces and Steel Works Ltd. (Hoogovens) for the sale of 12 million tons of Mano II concentrates, to be delivered over a period of 10 years beginning in 1973.

Liberia Mining Co. Ltd. (LMC), currently the smallest of Liberian producers, was nearing the end of ore reserves at Bomi Hills. The ore body, which has yielded 45 million tons of ore products since 1951, was expected to be exhausted by 1973. During 1971, the company continued to drill and explore low-grade deposits at Bie Mountain, 22 miles northwest of Bomi Hills.

The possible development of the Wologisi iron deposits in northwestern Liberia by a group of Japanese companies received much publicity during 1971, but no firm commitments were reported by yearend.

Malaysia.—Output of iron ore in 1971 was less than 25 percent of the quantity produced in the previous year. This resulted from closing of the country's two largest producers—the Dungun mine in Trengganu State, and the Rompin mine in Pahang State—late in 1970. Ore reserves at both mines were reportedly exhausted. About 3,000 employees were directly affected. The two mines had accounted for more than 80 percent of the iron ore produced in Malaysia in 1970. All output was sold to Japan.

Mexico.—Shipments of iron ore pellets from the new Colima plant of Hojalata y Lamina S.A. increased to 855,000 tons in 1971. In another development, agreement in principle was reached between Altos Hornos de Mexico S.A. and the Arthur G. McKee Co., for the latter firm to build a circular-grate pelletizing plant at the La Perla mine in Chihuahua. The plant would have a production capacity of 600,000 tons of pellets per year, and would be completed in 1974.

Plans to build an integrated steel works near Mexico's Pacific coast indicated that iron ore would be supplied at the annual rate of 900,000 tons from the Las Truchas deposits in Michoacan. In Colima, bids were being solicited for development of the Peña Colorada iron deposits; proven reserves of about 105 million tons were reported, with an average iron content of 47 percent.

Netherlands.—The iron ore pelletizing plant operated by Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. at IJmuiden was reported by the company to have a production capacity of 3.4 million metric tons of pellets per year. The plant utilizes the Dravo-Lurgi traveling grate process and was completed in 1970.

New Zealand.—Shipments of slurried iron ore concentrate from the Waipipi titaniferous iron sands began in May 1971. (See Transportation section).

Peru.—Shipments of iron ore products by Marcona Mining Co. from San Nicolas in 1971 declined to 8.9 million tons, 10 percent less than in 1970. The decline was mainly due to a strike by approximately 2,700 workers during the summer. About 82 percent of all shipments went to Japan.

The company's $25 million project to expand iron ore mining, concentrating, pelletizing, and shipping facilities was nearing completion at yearend. Dredging of the harbor at San Nicolas was completed, to allow berthing of ore carriers of up to 175,000 d.w.t.

South Africa, Republic of.—The Government was reported to have decided to proceed with construction of an iron ore terminal at Saldanha Bay. The terminal will be designed to handle 15 million tons of iron ore per year, with provision to expand capacity to 25 million tons. A rail line is to be built to the port from the Sishen iron ore deposits.

Sweden.—Output of iron ore in 1971 increased by 5 percent compared with 1970, but exports declined 6 percent to 25.8 million long tons owing to a decline in demand from steel producers in Europe.

A new pelletizing plant will be built near Malmberget for Luossavaara-Kiirunavaara AB (LKAB). The plant will have a production capacity of 2.5 million tons of pellets per year, and is scheduled for completion in late 1973. Design and construction are being handled by Dravo Corp. of Pittsburgh, Pa., and Lurgi-Gesellschaft of West Germany.

Venezuela.—Exports of iron ore in 1971 were estimated at 18.7 million long tons, down about 11 percent compared with 1970. About 70 percent of the shipments were destined for the United States.

Orinoco Mining Co. completed its iron ore reduction plant at Puerto Ordaz in 1971 (see Technology section) but full production was not yet underway. The company also announced plans to expand beneficiation facilities at Puerto Ordaz, designed to increase shipments of ore products to 25 million tons per year in 1973. The Dravo Corp. was awarded a contract to install equipment for crushing, screening, and drying iron ore at the rate of 13.5 million tons per year. Cost of the project was estimated at $40 million.

TECHNOLOGY

Two large projects involving beneficiation of hematite ores by cationic flotation of silica were underway in 1971. A flotation plant being built by Iron Ore Co. of Canada at Sept-Iles, Quebec, will process lower-grade natural ores mined from the Knob Lake area. Feed to the mill will average about 50 percent iron and 14 percent SiO_2; the pelletized concentrate is expected to contain about 65 percent iron and 5 percent SiO_2. Overall recovery of iron is expected to exceed 90 percent. Production at the rate of 6 million tons of pellets per year is expected to start in 1973.

In Michigan, the flotation plant to be built at the Tilden mine by CCI (see Domestic Production) will be more complex. The crude ore is fine-grained and will require grinding to about 90 percent minus 400 mesh. Preparation of the pulp for flotation requires selective flocculation of iron oxide, thickening of the flocculant, and removal of slime-size particles (10 microns or less) of silica by overflow from the thickener. The selective flocculation-desliming process, patented by the Bureau of Mines in 1966, prevents excessive loss of iron in the slimes so that the flocculant retains about 95 percent of the iron contained in the crude ore. Feed to the mill is expected to average about 36 percent iron and over 40 percent SiO_2, yielding a concentrate containing about 65 percent iron and 5 percent SiO_2. Overall recovery of iron is expected to be about 75 percent. Implementation of this project follows about 8 years of cooperative research between the Bureau and CCI,[20] and it increases the minable crude ore reserves of Michigan by at least 750 million tons.

In Minas Gerais, Brazil, a beneficiation plant being built for CVRD will use 26 high-intensity wet-magnetic separators of the Jones type to produce 12 million tons of concentrate per year from 20 million tons of fine-grained hematite ore (itabirite). The plant will be the first in the world to use this method of concentration for production of iron ore on a large scale. Crude ore feed is expected to contain 45 to 48 percent iron and 28 to 30 percent SiO_2, yielding a concentrate containing about 68 percent iron. Overall recovery of iron is expected to be about 95 percent. The project will increase minable reserves at the Cauê mine by about 500 million tons. The plant is being built by the West German firms of KHD-Humboldt and Thyssen-Stahlunion Export. Completion is expected by 1974.

At the taconite concentrator of Erie Mining Co. in Minnesota, plant-wide installation of fine-screening in the primary ball mill classification circuits has made it possible for the company to lower its goal for pellet silica content to 6.5 percent, compared with 7.1 percent in 1968–69 and 8 percent previously.[21]

Experiments by the Bureau of Mines on the effect of thermal treatments on grindability of low-grade nonmagnetic iron ores from Minnesota and Michigan indicated that a roasting atmosphere that brought about conversion of iron oxides to magnetite had the most significant effect. Roasting temperature was next in importance, and the cooling rate had the least effect.[22] The Bureau also continued to experiment with production of magnetic superconcentrates (containing less than 2 percent silica) from present standard-grade products.

Production of iron ore pellets continued to increase. Although world output rose only slightly, from an estimated 115 million long tons in 1970 to 121 million tons in 1971, new plants under construction were expected to add at least 11 million tons of capacity in 1972 and another 15 million tons in 1973.

Prereduction of iron ores continued to be an area of active research and commercial development. The second U.S. plant for production of metallized pellets was brought on stream in May 1971 at Georgetown, S.C. The plant was built and operated by the Midrex Division of Midland-Ross Corp. in a venture with Georgetown Steel Corp. Like the first plant, operated by Midrex in Portland, Oreg. since early 1970, the Georgetown plant has a production capacity of 400,000 tons of metallized pellets per year. A third plant of similar capacity was completed by Midrex at Hamburg, West Germany, during 1971; a fourth was under construction at Contrecour, Quebec; and a fifth was planned for construction at Taft, La. At Houston, Tex., the reduction plant being built by Armco Steel Corp. was expected to be completed in 1971. Capacity of the plant will be 1,000 tons per day of metallized iron ore or pellets. In Canada, Falconbridge Nickel Mines Ltd. began shipments of iron-nickel pellets (90 percent iron, 1.5 percent nickel) from its new plant at Sudbury. The plant uses the SL/RN reduction process and has a production capacity of about 300,000 tons of metallized pellets per year. In Venezuela, U.S. Steel Corp. completed construction of a reduction plant at Puerto Ordaz. The plant uses the Nu-Iron process and has a production capacity of 1 million tons per year of high-iron briquettes (86 to 92 percent iron). At Skopje, Yugoslavia, metallized pellets were being produced from low-grade chamositic iron ore pellets in a rotary kiln, using lignite as reductant. The plant is believed to have a production capacity of about 200,000 tons of metallized pellets per year. Together with plants already operating in Mexico, New Zealand, Republic of South Africa, and Republic of Korea (South), worldwide production capacity for prereduced iron

[20] Frommer, D. W. USBM–CCI Cooperative Research on Flotation of Nonmagnetic Taconites of Marquette Range. Blast Furnace and Steel Plant, v. 57, No. 8, August 1969, pp. 652–659.

[21] Keith, C. D. et al. "Further Development and Applications of Fine Screening With Rappers at Erie Mining Company and Other Pickands Mather & Co. Properties." Society of Mining Engineers of AIME, reprint 71–B–92, 17 pp. (1971).

[22] Vik, R. A., C. B. Daellenbach, and W. M. Mahan, Influence of Thermal Treatments Upon Grindability of Low-Grade Nonmagnetic Iron Ores. BuMines R.I. 7567, 1971, 30 pp.

ore at yearend 1971 appeared to exceed 4 million tons per year, and an additional 750,000 tons of capacity was scheduled for completion in 1972. In Australia, design and engineering work on the proposed reduction plant of Hamersley Iron Pty. Ltd. was reportedly well underway. This plant will use the SL/RN process to produce metallized agglomerate (HImet) containing 92 to 93 percent iron from hematite ore containing about 64 percent iron. Two reduction units are planned, each of which will have a production capacity of 600,000 tons of product per year.

Capital and production costs for a hypothetical plant manufacturing prereduced pellets from magnetic taconite on the Mesabi Range were estimated by the Bureau of Mines.[23] The operation was assumed to produce 1.32 million long tons of reduced pellets (93.6 percent iron, 3.0 percent SiO_2) from 6 million tons of crude ore per year. Capital cost was estimated at $103 million. Production costs were estimated to aggregate $25.85 per ton of reduced pellets, including charges of $1.11 per ton for superconcentration and $8.00 per ton for the reduction step. In a separate study,[24] the cost of reduction was estimated at $7.50 to $8.00 per ton of metallized pellets, using vertical furnaces with natural gas or horizontal kilns with coal. Capital costs of Midrex and SL/RN plants were estimated to be in the range of $35 to $40 per ton-year (excluding pelletization).

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[23] Fine, M. M. Production and Utilization of Metallized Ore. Skillings Min. Rev., v. 60, No. 9, Feb. 27, 1971, pp. 1, 8–11.

[24] Chlala, H. G. BF–LD versus DR–EL. Met. Bull. Monthly, No. 8, August 1971, pp. 16–18.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man by district and State, in 1971 p

District and State	Employment: Average number of men employed (thousands)	Employment: Time employed: Average number of days	Employment: Time employed: Total man shifts (thousands)	Employment: Time employed: Man hours: Average per shift	Employment: Time employed: Man hours: Total (thousands)	Production: Crude ore (thousand long tons)	Production: Usable ore: (Thousand long tons)	Production: Usable ore: Iron contained [1]: (Thousand tons)	Production: Usable ore: Iron contained [1]: Percent (natural)	Production: Average per man: Crude ore: Per shift	Production: Average per man: Crude ore: Per hour	Production: Average per man: Usable ore: Per shift	Production: Average per man: Usable ore: Per hour	Production: Average per man: Usable ore: Iron contained: Per shift	Production: Average per man: Usable ore: Iron contained: Per hour
Lake Superior:															
Michigan	2	316	778	8.0	6,227	27,017	11,919	7,413	62.2	34.73	4.34	15.32	1.91	9.53	1.19
Minnesota	8	319	2,585	8.0	20,683	129,343	51,283	30,714	59.9	50.03	6.25	19.84	2.48	11.88	1.48
Wisconsin	(2)	340	48	8.0	386	2,308	832	534	64.2	48.08	5.98	17.33	2.16	11.13	1.38
Total [3]	11	319	3,412	8.0	27,297	158,668	64,084	38,662	60.4	46.50	5.81	18.77	2.35	11.33	1.42
Southeastern States: Alabama, Georgia, North Carolina	(2)	252	45	9.3	415	1,757	527	251	47.8	39.04	4.23	11.71	1.27	5.58	.60
Northeastern States: New York and Pennsylvania	2	266	464	8.0	3,708	7,787	3,158	2,003	63.4	16.78	2.10	6.81	.85	4.32	.54
Western States: Arizona, Missouri, Montana, Utah, Wyoming	2	285	552	8.0	4,415	12,959	6,195	3,705	59.8	23.48	2.94	11.22	1.40	6.71	.84
Other western States [4]	1	324	443	8.0	3,547	15,225	6,133	3,580	58.4	34.37	4.29	13.84	1.73	8.08	1.01
Total [3]	3	301	994	8.0	7,962	28,185	12,328	7,285	59.1	28.36	3.54	12.40	1.55	7.33	.91
Grand total [3]	16	310	4,915	8.0	39,385	196,397	80,047	48,200	60.2	39.96	4.99	16.29	2.03	9.81	1.22

p Preliminary.
[1] Excludes byproduct ore.
[2] Less than ½ unit.
[3] Data may not add to totals shown because of independent rounding.
[4] Includes California, Colorado, Idaho, Nevada, New Mexico, and Texas.

Table 3.—Crude iron ore mined in the United States, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1970					1971				
	Number of mines	Hematite	Limonite	Magnetite	Total [1]	Number of mines	Hematite	Limonite	Magnetite	Total [1]
Lake Superior:										
Michigan	7	W	--	W	29,269	7	W	--	W	27,017
Minnesota	28	35,527	--	102,525	138,052	32	29,426	--	99,917	129,343
Wisconsin	1	--	--	2,208	2,208	1	--	--	2,308	2,308
Total reportable	36	35,527	--	104,733	169,529	40	29,426	--	102,225	158,668
Southeastern States:										
Alabama	8	1,125	W	W	3,277	3	--	1,228	--	1,228
Georgia and North Carolina						3		W	W	529
Total reportable	8	1,125	--	--	3,277	6	--	1,228	--	1,757
Northeastern States: New York and Pennsylvania	5	--	--	9,177	9,177	5	--	--	7,787	7,787
Western States:										
Arizona	1	12	--	--	12	1	16	--	--	16
Missouri	(2)	(2)	(2)	(2)	(2)	2	--	--	4,458	4,458
Montana	1	--	--	14	14	1	--	--	14	14
Utah	4	W	--	W	5,615	4	W	--	W	4,240
Wyoming	3	W	--	W	4,142	3	W	--	W	4,232
Other [3]	16	W	--	W	20,693	12	W	W	W	15,223
Total reportable	25	12	--	14	30,476	23	16	--	4,472	28,184
Total withheld	--	20,546	5,818	35,507	--	--	17,552	4,375	29,316	--
Grand total [1]	74	57,210	5,818	149,431	212,459	74	46,994	5,603	143,800	196,397

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with "Other" in 1970.
[3] Includes California, Colorado, Idaho, Missouri (1970 only), Nevada, New Mexico, and Texas.

Table 4.—Crude iron ore mined in the United States, by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1970 Open pit	1970 Underground	1970 Total [1]	1971 Open pit	1971 Underground	1971 Total [1]
Lake Superior:						
Michigan	25,926	3,344	29,269	24,203	2,814	27,017
Minnesota	138,052	--	138,052	129,343	--	129,343
Wisconsin	2,208	--	2,208	2,308	--	2,308
Total reportable	166,186	3,344	169,529	[1] 155,855	2,814	158,668
Southeastern States:						
Alabama	W	W	W	1,228	--	1,228
Georgia and North Carolina				529	--	529
Total reportable	--	--	3,277	1,757	--	1,757
Northeastern States: New York and Pennsylvania	W	W	9,177	W	W	7,787
Western States:						
Arizona	12	--	12	16	--	16
Missouri	(2)	(2)	(2)	--	4,458	4,458
Montana	14	--	14	14	--	14
Utah	5,615	--	5,615	4,240	--	4,240
Wyoming	W	W	4,142	W	W	4,232
Other [3]	W	W	20,693	W	W	15,223
Total reportable	5,641	--	30,476	4,270	4,458	28,184
Total withheld	27,425	9,865	--	23,264	3,981	--
Grand total [1]	199,252	13,209	212,459	185,145	11,252	196,397

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with "Other" in 1970.
[3] Includes California, Colorado, Idaho, Missouri (1970 only), Nevada, New Mexico, and Texas.

Table 5.—Crude iron ore shipped from mines in the United States, by district, State, and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1970 Direct to consumers	1970 To beneficiation plants	1970 Total [1]	1971 Direct to consumers	1971 To beneficiation plants	1971 Total [1]
Lake Superior:						
Michigan	1,512	28,426	29,938	1,439	26,267	27,706
Minnesota	3,892	134,275	138,167	3,335	125,519	128,853
Wisconsin	--	2,248	2,248	--	2,308	2,308
Total reportable	5,404	164,949	170,353	4,774	154,094	158,868
Southeastern States:						
Alabama	W	W	W	--	1,228	1,228
Georgia and North Carolina				--	529	529
Total reportable	--	--	--	--	1,757	1,757
Northeastern States: New York and Pennsylvania	--	9,185	9,185	--	7,772	7,772
Western States:						
Arizona	12	--	12	16	--	16
Missouri	(2)	(2)	(2)	--	4,497	4,497
Montana	14	--	14	14	--	14
Utah	W	W	r 2,619	W	W	4,277
Wyoming	W	W	4,143	W	W	4,232
Other [3]	W	r 20,025	W	389	14,142	14,531
Total reportable	26	r 20,025	r 6,788	419	18,639	27,566
Total withheld	1,967	r 8,412	r 23,642	1,278	7,231	--
Grand total [1]	7,397	r 202,571	r 209,968	6,470	189,492	195,962

r Revised.
W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with "Other" in 1970.
[3] Includes California, Colorado, Idaho, Missouri (1970 only), Nevada, New Mexico, and Texas.

Table 6.—Usable iron ore produced in the United States, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1970				1971			
	Hematite	Limonite	Magnetite	Total	Hematite	Limonite	Magnetite	Total [1]
Lake Superior:								
Michigan	W	--	W	12,757	W	--	W	11,919
Minnesota	20,728	--	35,345	56,073	17,513	--	33,771	51,283
Wisconsin	--	--	806	806	--	--	832	832
Total reportable	20,728	--	36,151	69,636	17,513	--	34,603	64,034
Southeastern States:								
Alabama	W	620	--	1,484	--	351	--	351
Georgia and North Carolina	--		W		--	W	W	176
Total reportable	--	620	--	1,484	--	351	--	527
Northeastern States: New York and Pennsylvania	--	--	3,491	3,491	--	--	3,158	3,158
Western States:								
Arizona	12	--	--	12	16	--	--	16
Missouri	(2)	--	(2)	(2)	--	--	2,642	2,642
Montana	--	--	14	14	--	--	14	14
Utah	W	--	W	2,004	W	--	W	1,715
Wyoming	W	--	W	1,947	W	--	W	1,809
Other [3]	W	W	5,903	10,337	W	W	2,836	6,133
Total reportable	12	--	5,917	14,314	16	--	5,492	12,328
Total withheld	12,844	930	8,233	--	9,817	1,057	8,042	--
Total all States	33,584	1,550	53,792	88,925	27,345	1,408	51,294	80,047
Byproduct ore [4]	--	--	--	835	--	--	--	715
Grand total [1]	33,584	1,550	53,792	89,760	27,345	1,408	51,294	80,762

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with "Other" in 1970.
[3] Includes California, Colorado, Idaho, Missouri (1970 only), Nevada, New Mexico, and Texas.
[4] Mostly cinder and sinter obtained from treating pyrites. Ore was treated in Colorado, Delaware, New Mexico, Pennsylvania, Tennessee, and Virginia.

Table 7.—Usable iron ore produced in the United States, by district, State, and type of product

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1970				1971			
	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)
Lake Superior:								
Michigan	940	11,172	645	62	732	10,560	627	62
Minnesota	3,892	35,345	16,836	59	3,335	33,771	14,178	60
Wisconsin	--	806	--	63	--	832	--	64
Total reportable	4,832	47,323	17,481	59	4,067	45,162	14,805	61
Southeastern States:								
Alabama	W	--	1,288	46	--	--	351	47
Georgia and North Carolina	--	--			--	--	176	48
Total reportable	--	--	1,288	46	--	--	527	47
Northeastern States: New York and Pennsylvania	--	W	W	63	--	W	W	63
Western States:								
Arizona	12	--	--	e 58	16	--	--	e 58
Missouri	--	(1)	(1)	(1)	--	2,625	17	65
Montana	14	--	--	e 45	14	--	--	e 45
Utah	W	--	W	54	W	--	W	53
Wyoming	W	W	W	58	W	W	W	59
Other [2]	496	5,540	W	61	383	W	W	59
Total reportable	522	5,540	--	60	413	2,625	17	60
Total withheld	1,625	4,286	6,028	59	1,278	6,723	4,430	60
Total all States [3]	6,979	57,149	24,797	59	5,757	54,511	19,779	60
Byproduct ore [4]	--	691	144	65	--	603	112	64
Grand total [3]	6,979	57,840	24,941	59	5,757	55,114	19,891	60

e Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."

1 Included with "Other" in 1970.

2 Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.

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

4 Mostly cinder and sinter obtained from treating pyrites.

Table 8.—Shipments of usable iron ore from mines in the United States in 1971

(Thousand long tons and thousand dollars; exclusive of ore containing 5 percent or more manganese)

District and State	Gross weight of ore shipped				Iron content of ore shipped				
	Direct shipping ore	Agglomerates	Concentrates	Total quantity [1]	Direct shipping ore	Agglomerates	Concentrates	Total quantity [1]	Total value [1]
Lake Superior:									
Michigan	1,439	9,922	472	11,833	732	6,273	259	7,264	$159,854
Minnesota	3,335	32,619	13,100	49,054	1,728	20,454	7,128	29,311	547,606
Wisconsin	--	824	--	824	--	529	--	529	W
Total reportable	4,774	43,365	13,571	61,710	2,460	27,257	7,387	37,104	707,459
Southeastern States:									
Alabama	--	--	415	415	--	--	185	185	2,773
Georgia and North Carolina	--	--	176	176	--	--	86	86	1,162
Total reportable	--	--	592	592	--	--	271	271	3,934
Northeastern States: New York and Pennsylvania	--	W	W	2,849	--	W	W	1,820	44,979
Western States:									
Arizona	16	--	--	16	9	--	--	9	W
Missouri	--	2,709	17	2,727	--	1,762	12	1,775	W
Montana	14	--	--	14	6	--	--	6	W
Utah	1,271	--	410	1,681	662	--	228	890	11,886
Wyoming	7	W	W	1,809	4	W	W	1,066	W
Other [2]	389	W	W	5,710	228	W	W	3,329	49,176
Total reportable	1,696	2,709	427	11,955	908	1,762	240	7,075	61,062
Total withheld	--	6,589	3,382	--	--	4,100	1,884	--	73,566
Total all States	6,470	52,663	17,972	77,106	3,369	33,119	9,783	46,270	891,001
Byproduct ore [3]	--	586	--	586	--	377	--	377	5,753
Grand total [1]	6,470	53,249	17,972	77,692	3,369	33,496	9,783	46,647	896,754

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes California, Colorado, Idaho, Nevada, New Mexico, and Texas.
[3] Mostly cinder and sinter obtained from treating pyrites. Ore treated in Colorado, Delaware, New Mexico, Pennsylvania, Tennessee, and Virginia.

Table 9.—Usable iron ore produced in Lake Superior district, by range

(Thousand long tons and exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Black River Falls	Total [1]
1854–1966	349,370	292,799	320,285	103,326	2,564,910	68,334	8,008	--	3,707,032
1967	10,231	3,792	49	202	48,857	1,041	58	--	64,229
1968	10,086	3,684	--	--	51,411	961	83	--	66,224
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
Total	399,593	308,462	320,334	103,528	2,827,809	70,336	8,149	1,676	4,039,885

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

Table 10.—Average analyses of total tonnage [1] of all grades of iron ore shipped from the U.S. Lake Superior district

Year	Thousand long tons	Content, percent [2]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1967	63,845	57.81	r 0.060	7.63	0.47	0.57	5.69
1968	64,065	58.70	.051	7.35	.40	.52	5.16
1969	71,389	59.02	.045	7.32	.45	.69	4.82
1970	69,072	59.26	.041	7.38	.39	.72	4.64
1971	61,776	59.93	.037	7.13	.34	.60	4.32

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, p. 83.

Table 11.—Consumption of iron ore and agglomerates in the United States in 1971

(Thousand long tons, and exclusive of ore containing 5 percent 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	2,981	W	6,775	W	NA	9,756
California, Colorado, Utah	2,029	W	4,696	W	NA	6,725
Ohio and West Virginia	3,906	W	18,306	W	NA	22,212
Illinois and Indiana	2,807	W	24,036	W	NA	26,843
Michigan and Minnesota	376	W	9,518	W	NA	9,894
Maryland, New York, Pennsylvania	9,989	W	28,344	W	NA	38,333
Undistributed	--	1,315	--	547	e 571	2,433
Total	22,088	1,315	91,675	547	e 571	116,196

e Estimate. NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Not including pellets or other agglomerated products.
[2] Includes 47,402,000 tons of pellets produced at U.S. mines, and 9,685,000 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.
Note: 1970 iron ore (blast furnaces) figures for the following States are revised as follows: California, Colorado, Utah, 5,036 (total 8,131); Illinois and Indiana, 18,563 (total 29,647); Maryland, New York, Pennsylvania, 20,737 (total 45,795) and total (all States) iron ore (blast furnaces), 77,811 (total 131,571). In addition, figure in footnote [1] (for 1970) was revised to 50,237,000 tons.

Table 12.—Beneficiated iron ore shipped from mines in the United States [1]

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1967	66,243	82,415	80.3
1968	72,781	81,934	88.8
1969	80,157	89,854	89.2
1970	79,779	87,176	91.5
1971	70,456	77,106	91.4

[1] Beneficiated by further treatment than ordinary crushing and screening. Excludes byproduct ore.

Table 13.—Iron ore consumed in production of agglomerates at iron and steel plants in 1971, by State

(Thousand long tons)

State	Iron ore consumed [1]	Agglomerates produced
Alabama, Kentucky, Texas	3,033	3,446
California, Colorado, Utah	1,751	2,322
Ohio and West Virginia	2,864	4,398
Illinois, Indiana, Michigan	7,070	9,456
Maryland, New York, Pennsylvania	11,529	14,093
Total	26,247	33,715

[1] Including domestic and foreign ores.
Note: Agglomerates produced (total 1970) revised, 39,264.

Table 14.—Production of iron ore agglomerates [1] in the United States, by type

(Thousand long tons)

Type	Agglomerate produced	
	1970	1971
Sinter, nodules, and cinder	[2] 41,661	[3] 35,775
Pellets	55,444	53,055
Total	97,105	88,830

[1] Production at mines and consuming plants.
[2] Includes 20,094 thousand tons of self-fluxing sinter.
[3] Includes 17,664 thousand tons of self-fluxing sinter.

Table 15.—Stocks of usable iron ore at mines [1] Dec. 31, by district

(Thousand long tons)

District	1970	1971
Lake Superior	8,820	10,711
Southeastern States	834	778
Northeastern States	4,658	4,968
Western States	1,004	1,196
Total	15,316	17,653

[1] Excluding byproduct ore.

Table 16.—Average value of usable iron ore [1] shipped from mines or beneficiating plants in the United States in 1971

(Dollars per long ton)

Type of ore	District			
	Lake Superior	South-eastern	North-eastern	Western
Direct-shipping, hematite	6.35	--	--	e 2 6.65
Concentrates, hematite	7.33	W	--	e 2 6.80
Concentrates, hematite	--	e 6.70	--	W
Agglomerates	13.67	--	16.02	12.65

e Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] F.o.b. mine or plant. Excludes byproduct ore.
[2] Combined average of hematite and magnetite ores.

Table 17.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Destination	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	1	$38	127	$1,756	(1)	$15
Canada	2,085	26,255	2,045	27,111	1,245	17,180
Germany, West	62	409	34	96	19	53
Japan	3,009	35,529	3,206	37,727	1,794	20,850
Spain	--	--	75	1,095	--	--
Other	3	79	5	113	3	49
Total	5,160	62,310	5,492	67,898	3,061	38,147

[1] Less than ½ unit.

Table 18.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	50	$701	--	--	--	--
Australia	315	3,556	638	$7,389	1,008	$12,692
Brazil	1,233	11,300	1,991	17,865	1,772	16,547
Canada	18,978	219,347	r 23,934	r 297,203	20,342	267,424
Chile	1,783	14,371	1,581	12,805	878	7,152
Liberia	3,144	27,227	1,873	17,216	1,838	16,768
Libya	--	--	103	789	--	--
Mauritania	--	--	72	664	--	--
Nigeria	--	--	30	152	52	399
Norway	269	1,937	49	356	--	--
Peru	1,003	10,738	1,329	13,771	1,063	12,443
Sweden	155	1,659	172	1,909	178	2,200
Uruguay	39	354	49	444	--	--
Venezuela	13,751	110,745	13,026	108,493	12,953	114,176
Other	12	243	44	462	40	843
Total	40,732	402,178	r 44,891	r 479,518	40,124	450,644

r Revised.

Table 19.—U.S. imports for consumption of iron ore, by customs district

(Thousand long tons and thousand dollars)

Customs district	1970 Quantity	1970 Value	1971 Quantity	1971 Value
Baltimore	10,068	$106,069	8,452	$91,103
Buffalo	2,954	40,960	2,507	38,122
Chicago	5,922	70,857	4,596	57,961
Cleveland	r 6,861	r 76,263	6,026	72,880
Detroit	1,104	16,294	859	13 851
Houston	844	11,000	258	3,690
Los Angeles	52	401	101	812
Mobile	4,787	44,712	4,762	46,717
New Orleans	602	5,734	500	4,944
Norfolk	16	183	--	--
Ogdensburg	4	350	3	337
Philadelphia	11,419	104,034	11,718	115,999
Portland, Oreg	176	1,774	114	1,332
San Juan	11	91	--	--
Wilmington, N.C	69	781	223	2,516
Other	2	15	5	380
Total	r 44,891	r 479,518	40,124	450,644

r Revised.

Table 20.—Iron ore, iron ore concentrates and iron ore agglomerates:[1] World production by country

(Thousand long tons)

Country [2]	1969	1970	1971 p
North America:			
Canada [3]	35,763	46,709	43,281
Guatemala	e 3	2	e 2
Mexico [4]	3,440	4,285	4,624
United States [3]	88,328	89,760	80,762
South America:			
Argentina	295	235	e 236
Bolivia	2	4	6
Brazil	r 26,728	e 39,600	e 42,000
Chile	11,352	11,087	11,051
Colombia	346	446	435
Peru	9,123	9,559	8,691
Uruguay	--	1	3
Venezuela	r 19,405	21,751	20,176
Europe:			
Albania [5]	399	531	558
Austria	3,919	3,934	4,105
Belgium	r 92	92	92
Bulgaria	2,646	2,371	2,954
Czechoslovakia	1,544	1,582	1,583
Denmark	31	e 30	e 30
Finland [6]	870	846	732
France	54,550	55,908	54,990
Germany, East [7]	885	415	313
Germany, West	5,965	5,444	6,290
Hungary	670	619	676
Italy [8]	751	745	672
Luxembourg	6,211	5,632	4,436
Norway	3,793	3,943	3,849
Poland	2,777	2,513	2,045
Portugal [9]	160	124	98
Romania	2,952	3,156	3,412
Spain	6,308	6,844	7,192
Sweden	32,661	31,272	32,811
U.S.S.R	183,194	191,133	199,794
United Kingdom	12,104	11,828	10,067
Yugoslavia	2,678	3,636	3,666
Africa:			
Algeria	2,923	2,818	3,002
Angola	5,391	5,956	6,061
Arab Republic of Egypt (formerly United Arab Republic)	453	444	500
Liberia	22,505	22,294	22,813
Mauritania	r 8,543	8,959	8,313
Morocco	737	859	613
Rhodesia, Southern e	500	500	500
Sierra Leone	2,337	2,259	2,507
South Africa, Republic of [10]	9,081	7,605	10,509
Swaziland	2,266	2,512	2,841
Tunisia	931	762	921

See footnotes at end of table.

Table 20.—Iron ore, iron ore concentrates and iron ore agglomerates:[1] World production by country—Continued

(Thousand long tons)

Country [2]	1969	1970	1971 p
Asia:			
China, People's Republic of e	39,000	43,000	54,000
Hong Kong	163	168	160
India	29,097	30,871	31,778
Iran [11]	7	10	15
Japan [12]	1,824	1,550	1,398
Korea, North e	7,400	7,900	8,400
Korea, Republic of	698	562	496
Malaysia	5,151	4,420	937
Pakistan	505	--	--
Philippines	1,537	1,840	2,208
Taiwan	8	6	--
Thailand	470	22	39
Turkey	[13] 1,956	2,604	2,047
Oceania:			
Australia	r 37,966	50,380	61,119
New Caledonia	81	--	--
New Zealand [14]	20	146	567
Total	r 701,495	754,484	773,376

e Estimate. p Preliminary. r Revised.

[1] Insofar as availability of sources permit, data in this table represent the non-duplicative sum of marketable iron ore, iron ore concentrates and iron ore agglomerates produced by each of the listed countries. Moreover, concentrates 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, are not available.

[3] Includes byproduct ore.

[4] Calculated from reported iron content assuming a grade of 60 percent iron.

[5] Nickeliferous iron ore.

[6] Includes pelletized iron oxide produced from pyrite sinter, but excludes additional pyrite sinter not processed to oxide.

[7] Includes pyrite sinter, not separable from available sources.

[8] Excludes iron oxide pellets produced from pyrite sinter.

[9] Includes manganiferous iron ore as follows, in thousand long tons: 1969—55, 1970—53, 1971—44.

[10] Includes byproduct magnetite as follows in thousand long tons: 1969—1,852, 1970—1,936, 1971—2,193; and manganiferous iron ore (20–35 percent iron, 15–30 percent manganese) as follows in thousand long tons: 1969—432, 1970—368, 1971—179.

[11] Year beginning March 21 of that stated.

[12] Concentrates, including concentrate derived from iron sand as follows in thousand long tons: 1969—884, 1970—701, 1971—581.

[13] Sales.

[14] Largely concentrates from magnetite-titanium sands.

Iron and Steel

By F. E. Brantley [1]

The year started with cautious optimism in the domestic steel industry and raw steel [2] production continued to exceed that for 1970 during the first few months. By July it was evident that production had been buoyed up by stockpile buying against a possible strike on expiration of the labor contract July 31. Agreement was reached August 1 on a new 3-year pact, leaving stocks to be worked off. This, combined with record imports of 18.9 million short tons, resulted in diminishing orders for mill products, from which the market did not fully recover by yearend. Domestic raw steel production totaled 120.4 million tons, down 8.4 percent from that of 1970. However, apparent consumption of steel products, adjusted for imports and exports, was up 5.6 percent.

A general steel recession in the free world was evident as total world production decreased approximately 2 percent from that of 1970. Hardest hit of major producers was the United Kingdom, down 14.6 percent, followed by West Germany with a reduction of 10.5 percent, and Japan with 5.1 percent. The U.S.S.R. increased its production by 4.4 percent, and for the first time exceeded U.S. production, by a margin of 10.7 percent.

Prices continued to advance in most countries, as pollution control and currency adjustments became increasingly important factors to be dealt with. Capital spending by U.S. steelmakers was slightly over $1.6 billion for 1971. Environmental quality control facilities added in 1971 totaled $162 million, or approximately 10 percent of capital investments.

One merger of importance occurred as National Steel Corp. acquired Granite City Steel Co., effective August 16. Increasing interest was shown by a number of steel companies in the housing market, either through subsidiaries or company divisions.

[1] Physical scientist, Division of Ferrous Metals.
[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)

	1967	1968	1969	1970	1971
United States:					
Pig iron:					
Production	86,799	88,767	95,003	91,293	81,382
Shipments	86,819	89,085	95,472	91,[illegible]72	81,332
Exports	7	9	44	310	34
Imports for consumption	605	786	405	249	306
Steel: [1]					
Production of raw steel:					
Carbon	113,190	116,269	124,832	117,411	107,007
Stainless	1,451	1,432	1,569	1,279	1,263
All other alloy	12,572	13,761	14,861	12,824	12,173
Total	127,213	131,462	141,262	131,514	120,443
Index (1967 =100)	100.0	103.1	111.0	103.4	94.7
Total shipments of steel mill products	83,897	91,856	93,877	90,798	87,038
Exports of major iron and steel products	2,100	2,673	5,788	7,657	3,528
Imports of major iron and steel products [2]	11,831	18,335	14,530	13,882	18,814
World production:					
Pig iron	385,707	418,108	453,126	471,006	474,347
Raw steel (ingots and castings)	544,000	584,000	632,561	655,380	641,673

[1] American Iron and Steel Institute. Includes ingots, continuous cast steel, and all other cast forms.
[2] Data not comparable for all years.

PRODUCTION AND SHIPMENTS OF PIG IRON

Domestic production of pig iron totaled 81.4 million tons in 1971, a decrease of 9.9 million tons, or 10.9 percent less than that produced in 1970. Average production of pig iron per blast-furnace-day increased to 1,654.3 tons, compared with 1,641.6 tons in 1970, and 1,609.0 tons in 1969, according to the American Iron and Steel Institute (AISI). A total of 152 blast furnaces were in blast at the beginning of the year, including two producing ferroalloys. At yearend the total number in blast had decreased to 126, with three producing ferroalloys. There were 219 producing furnaces at the beginning of the year, and 216 at yearend, of which eight were being relined.

Shipments of pig iron approximated total production for 1971. Yearend stocks at consumer and supplier plants were down 303,000 tons, 14.6 percent under those of 1970.

Metalliferous Materials Consumed in Blast Furnaces.—For each ton of pig iron produced in 1971, an average of 1.632 tons of metalliferous materials was consumed in the blast furnaces. Total net iron ore consumed in blast furnaces including agglomerates, was 125 million short tons. The total tonnage of iron ore including manganiferous ore, consumed by agglomerating plants at or near the blast furnaces in producing 37.8 million tons of agglomerates was 29.7 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 52.9 million tons, and sinter charged was 39.2 million tons. Pellets and other agglomerates from foreign sources added an additional 10.5 million tons.

Blast furnace oxygen consumption totaled 13.3 billion cubic feet according to the AISI, compared with 13.5 billion in 1970, and 9.1 billion cubic feet in 1969.

Data reported to the Bureau of Mines by the iron and steel industry showed that blast furnaces, through tuyere injection, consumed 22.6 billion cubic feet of natural gas, 8.1 billion cubic feet of coke oven gas, 110.8 million gallons of oil, and 39.2 million gallons of tar, pitch, and miscellaneous fuel in 1971.

PRODUCTION AND SHIPMENTS OF STEEL

Domestic production of raw steel for the first 6 months, 71.8 million tons, exceeded that for the same period in 1970 by 5.7 percent, with a monthly high of 12.9 million tons being poured in May. A sharp decline began in the second half which reached a low monthly output of 5.8 million tons in August. Production then trended upward for the remainder of the year but not enough to keep the total annual production, 120.4 million tons, from being the lowest since 1963.

The 1971 steel index, based on production in 1967 as 100, was 94.7, compared with 103.4 for 1970, and 111.0 for 1969. Production in 1971 was proportioned between the basic oxygen process (BOP), 53.1 percent, the open-hearth furnace, 29.5 percent, and the electric furnace, 17.4 percent. Domestic BOP production, which exceeded the 50 percent mark for the first time in the last half of 1970, gradually increased its lead during 1971 as more open-hearth furnaces were taken out of service.

Shipments of steel products for the year declined by 4.1 percent, from 90.8 million tons in 1970 to 87.0 million tons in 1971. First-half shipments were up 9.8 percent from the like period in 1970, indicating the degree of hedge buying in anticipation of the steel strike threatened for August. Continued high imports and the general steel recession throughout the free world contributed to lowered domestic steel output during the second half of the year.

On a percentage basis, domestic shipments followed essentially the same grade pattern as for 1970, the only significant change being a 2-percent rise in sheet and strip shipments. Recovery of the automotive industry was indicated with 20.1 percent of net shipments made directly to this market, compared with 15.9 percent in 1970 and 19.5 percent in 1969.

Materials Use in Steelmaking.—Metallics charged to domestic steel furnaces in 1971 per ton of steel produced averaged 1,269 pounds of pig iron, 1,051 pounds of scrap, and 35 pounds of iron ore including agglomerates. In 1970 comparable amounts were 1,244 pounds of pig iron, 1,011 pounds of scrap, and 51 pounds of iron ore.

According to the AISI, steelmaking furnaces consumed 543,300 tons of fluorspar, 2.1 million tons of limestone, 5.9 million tons of lime, and 817,000 tons of other fluxes. Oxygen consumption by the iron and steel industry amounted to the equivalent of 166.7 billion cubic feet, compared with a revised total of 177.6 billion in 1970.

CONSUMPTION OF PIG IRON

Pig iron consumed in steelmaking totaled 76.42 million tons. Basic oxygen converters consumed 51.80 million tons; open hearths, 24.00 million tons; and electric furnaces, 0.60 million ton. An additional 2.13 million tons was consumed by iron foundries and miscellaneous users, primarily for charging cupola furnaces. Also, 4.99 million tons in the form of molten metal was used in making ingot molds and direct castings.

PRICES

Prices throughout the steel industry trended upward during the year, except for a 90-day freeze period. Iron and steel were included in the President's general executive order to stabilize prices, rents, wages, and salaries from mid-August to mid-November.

In January, increases of up to 12.5 percent on some construction steel products were announced by the two leading domestic steelmakers. These were later revised downward by about 25 percent and the lower increases were followed by most steelmakers. Additional increases were posted in March on certain semifinished steels, wire, pipe, and bar mill products; the increases were to become effective at announced future dates. The pattern of increasing prices according to type of product appeared to be established and was followed by most of the major producers.

In April, the board chairman of Jones & Laughlin Steel Corp. reported that steel price increases of $21 per ton over the preceding 2-year period failed to cover the added increases in the cost of producing steel by $10. In May, blast furnace operators boosted the price of merchant pig iron by $5 per long ton or the equivalent of $4.46 per short ton. Major stainless steel producers announced base price increases averaging approximately 6.5 percent during the month. These increases were offset somewhat by widespread discounting practices. Boosts on sheet and strip products, averaging slightly over 6 percent, were quoted by the larger mills to become effective by July 1. Increases on selected items continued into August, with prices moving upward on a large number of products. A major producer announced price raises averaging 8 percent on most mill products to go into effect in August, October, or December, depending on the type of product. Some stainless steel producers cut price discounts which had been in effect, and prices of specialty steels were increased by others.

In mid-August, the President issued a 90-day wage-price freeze order which was to terminate November 12. Except for exports, which were not included, iron and steel prices remained fixed for this period. Actual prices charged during the period of July 16, 1971, to August 14, 1971, could be used if a price reduction resulted and the seller wished. A Federal Price Commission set up to control wages and prices after the freeze order expired granted both general price increases, as well as increases on a number of mill products. These raises were based on individual company decisions and specific cases, and continued to be granted throughout the remainder of the year.

In December, one stainless steel producer rolled back strip, sheet and plate base prices that were in effect as of May 25, 1970, as allowed by the Presidential freeze order. At the same time, discounts previously granted distributors were cut, with the idea of creating a more stable pricing level. Iron Age's composite price for No. 304 stainless sheet in December was 4 cents per pound over that for January.

The composite price of pig iron, according to Iron Age, increased from $65.71 per short ton at the beginning of the year to

$70.18 at yearend, and the composite price of finished steel went from $156.76 per ton for January to $175.54 for December. Comparable January and December prices, at Pittsburgh, for hot-rolled sheets were $150 and $159 per ton, and for cold-rolled sheets $179 and $191 per ton.

Other principal free-world producers had boosted or indicated intentions to raise prices of iron and steel by mid-year, owing to inflation and general increases in costs. The nationalized steel industry of the United Kingdom was restricted by Government order to about one-half its requested price increase, and finished the year with a deficit.

World currency realignments near the close of 1971 resulted in mixed pricing effect, with shifts in the competitive pattern of various countries. Major steel producers in Japan announced increases on exports to the United States of from $10 to $16 per ton on all contracts signed from September 1971; deliveries were to start in 1972.

FOREIGN TRADE

The 3-year voluntary steel import quota agreements with steelmakers of Japan and the European Economic Community (EEC) countries expired at the end of 1971. Negotiations between U.S. officials and spokesmen for these countries resulted in renewal of the voluntary pacts for an additional 3-year period. A major change was a reduction in the annual rate of growth of steel mill product exports from 5 percent to 2.5 percent; also the addition of the United Kingdom to the pact. Interest among domestic steelmakers for import quota legislation remained high in 1971 and, prior to the voluntary agreements, bills were introduced in the House and Senate to set limits.

Data compiled by AISI showed that exports of total steel products decreased to 3.2 million tons in 1971, from 7.5 million in 1970, and 5.6 million in 1969. Imports of total steel products reached a record high of 18.9 million tons, compared with 13.4 million in 1970, and 14.0 million in 1969. A major increase in imports over 1970 of 2.5 million tons of sheet and strip mill products occurred, which was thought to be due largely to increased overseas orders placed by the automobile industry in anticipation of a possible steel strike.

Exports of iron products totaled 304,300 tons in 1971, 527,500 in 1970, and 236,900 in 1969. Imports of iron products, largely pig iron, totaled 304,300 tons in 1971, 327,400 in 1970, and 495,000 in 1969.

Increasing movement of Japanese steel into the West European marketplace was slowed by a 3-year voluntary agreement with the Japan Iron and Steel Federation. Under a quota system, 1972 exports would be 1.25 million metric tons to the Common Market countries, including Great Britain.

WORLD REVIEW

The International Iron and Steel Institute (IISI) held its fifth annual meeting in Toronto, Canada, in October. Strengthening the steel industries of the member countries remained a primary objective. Finding practical solutions to the environmental problems and energy needs of the industry were subjects of discussion among the steelmakers. Delegates from 24 free world countries attended, representing about 100 steel companies.

The 11th Latin American Iron and Steel Congress was held in Mexico City in October also, by the Instituto Latino Americano del Fierro y el Acero (ILAFA). Planned increases in raw steel production discussed by one speaker, would make 1977 production almost twice that of 1970.[3] Every member country was expected to add at least 50 percent to its steelmaking capacity. Mexico's new Las Truchas steel complex plans, and the future of direct reduction in Latin America were subjects of considerable interest at the meeting.

Argentina.—The expansion program by Sociedad Mixta Siderúrgia Argentina (SOMISA) at its San Nicolas steel plant continued. Approximately $300 million was authorized in 1968 to raise the Govern-

[3] Journal of Metals. ILAFA—Steelmakers Look at a Bright Future. V. 23, No. 12, December 1971, pp. 16–17.

ment-owned plant's steel capacity to approximately 2.8 million tons per year. Completion has been scheduled by the end of 1972. The plant installations are to be such that future expansions will be possible to 4 million tons with minimum modifications.

Also underway was the Propulsora Siderúrgia project of installing 1.7 million tons of raw steel capacity, with projected plans for 2.8 million tons annually by 1975–76.

Argentina's pig iron and steel production in 1971 showed an increase of 8 and 5 percent over that for 1970. In 1969–70 the domestic steel industry was able to supply only about 55 percent of the country's needs. Plans for 6.6 million tons of capacity by 1975–76 will theoretically balance domestic demand.

Australia.—The Premier of Western Australia announced in April that a preliminary study on the feasibility of developing a large-scale steelworks at Kwinana, had been completed by Broken Hill Proprietary Co. Ltd. (BHP) for the company and other members of the Mount Newman Joint Venture, an iron ore project. The other members of the joint venture were American Metal Climax, Inc., and The Colonial Sugar Refining Co. Ltd. Proposed was a plant for making semifinished steel largely for export. Production should reach 4 million tons after initial output begins in 1975–76, and future expansion to 11 million tons will be considered as warranted. The port facilities in Cockburn Sound would be utilized and improved to handle vessels of up to 150,000 tons.

Two other groups, the Hanwright group and Jervis Bay consortium, were also competing for ore reserves as a basis for steelworks on Jervis Bay. The Jervis Bay consortium (Armco-Kaiser-Thyssen) has been engaged in feasibility studies for some time concerning a similar proposed development. The Hanwright group apparently holds the key to important iron ore rights.

BHP continued its expansion program at Port Kembla, and planned expenditures through its subsidiary, Australian Iron and Steel Pty. Ltd., will amount to over $300 million for the 4-year period through 1973. Production of steel would be boosted to 8.0 million tons per year.

Brazil.—In January President Medici announced a $3 billion plan to quadruple Brazil's steel output and reach 22 million tons annually by 1980. During the year, the three Government-controlled steel companies, Cia. Siderúrgica Nacional (CSN), Usina Siderúrgica de Minas Gerais (USIMINAS), and Cia. Siderúrgica Paulista (COSIPA), received approvals from the National Council for the Steel Industry (CONSIDER) for planned expansions involving approximately $1 billion in investments. International tenders for prequalification of suppliers of steel mill equipment to provide for an additional 3 million tons capacity were requested; procurement was to start in 1971 and installation is to be completed in 1975. Included in the installations would be three blast furnaces. Estimated cost would be $480 million for equipment and $615 million for other items, including interest and working capital.

Additional projects included a steel mill at Santa Cruz scheduled by Cia. Siderúrgica da Guanabara (COSIGUA) to begin production in 1972 at a rate of 275,000 tons per year and reach 2-million-ton capacity by 1980 and two plants based on direct reduction, one based on the HyL process, the other on the SL/RN process.

Two blast furnaces were expected to be imported from Japan, one for USIMINAS and the other for CSN. IHI would supply the former, to be completed by 1974, with a 2,700-cubic-meter capacity and a cost of approximately $13 million. The other would be supplied by Nippon Steel Corp. To be completed in 1975, it would have a 3,200-cubic-meter capacity and cost approximately $16 million.

Canada.—Raw steel production in Canada for 1971 was only 1.7 percent below the alltime high of 12,346,000 tons in 1970, and 1972 was expected to be another record year. Expenditures made or firmly committed in 1971 by the iron and steel industry, including foundries and pipe and tube mills, totaled about $500 million.[4]

The Algoma Steel Corp. Ltd. continued construction on its new basic oxygen shop and a new blast furnace. The basic oxygen plant, with two 250-ton converters, was to be in operation in 1973 and the blast furnace, in 1974. A new $75 million, 160-inch plate mill started production during the year.

The Steel Co. of Canada, Ltd. (STELCO) completed construction of

[4] Department of Energy, Mines and Resources. Canadian Mineral Industry in 1971—Preliminary. Miner. Bull. 122, Ottawa, Canada, 1972, p. 93.

three basic oxygen converters at its Hilton works, which were expected to begin producing early in 1972. Additional expenditures were made to increase finished products capacity, including a new electrolytic tinning line.

The new blast furnace and coking ovens of Dominion Foundries and Steel, Ltd. (DOFASCO) started up in 1971, and improvements were made in the basic oxygen shop. The Sydney Steel Corp. continued its modernization program, which is expected to cost about $100 million. The Government steel company, Sidérurgie du Québec (SIDBEC) continued its expansion and modernization program, including a new steel-producing plant at Contrecoeur. A metallized pellet facility was being built by Midland-Ross Corp. to supply feed for two new 100-ton electric furnaces scheduled to start up at the end of 1972.

The British Steel Corp., through its subsidiary Stanton Pipes Ltd. entered the Canadian mini-mill steel production by partial ownership of Burlington Steel Co. The works at Hamilton, Ontario, are equipped with three electric furnaces and two continuous-casting units.

Finland.—Rautaruuki Oy, a Government-controlled steel plant, planned additional expansion to double its capacity during the present decade. This was to follow completion of the new cold-rolling and galvanizing mill at Hämeenlinna. Expansion of hot-rolling facilities at Raahe was completed, and the facilities were expected to be used to process the output of a proposed stainless steel shop to be constructed by Outokumpu Oy, also a Government-controlled company.

The new Koverhar steelworks, controlled by the Ovako group, began operations and was expected to have an output of 385,000 tons annually, with about one-third to be exported to Sweden in the form of billets.

France.—Construction of initial sections of the Fos-sur-Mer steel complex continued during the year. An agreement was reached between the Government and Sollac (Wendel-Sidélor) on costs. These were estimated at approximately $1 billion for the period to 1975. A subsidiary of Sollac, Société Lorraine et Meridional de Laminage Continu (SOLMER), would be responsible for the complex. An additional expenditure of about $350 million would be made for the period from 1975 to 1980. Steel capacity was set at 3.9 million tons per year by 1974, and an additional 4 million tons is tentatively set for 1980.

A high-grade steel alloy complex near Fos was planned for by Péchiney Ugine-Kuhlmann. (Ugine-Kuhlmann's merger with Péchiney became official in 1971.) The stainless steel capacity is to be 440,000 tons per year; production is scheduled to start in 1973. Facilities for an additional 200,000 tons of special low-alloy steel will be installed and include a 100-ton ultra-high-power furnace. Investments for these two facilities will exceed $200 million.

Fos will typify the modern coastal steel complex. The Mediterranean port receives 250,000-ton tankers and by the late 1970's will be developed with a minimum of dredging to take ships of over 500,000 deadweight tons.

At Dunkirk, the other large French coastal steelworks, Usinor, awarded an order to a member of the Schneider Group, Société Industrielle Delattre-Levivier, to build a fourth blast furnace. This would have a hearth diameter of 45.93 feet (14 meters), and a daily capacity of 9,000 to 10,000 tons. Three 200-ton oxygen converters also will be installed as a part of the expansion program to bring steel capacity at Dunkirk to approximately 9 million tons by 1975.

The shift in location of and technology in French steelmaking was evident in an October announcement made in Lorraine by the Wendel-Sidélor complex which would eliminate 10,650 jobs by 1975. A large percentage would be made up at the Fos complex. In the 5-year period to 1971, French steel companies fell from 82 to 66, and works in operation from 118 to 99. This was due largely to mergers and elimination of smaller facilities.

Germany, Federal Republic of.—Steel production declined about 10 percent from that of 1970, resulting in the lowest output since 1967. The country was unchallenged, however, for its position as the world's fourth largest steel producer. Raw steel capacity utilization was rated at 70 percent, reflecting in part added capacity of about 5 million tons in 1971.

Capital investment in the industry had been planned for an estimated $690 million during the year, and the reduced steel demand was not expected to hamper further expansion plans and increased exports for the remainder of the 1970's.

Plans for a merger between the country's second largest producer, Hoesch A. G., and Hoogovens of the Netherlands were reported nearing completion. The new combine was to increase production by expansion of the Hoogovens plant at Ijmiden, or by building a new plant at Rotterdam.

Fried. Krupp Hüttenwerke A. G. approved a $125 million investment program calling for a 5,000-ton-per-day blast furnace and a 300-ton steel converter at Rheinhausen. The company's first continuous slab casting facility was completed at this location. Rated at approximately 1 million tons per year, it would supply the Bochum plant.

Mannesmann A.G.'s program included construction of a high-capacity pressurized blast furnace with a hearth diameter of 34 feet at its Duisburg-Huckingen works.

August Thyssen-Hütte A.G. completed a 300-ton steel converter at its Duisburg-Hamborn plant and had a 46-foot-hearth-diameter, 3-million-ton-per-year-capacity blast furnace under construction.

The mini-steelworks at Hamburg-Finkenwerder was near operating stage. Included was a direct-reduction facility using the Midrex (Midland-Ross) process, two 90-ton ultrahigh-power electric arc steelmaking furnaces, and continuous-casting facilities. The plant, with a capacity of 500,000 tons of finished steel products, is owned by the Korf group, and was to operate under the name Hamburger Stahlwerke G.m.b.H.

Greece.—The Ministry of Industry announced that two small steel mills, both with electric furnaces, were authorized for construction. One, a $5.8 million mill, was planned for Stylis, on the eastern coast of Central Greece, and the other, to cost $2 million, for the Patras area.

The Japanese were active in negotiations for participating in the $150 million Hellenic Steel Co. expansion. The additions, to be completed by 1975, would raise the company's employment from 600 to 1,500. Nippon Kokan of Japan announced that agreement in principle was reached for establishing a 1.5-million-ton hot-rolling mill, expansion of existing rolling facilities, and installation of electric furnaces.

India.—The Government licensed nine steel mini-mills in an effort to reduce continuing steel shortages and the necessity for increased imports. The new mills were to have an annual capacity of 30,000 to 100,000 tons each; others expected to be added on a joint government-private basis. The Minister for Steel and Mines expressed hope that enough units of this type could be installed to produce up to 1.5 million tons by 1976. Efficiency of installed steel capacity continued low and the mini-mills were to serve as a stop-gap measure. Two were to use sponge iron to supplement scrap resources.

Labor and technical troubles combined to disrupt the steel industry and production declined despite Government efforts to increase supply. Utilization of public sector steel plants was reported at 59 percent of capacity, with utilization of all installed steel capacity at 67 percent.

Emphasis on construction has been placed on the Bokaro project, Bhilai expansion, and Indian Iron and Steel Co. (IISCO) expansion, by the Steel Ministry to reach the Government's Fourth Plan projected capacity. The first stage of the Bokaro plant was scheduled to start up in 1973, and have a 2-million-ton-per-year production rate; construction would proceed simultaneously on a second stage 4-million-ton section. The Bhilai plant of Hindustan Steel, Ltd., commissioned a 600,000-ton-capacity blast furnace in July. The IISCO steel expansion plan for 300,000 tons added capacity is expected to be completed during the Fourth Plan period.

Italy.—The long-term outlook for growth in steel production appeared good, and expansions were planned and started accordingly. Construction continued in raising the capacity of Italsider's Taranto steel complex from 5 to 11 million tons per year by 1975.

The Piombino plant was to be changed by the Finsider group into a $160 million company jointly owned by Italsider and Fiat, and expanded to meet Fiat's steel needs. Completion of a new oxygen converter gave the plant a 2-million-ton capacity. The new company would be known as Acciaierie di Piombino S.p.a.

A fifth iron and steel center, planned for Southern Italy, in Reggio Calabria Province, was expected to have a steel capacity of 5 million tons per year. Enactment of the Mezzogiorno Development Bill, which provided $11.2 billion for a 5-year industrial expansion program for southern Italy, appeared to guarantee the new center, as well as other plants.

Siderurgia Monfalcone, in the private sector, was to install four more electric furnaces within 2 years. This would give the company a total annual steel capacity of 500,000 tons.

Japan.—After 9 years of high annual growth rates, Japan's steel production was caught in the depressed world steel market, resulting in a 5-percent reduction in the country's output. However, pig iron production increased over that of 1970 by 5.2 million tons. Some furnaces were banked the latter part of 1971 as expected increases in demand failed to materialize, and installation of some new iron and steel facilities were rescheduled.

Late in 1971 the Ministry of International Trade and Industry (MITI) permitted the six major steel companies to apply to the Fair Trade Commission to form a cartel for countering effects of the steel recession. This was approved in December and crude steel production adjustments were made. Cutbacks were in effect in iron ore and ferrous scrap purchases during the year.

In June, MITI established rules for blast furnace construction that permitted a new installation only when an older furnace was shut down. The older furnace could not be refired before 1974. Estimates for production in 1975, based on this decision, placed crude steel capacity at between 160 and 171 million tons, and pig iron at between 125 and 134 million tons.

Agreements were reached by the Japanese on steel exports to the Common Market and United Kingdom. No minimum price requirement was involved. Agreement in principle also was reached with the United States to extend voluntary controls.

Japan was informally requested by the Canadian steel industry to carry out orderly marketing of its steel exports to Canada, and the request was reportedly agreed to. Japan claimed the world's nine largest blast furnaces, ranging in size from 2,705 to 4,197 cubic meters; the latter of which Nippon Kokan's Fukuyama plant was fired in April and had a capacity of 10,000 tons per day.

The first Sendzimir mill to produce 60-inch stainless steel sheets was started up by Nippon Yakin's Kawasaki plant in April. Four other mills were under construction at other sites. These mills are capable of rolling stainless sheets with thickness up to 6 to 7 millimeters.

Mexico.—The final approval for Mexico's long-discussed Las Truchas steel complex was announced by President Echeverría in August, with construction to begin in 1972. The overall project, involving iron mines and a port, as well as a complete steel mill, would be Government-controlled. The Mexican Government and its development bank, Nacional Financiera, would own 76 percent of the shares. Initial ingot production, scheduled for 1975, would be approximately 2 million tons, and eventual capacity in 1978 would be 3 million tons.

It was also announced that the four existing steel mills would not be allowed to expand beyond their expected 1975 steelmaking capacity of 7.2 million tons. Annual capacity expansion plans of the existing industry were as follows: The Fundidora, addition of a basic oxygen plant, and capacity to reach 1.7 million tons of raw steel by 1975; Altos Hornos de México, to increase raw steel capacity to 2.2 million tons by 1972 and 4.4 million tons by 1975; Hojalata y Lámina, S.A., to reach 1.5-million-ton capacity by 1975; Tubos de Acero de México, S.A., capacity increased to 440,000 tons by 1972. The Fundidora conducted negotiations with Ugine-Kuhlmann for starting a Mexican plant to produce stainless steel.

Mexico City was the site of the 11th Latin American Iron and Steel Congress in October, which was attended by about 130 U.S. representatives.

South Africa, Republic of.—Expansion plans of the country's three major steelmakers proceeded on schedule during 1971. The Government-controlled South African Iron and Steel Industrial Corp. Ltd. (ISCOR), largest of the companies, would have the highest expenditure. Major work was in process at Vanderbijlpark, where a $100 million, 80-inch hot-strip mill was to be installed. Ancillary equipment included a continuous annealing line for tinplate products, and an HCl pickling line. ISCOR's new works at Newcastle, estimated to cost over $500 million, was scheduled to roll its first steel in 1973. Planned combined output from plants at Newcastle, Pretoria, and Vanderbijlpark would exceed 7.5 million tons by 1977.

Some shortages developed for steel products during the first half of 1971, but a drop in demand during the latter half enabled most domestic orders to be filled. Essentially all needs are expected to be met on completion of the expansions at Newcastle and Pretoria by 1974.

Spain.—The iron and steel sector was to receive priority, along with other basic industries, under Spain's third development plan (1972–75). Production of steel planned will satisfy 90 percent of domestic requirements. The merger of Unión de las Siderúrgicas Asturianas (UNINSA) and Empresa Nacional Siderúrgica S.A. (ENSIDESA) was expected under the plan, also further coordination among nonintegrated companies.

The Veriña steelworks of UNINSA was inaugurated and the first blast furnace blown in on May 6. Two additional blast furnaces have been scheduled. A 2-million-ton-per-year oxygen steel shop also was commissioned in May. This plant is expected to account for 20 percent of Spain's steel production in 1975. Situated at a deep-water Atlantic port site, it is also expected to be internationally competitive.

The new stainless steel works of Compañia Española para la Fabricacion de Acero Inoxidable (ACERINOX) was under construction with the first stage expected to be producing late in 1972.

Approval was given for a fourth integrated steel plant to be constructed in Sagunto. Annual production would be 5 to 6 million tons; startup will possibly be in 1975.

Sweden.—A number of investments in the iron and steel sector were being carried out; annual investments to 1976 of $130 to $140 million were planned. Labor availability and investment capital were given in a Government report as limiting factors in the expected overall future expansion program.

The Government-owned Norrbottens Järnverk was starting on a modernization program totaling about $83 million over a 4-year period. Included was a new blast furnace to replace the electric smelting furnaces and increase pig iron capacity from 0.6 to 1.8 million tons per year. A new oxygen steel converter was to be installed and replace most of the Kaldo capacity. The new equipment is expected to put the plant on a profitable basis by 1975.

The Gränges Co., formerly Grängesberg Co., started up a new furnace for treating slabs, and a 130-ton ASEA-SKF ladle furnace for making high-quality specialty steel. The company also installed a new version of the SKF melting-refining process at its Nyby Bruk plant, to produce high-quality stainless steel. Details of a new type of quenched and tempered steel plate, and its production at Oxelösund were published.[5] Development work for the process was carried out in the United States by Bethlehem Steel Corp. assisted by the Drever Co. The high-tensile steel is said to have superior qualities and to allow additional weight reductions when used for purposes such as construction and shipbuilding.

United Kingdom.—The British Steel Corp. (BSC) continued with the planned restructuring of its iron and steel industry. Several objectives were being achieved: Uniform systems of financial and management control were being installed in all plants, to include common accounting methods and definition of terms; additional older and uneconomic plants were closed; centralized purchasing and reduction of working capital further strengthened; and product orders were being shifted to the lower cost plants. Plans announced in April called for closing 10 plants affecting 7,255 workers.[6] This was to be accomplished between mid-1971 and 1973. Some of the workers would be utilized at other BSC steel installations. BSC's chairman pointed out that only through continued rationalization and installation of modern plants could it expect to meet the challenge of world competition.

Major construction work in 1971 occurred at Scunthorpe, Teesside, and the Rotherham areas. At Scunthorpe, the Anchor project was on schedule. When completed this will be the largest steel plant in the United Kingdom. New investments here will total about $500 million. In the Teesside area, about $200 million was being invested. Included in the plans was a new deep-water ore terminal at Redcar, and a new oxygen steel plant. In the Rotherham area, capacity of the Templeborough melting shop, largest electric steelmaking facility in the world, was to be increased. With other improvements, investments in the next 5 years for this area are expected to be $120 million. A decision was made to de-

[5] Carden, Philip. New Type of Quenched and Tempered Steel Plate in Production at Oxelösund. Steel Times, v. 199, No. 7, July 1971, pp. 593–597.

[6] Metal Bulletin. Ten Plants To Be Closed. No. 5593, Apr. 23, 1971, p. 29.

velop a deep-water port with an iron ore terminal in Scotland on the Clyde estuary, with a future steelworks in the planning stage.

The Government decided to push for entry into the Common Market during 1971 with mixed reactions in the iron and steel sector. Steel personnel were mostly in favor of the plan, and expected it to be beneficial over the long term for the industry.

The decision to change to the metric system over a 10-year period was made in 1965, and BSC announced that the metric system based on unit of sale of 1,000 kilograms would be used from April 1, 1972, for those products priced by weight.[7] This action was agreed on also by the British Independent Steel Producers Association.

U.S.S.R.—Steel production for 1971 was 133 million tons, exceeding that of the United States by 13 million tons. The Soviet Prime Minister announced that production may reach 165 million tons in 1975, the last year of the current 5-year plan. The previous 5-year plan showed an annual increase of over 5 million tons. The increase was credited by the Director of Technical Sciences largely to building of new facilities. In an article touching on all phases of the Soviet iron and steel industry, he reported that priority would be given to rolled sheet, with production of cold-rolled sheet to rise by 67 percent during the next few years.[8] This will call for a number of new rolling mills to be built.

Pig iron production in the U.S.S.R. was covered for the period from World War II in a summary of a Soviet "Industrial Series," 1971, pamphlet.[9] A 5,000-cubic-meter blast furnace was reported in the process of development. This would be located in the Novolipzek steel combine.

The first vacuum steel-melting plant began operating in Gorki during the year. Production of steel pipe, using a modified continuous-casting process was being carried out at the works in Tula, Central Europe. Cost savings over the standard method were reported as 13 percent.

The Soviet Minister of Metallurgy announced that an agreement had been reached between the U.S.S.R. and Japan, following a meeting with Japanese steel executives, to exchange technical information on steelmaking. Meetings were to be held periodically. Discussions would include possibilities for joint technology development programs, as well as data exchange.

TECHNOLOGY

Blast Furnace.—The economics involved in the future of the blast furnace—BOP method of steelmaking were compared with direct reduction—electric furnace production in two publications.[10] Comparisons made for United Kingdom conditions indicated the blast furnace to have the highest economic advantage when producing about 3 million tons per year or more of hot metal. Under coke and electricity costs prevailing at the time, and assuming coke continued to be available, the blast furnace was expected to remain as the principal hot-metal-producing process for two or three decades in all major steel-producing countries.

A 10,000-ton-per-day blast furnace was placed in production at the Fukuyama works of Nippon Kokan (NKK). This had a volume of 4,193 cubic meters and a hearth diameter of 13.8 meters, or 45.3 feet. The furnace, approximately 318 feet high, would operate at a top pressure of 35.5 pounds per square inch. Other units approximating this size were under construction or planned and would replace some of the smaller blast furnaces in Japan.

Blast furnace construction costs have been given as the major stumbling block to more steel capacity in the United States. For maximum efficiency, a proposal was made to install a battery of large blast furnaces as a common source of hot metal in major use areas. This would be backed by several steelmakers.[11] The arrangement

[7] Steel Metrication Bulletin. British Steel Corp., (London), June 1971, 8 pp.

[8] Shalimov, Anatoly. Technical Level of the Soviet Iron and Steel Industry. Iron and Steel Eng., v. 48, No. 11, November 1971, pp. 41–49.

[9] Intermet Bulletin. Development of Pig Iron Production in USSR. V. 1, No. 3, January 1972, pp. 35–39.

[10] Berczynski, Frank A. The Blast Furnace—The Old Girl's Alive and Kicking. Blast Furnace and Steel Plant, v. 59, No. 3, March 1971, pp. 154–160.

Cartwright, W. F. The Economic Survival of the Blast Furnace. J. Iron and Steel Inst., February 1971, pp. 89–95.

[11] Iron Age. Blast Furnace Complex: Steelmaking's Next Step? V. 207, No. 23, June 10, 1971, p. 71.

could be similar to arrangements now existing to supply pelletized ore on a partial ownership basis from large pellet plants.

Development of the blast furnace and its present-day basic concepts were considered along with engineering design problems of the larger blast furnaces in a publication covering proceedings of the conference held in the Netherlands in April 1970.[12]

Bethlehem Steel Corp. completed its second large blast furnace at Burns Harbor, Ind. The new furnace, with a hearth diameter of 38 feet, 3 inches, is the largest in the Western Hemisphere. U.S. Steel Corp. started construction on a furnace at its Gary, Ind., works which would have a capacity of 10,000 tons per day.

A paper presented at the British Iron and Steel Research Association (BISRA) 38th Blast Furnace Conference in England was published. It discussed alternative methods for producing solid fuel for the blast furnace.[13] The author narrows the choice for practical purposes to three: the Bergbau-Forschung, the FMC, and a Soviet process.

Shortage of coking coals and air pollution problems of present-day coke ovens have been of major concern in future operation of the blast furnace. Successful large-scale blast furnace tests in the use of formed or briquetted coke were reported in the United Kingdom and West Germany. Average weight ratios of coke consumed in blast furnaces to pig iron produced in 1971 were 0.451 for Japan and 0.627 for the United States.

Basic Oxygen Process (BOP).—Steel produced by the BOP in 1971 was 53.1 percent of the domestic total, exceeding the 50-percent mark for the first full year. Capacity throughout the world continued to increase; 42 million short tons was added in 1971. Five million of this was credited to the United States, and 17 million to Japan, giving yearend capacities of 78 million and 106 million tons, respectively. According to the latest Kaiser Engineers' survey, the world total amounted to 338 million tons.[14] An additional 117 million tons was scheduled, of which BSC accounted for approximately 10 percent.

The basic oxygen converter was scheduled to replace one of the world's few Kaldo operations, that of Norrbottens Järnverk Aktiebolag in Luløa, Sweden, as the plant began a modernization program.

A modified basic oxygen process developed in West Germany by Eisenwerk-Gesellshaft-Maximilianshüette m.b.H. (Maxhutte) and used in Europe for several years was introduced in the United States by Pennsylvania Engineering Corp. and the U.S. Steel Corp. The process, known as the OBM process, involves oxygen and hydrocarbon gas injection through the bottom tuyeres of the Bessemer or Thomas converter. Modified by U.S. Steel to include larger capacity converters than used in Europe, the process has been named the Q-BOP process. The first U.S. installation will be at the Fairfield, Ala., works of U.S. Steel where two 200-ton converters are scheduled.[15] Additional scrap usage and reduced refining time are two advantages claimed over regular BOP processing.

Bethelehem Steel Corp. patented a rapid method of sampling and temperature measurement in the BOP converter which involved an auxiliary lance. End-point corrections were said to be reduced and accuracy improved.

Experimental results of bottom injection of oxygen and powdered lime in an experimental converter to refine high-phosphorus pig iron indicated low-phosphorus content in the resulting metal and high P_2O_5 content in the slag. A single slag was possible, and the process was said to have some advantages over top-lancing practices.[16]

Electric Furnaces.—The electric furnace continued to increase its share of domestic steelmaking; 17.4 percent was produced by this method in 1971, compared with 15.3 percent in 1970. Total U.S. electric furnace capacity was estimated at 25 million short tons per year. In Japan, 17.7 percent of that country's steel production came from electric furnaces, compared with 16.7 percent in 1970. Planned Japanese expansion indicated that between JFY 1970/71 and 1975/76, 127 new electric furnaces would be

[12] Iron and Steel Institute. Proc. Engineering Design Problems of Large Iron- and Steelmaking Furnaces, Noordwijk aan Zee and Ijmuiden, Netherlands, Apr. 9–10, 1970. ISI Pub. 136, 1970, 139 pp.
[13] Barker, J. E. Possible Alternative Methods for the Manufacture of Solid Fuel for the Blast Furnace. J. Iron and Steel Inst., February 1971, pp. 100–108.
[14] Stone, J. K. Worldwide Round/Up of BOF Installations. 33 Magazine, December 1971, p. 48.
[15] Chemical Engineering. And U.S. Steel Will Be the First User of a German-Derived Steelmaking Method. V. 78, No. 29, Dec. 27, 1971, p. 18.
[16] Shenouda, F., E. Förster, H. Richter. Refining of High-Phosphorus Pig Iron by a Bottom Injection of Oxygen and Powdered Lime. Iron and Steel, v. 44, No. 3, June 1971, pp. 167–172.

installed with a total capacity of 16.5 million tons per year; 80 older units, with a combined annual capacity of 3.7 million tons, were to be taken out of service.

Major U.S. electric furnace startups during the year were U.S. Steel's Texas works with two 200-ton furnaces, Armco's Houston works with two, 175-ton furnaces, and addition of a 150-ton furnace for Timken at its Canton, Ohio plant. The largest operating electric furnace, 400 tons, began producing at the Sterling, Ill., works of Northwestern Steel & Wire Co.

The increasing use of and advancements in the electric furnace for steelmaking was brought out at the International Congress on Electric Arc Furnace in Steelmaking, held in Cannes, France in 1971.[17] Specific advancements discussed included design development allowing furnace capacities of up to 400 tons; new control techniques, with use of electronic computers; advanced transformer technology allowing higher power inputs; relative reduction in cost of electric power; and development in fields of electrodes and refractory products. Also discussed were Armco's new electric furnace shop at Houston, and BSC's Templeborough electric shop, already the world's largest, which would have additional capacity. Some improvements in furnace design noted included continuous charging systems, slanted electrodes for better power, and coatings for electrodes to decrease electrode consumption.

Electric steelmaking furnace research underway by BSC included a new arc initiation technique, which depends on bridging the arc gap with a seeded gas flame rather than mechanical contact, heat transfer mechanisms in arcs, and the influence of slags on arc characteristics.

Indications pointed to increasing electric furnace steelmaking capacity throughout the world for the next decade. Several factors, including adaptability to limited production at relatively lower capital and operating costs, and pollution control capabilities favor this method of steelmaking in many areas. The place of the small or mini-steelworks in the world and circumstances under which they are preferred was discussed by the deputy director of BSC in his delivery of the 22d Hatfield Memorial Lecture, University of Sheffield, December 9, 1971.

Iron and Steel Refining.—Electroslag remelting (ESR), after being favored in the U.S.S.R. for many years, began to be installed in the United States, replacing some air-melting and vacuum-degassing operations. Carpenter Technology Corp. started up two units designed to produce higher quality special steels.[18] Estimates for 1970 placed 80 percent of the world capacity in the U.S.S.R. and 10 percent in the United States.

Electron beam (EB) refining secured a start in domestic specialty steel production. Airco, for the second year, operated its EB facility using continuous hearth refining. The Cyclops Corp., Universal-Cyclops Specialty Steel Div., placed electron-beam-refined stainless steel products on the market in standard forms for the first time. Another division of Cyclops was manufacturing and marketing tubing from stainless produced by the EB method.

Modifications were made to the ASEA-SKF steel refining process to improve operation, including induction stirring and visual control. Additional capacity was installed during the year in Europe. Operation of a refining plant in Sweden using this process was described in a paper.[19] Larger sized vacuum refining equipment for conventional processing continued to be installed to replace older units and in new producing facilities. A review of the principal processes and installations were presented.[20] The Argon-oxygen decarburization (AOD) process developed by Union Carbide and Joslyn's Stainless Steels Div., received an increasing amount of publicity as additional units began operation. Five domestic plants and five foreign plants had a startup date of 1971; at least seven additional plants were expected to begin in 1972. A large percentage of the stainless steel made in the United States is expected to be refined by this process, which has been proven in several commercial operations during the past year.

Direct Reduction.—A second metallized pellet plant started operating in the

[17] Congrès International sur le Four électric à Arc en Aciérie. (International Conference on the Electric-Arc Furnace in Steelmaking) Cannes, France, June 7–9, 1971, 500 pp.

[18] McManus, G. J. Tool Steels Take the ESR Route. Iron Age, v. 208, No. 13, Sept. 23, 1971, pp. 55–57.

[19] Grevillius, N., P. Geete, and T. Krey. Operational Experience of the ASEA-SKF Ladle Furnace Process at Bofors Steelworks. Pres. at 28th Annual Electric Furnace Conference, AIME, Dec. 9–11, 1970, Pittsburgh, Pa. 14 pp.

[20] Leach, J. C. C. Vacuum Degassing and Secondary Refining of Steel. Iron and Steel, v. 44, No. 2, April 1971, pp. 105–114.

United States at Georgetown, S.C. Rated at 400,000 tons per year, the plant, operated by Midland-Ross Corp., was to serve as a source of melting stock for the adjoining electric furnace steelmaking plant of Korf Industries. Midland-Ross began construction of another metallized pellet plant at Contrecoeur, Canada. This also would supply 400,000 tons of metallized product as part of the steelmaking operation owned by Sidérurgie du Québec (SIDBEC).

Swindell-Dressler Co. was constructing a plant in Brazil using the HyL process. The plant, near Salvador, would be part of an integrated steelworks owned by Usina Siderúrgica da Bahia, S.A. (USIBA), and would have an initial capacity of 200,000 per year. Another plant, Aços Finos Piratini S. A., at Charqueadas, would produce, by the SL/RN process, approximately 65,000 tons per year in a new special steel plant to start operations in 1973.

Engineers of Hojalata y Lámina, S.A., published test results demonstrating the suitability of the HyL sponge iron product as a coolant in BOF steelmaking.[21]

U.S. Steel Corp.'s direct reduction plant in Venezuela was scheduled to start production during the year. The chairman of the board of U.S. Steel reported that the Orinoco plant, said to be the largest direct reduction facility in the world, would produce briquets to be converted into steel at the company's plants in Texas and Pennsylvania.[22]

The United Nations, under the auspices of Economic Commission for Europe (ECE), scheduled a seminar on the economic aspects of direct reduction to be held in Romania in 1972. One session would cover the place of direct reduction in iron and steelmaking.

Continuous Casting.—Two plants in the United States completed continuous-casting facilities during the year, and several others had construction underway or in the planning stage. Bethlehem Steel Corp. announced that its Burns Harbor plant would install the company's first continuous slab casting machine. U.S. Steel Corp. completed slab-casting facilities at its Baytown, Tex., installation and reported production records for the new Gary, Ind., slab caster. Startup of Armco Steel Corp.'s slab caster at the Butler, Pa., works was covered in an article.[23] Lukens Steel Co. operated its new $12.8 million slab-casting facility to produce sizes as large as 85 inches wide by 12 inches thick. High-strength and alloy steels were successfully cast on production basis, as well as carbon steels. Startups of new strands were announced in many of the other major steel-producing countries of the world. New machines were completed at three Italian, three West German, and four Japanese steelworks. Additional capacity also was scheduled to start up during the year in France, Spain, Portugal, Greece, and Finland. Total world capacity was estimated to be approximately 40 million tons; continuous-cast steel represented 6 to 8 percent of the world's raw steel production.

Nippon Kokan of Japan reported a new method of adding aluminum to the ladle for continuous casting. High-speed wire addition combined with bottom injection of inert gas was said to reduce aluminum consumption by 50 percent.

Thin-slab continuous casting for direct hot rolling to produce quality steel strip was promised by Continuas of Italy. A new machine offered by the company would produce slabs as thin as 25 millimeters and allow bypassing of the blooming mill.[24]

A horizontal process to continously cast steel developed in the United Kingdom was operated on a pilot scale. Advantages of height reduction and simplified design were cited for commercial use.[25]

The status of the Hazelett continuous-casting process was reviewed, including a feasibility study to use a pressure pouring furnace in connection with the caster. The latter was carried out by Oregon Steel Mills.[26]

Powder Metallurgy.—Forecasts of additional domestic iron powder growth were made with the commercial acceptance of powder metal (PM) forging. Growth rate for conventional ferrous PM parts, as anticipated by a vice president of Hoeganaes

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[21] Peña, J. M. and D. Radke. HyL Sponge Iron As a Coolant in BOF Steelmaking. J. Metals, v. 23, No. 8, August 1971, pp. 27–32.

[22] Chemical and Engineering News. Direct Iron Reduction. V. 49,No. 19, May 10, 1971, p. 55.

[23] Todd, David E. Design and Start-Up of 2-Strand Slab Caster at Armco's Butler Works. Iron and Steel Eng., v. 48, No. 10, October 1971, pp. 48–53.

[24] 33/Magazine. Continously Cast Thin Slab Feeds Direct to Hot Strip Mill. V. 9, No. 1, January 1971, pp. 51–58.

[25] Marsh, J. A New Horizontal Continuous Casting Process for Steel. Steel Times, v. 199, No. 6, June 1971, pp. 515–521.

[26] Wood, J. F. B., and P. C. Regan. The Hazelett Continuous Casting Process. Iron and Steel Eng., v. 48, No. 12, December 1971, pp. 47–55.

Corp., would be about 10 percent per year to 1980, reaching 210,000 tons annually. PM forging was expected to raise this an additional 100,000 tons.[27] Total iron powder production in the United States and Canada was approximately 120,000 tons in 1971.

Interlake, Inc., increased its ownership in Hoeganaes Corp., Riverton, N.J., to 80 percent by acquiring an additional 13⅓-percent interest in the company. The remainder was held by Hoeganaes Aktiebolag of Sweden.

A review of PM development in the United States was presented at a symposium on high-performance metals at the U.S. Trade Center in London.[28] An increasing interest in alloy steel powders and special tool steel powders was noted. The automotive field was pointed out as a major area of PM application for hot forgings.

Expansion of iron powder facilities occurred in Japan at the Chiba works of Kawasaki Steel, where monthly output was being expanded to 1,500 tons. Kobe Steel was to raise capacity at its Iwaya works from 100 to 450 tons per month. Kobe produces powder under a license agreement with A.O. Smith-Inland, Inc.

Research and development has played a major role in elevating iron powder metallurgy from a simple press and sinter operation to processing methods that offer opportunities for producing both conventional and complex components in many industrial areas.

Foundry.—Capital spending in the domestic foundry industry increased each year for the 10-year period prior to 1971, with expenditures of $180 million in 1961 and $1,110 million in 1970. Of the 1961 total, approximately 25 percent was for new plants and additions, and 75 percent for new machinery and equipment; in 1970, the percentage was 35 and 65 percent, respectively.[29] Iron and steel castings account for approximately 90 percent of foundry production; the remainder was nonferrous metals.

Foundry trends continued to be toward larger plants with increasing capacities, and away from smaller installations. The new foundry facility of Ford Motor Co. at Flat Rock, Mich., started pilot operations prior to full-scale production. To be known as Ford's Michigan Casting Center, it has been described as the largest casting facility in the world, and to represent the largest single-plant investment in the history of the company. Major items of equipment are six 50-ton electric-arc furnaces for melting and five 80-ton holding furnaces. The melting furnaces, with a capacity of about 3,000 tons per day, will be computer controlled and initially are expected to use 100 percent scrap. Ford also plans an expansion at its Cleveland foundry to produce castings for small car engines. Plant startup was expected by 1973; the project will increase the number of workers by 575.

Ductile iron has shown a steady growth rate over the past few years, and forecasts indicate that this will continue. The technical director of the Malleable Founders Society, at its annual meeting, reported on a new process for making ductile iron from malleable base iron that is 40 to 50 percent cheaper than conventional methods.[30] The process, developed in Switzerland, treats iron in a converter that has a chamber in the bottom to hold magnesium. Another development from Sweden involves magnesium addition in a treatment ladle by means of sponge iron briquets that incorporate pure magnesium. The product has a delayed reaction time, as the magnesium vaporizes and is dispersed through the pores of the briquet into the metal. A new nodularizing agent, developed by U.S. Pipe and Foundry Co., was offered by Union Carbide's Ferroalloy Division. The alloy, called Remag, contains both magnesium and rare-earth elements in a composition to give effective nodular treatment with a minimum of reactivity and vibration.

Results of a study relating to the costs and the economic impact of air pollution controls on gray iron foundries were published by the U.S. Department of Health, Education, and Welfare.[31]

A new edition of the Iron Castings Handbook was issued by the Gray and Ductile Iron Founders' Society which con-

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[27] Iron Age. PM Forging Logjam Starts to Break Up. V. 208, No. 20, Nov. 11, 1971, pp. 64–65.

[28] Knopp, Walter V. US Powder Metal Progress. Metal Bull. Monthly, No. 8, August 1971, pp. 37–40.

[29] Industry Week. Whatever Happened to Iron? V. 170, No. 2, July 12, 1971, pp. 33–39.

[30] Herrmann, Robert H. 1971 Annual Meeting-Malleable Founders Society. Foundry, v. 99, No. 7, July 1971, pp. 100–103.

[31] U.S. Department of Health, Education, and Welfare. Economic Impact of Air Pollution Controls on Gray Iron Foundry Industry. Nat. Air Pollution Control Admin. Pub. AP-74, November 1970, 124 pp.

tained an added chapter on Metallurgy of Cast Iron.[32]

Research and Development.—Investigations at Bureau of Mines research installations included projects on continuous electric furnace steelmaking, ferrous metal recovery from urban refuse, removal of copper from molten ferrous scrap, production of ductile iron from shredded scrap, and separation of coke from blast furnace dusts.

Progress was reported on continuous steelmaking at the Albany Research Center.[33] A stationary arc furnace was used in continuously making both carbon and low-alloy steels. Recovery of mineral values from urban refuse was demonstrated at the College Park Research Center pilot plant in College Park, Md. Recoverable ferrous metal in a ton of residue amounted to 610 pounds.

The Director of the Bureau of Mines, in a speech at an AISI meeting, called for increased emphasis on research and development in the steel industry to help meet foreign competition. He also announced the signing of a contract with the National Academy of Engineering to review the laboratory research programs of the Bureau. A review committee, reporting to the Secretary of the Interior, would make periodic recommendations on modifications, extensions or other changes in projects.[34]

The University of Alabama added new foundry facilities costing in excess of $500,000 to allow expansion of research and instruction. Included in the new programs was industrial research of foundry problems.

In the private sector, the AISI, as well as individual steel companies, supported projects in steelmaking at several universities. The major steelmakers continued research in company laboratories, but an overall reduction in both personnel and projects occurred in the industry as part of a general austerity program.

General Motors Corp. was developing its Oldsmobile Division's new process for converting in-plant scrap into hot metal, and continously casting the metal into horizontal molds. Vacuum degassing and bars cast directly to forging stock size has been used to produce ring gears and other car parts by its XTruCast method. The Institute of Scrap Iron and Steel, through its Scrap Metal Research and Education Foundation, joined with the Division of Solid Waste Management, Department of Health, Education, and Welfare, to fund a project at Battelle Memorial Institute. This was designed to identify problems preventing efficient recycling of an estimated 20 million junked cars, defunct home appliances, and metal containers, and to come up with new ways to get the scrap off the landscape and into the steel mill furnaces.[35]

Two continuous steelmaking processes were being actively developed. IRSID's process operated during the year in a 500-ton-per-day plant at the Hagondage, France, steelworks of Wendel-Sidélor. The British Iron & Steel Research Association (BISRA) spray steelmaking project was still being funded, and various phases of the process studied at the Sheffield, England, laboratories.

Research was directed toward producing higher quality steels that are free of all inclusions in several European research centers. In Japan the Nippon Steel Corp. was reported as planning a force of 2,000 scientists in its new research center. The use of nuclear energy in steelmaking continued to attract attention in Japan and West Germany, where iron production was proposed using helium heat transfer from gas-cooled reactors prior to its use for power generation.

The United Nations published a survey of important steel technologies of recent years, and some of the new properties introduced in steel products.[36]

Pollution Control.—Control of emissions from iron and steel plants was a topic of interest in all major producing countries. In the United States it was the subject of numerous articles which set forth the problems and possible solutions.[37] Laws in

[32] Gray and Ductile Iron Castings Handbook. 1971, 679 pp.

[33] Bureau of Mines Research 71. Continuous Electric Furnace Steelmaking, pp. 23,24.

[34] Research/Development. Steel Industry is Dragging Its Heels in Research, U.S. Bureau of Mines Director Charges. V. 22, No. 12, December 1971, p. 6.

[35] Blast Furnace and Steel Plant. Reclaim Metal Resources. V. 59, No. 2, February 1971, p. 77.

[36] United Nations. Development of Production Technology and New Properties of Steel Products, 1970. No. E. 70 II. E. 7, 1971 (price $1.00), 49 pp.

[37] Bramer, Henry C. Pollution Control in the Steel Industry. Environ. Sci. & Technol., v. 5. No. 10, October 1971, pp. 1004–1008.

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general were being passed and standards set by local and State Governments. However, Federal Standards for particulate matter in the atmosphere were applied in 1971 by the Environmental Protection Agency (EPA) under the Clean Air Act of 1970. A Federal court order directed 23 companies in the Birmingham, Ala., area to temporarily curtail air-polluting operations after the danger level was reached. About one-half of the operators were involved in making iron and steel, or products therefrom. The shutdown was the first under the act, and was short-lived, but it indicated the necessity for proper environmental protection facilities throughout the industrial community of the United States.

AISI reported that $161.6 million was spent by the domestic steel industry in 1971 for air and water pollution control, about evenly split between the two. Budgeted for future facilities in 1972 and beyond by the steel industry was $320.3 million. To keep the installed facilities operating and maintained was expected to require about 12 percent annually of the original cost.

In other countries, concern over pollution by the iron and steel operations depended largely on the locations of the particular plants and number of people directly affected. In general, isolated operations were not being pressured into making changes. In populated areas such as the West German steel centers, pollution was being carefully watched by both the authorities for compliance with regulations and the operators to prevent penalties from being imposed. In the United Kingdom, stricter laws were expected in the future. In Japan, growing public concern over pollution was reported, and measures were taken by both industry and the Government to cope with the situation. Agreements were being reached between local governments and the steel corporations owning plants to cut the discharge of sulfur dioxide. About $167 million was spent in 1971 on control facilities by the steel industry.

In the Netherlands, the city of Rotterdam prevented an effort by Hoogovens and Hoesch to build a steel mill on reclaimed land in Europort because of possible pollution. The French Government adopted a series of measures to detect and control pollution at the new Fos steel project.

The ECE held a seminar on air and water pollution arising in the iron and steel industry, at Leningrad, U.S.S.R., in August. A number of papers were presented.

Table 2.—Pig iron produced and shipped in the United States, in 1971, by State

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces	
		Quantity	Value
Alabama	3,946	3,862	$263,696
Illinois	6,500	6,466	446,534
Indiana	12,695	12,740	895,737
Ohio	13,703	13,739	1,014,840
Pennsylvania	18,812	18,819	1,288,740
California, Colorado, Utah	4,492	4,499	321,489
Kentucky, Maryland, Texas, West Virginia	9,772	9,808	695,489
Michigan, Minnesota	7,283	7,281	496,453
New York	4,179	4,118	289,063
Total	81,382	81,332	5,712,041

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	1970 [1]	1971 [2]
Australia	526	729
Brazil	r 751	62
Canada	r 1,903	1,677
Chile	r 1,123	370
Venezuela	5,012	4,376
Other countries	r 904	198
Total	r 10,219	7,412

r Revised.
[1] Excludes 22,489 tons used in making agglomerates.
[2] Excludes 18,466 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	1970			1971		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1,780	$110,281	$61.96	1,902	$128,480	$67.56
Basic	r 86,090	r 5,603,005	r 65.08	75,804	5,324,194	70.24
Bessemer	1,346	88,772	65.95	1,295	91,916	70.98
Low-phosphorus	131	8,718	66.55	153	10,900	71.24
Malleable	1,548	95,763	61.86	1,935	139,502	72.09
All other (not ferroalloys)	377	23,932	63.48	243	17,049	70.16
Total	r 91,272	r 5,930,471	r 64.98	81,332	5,712,041	70.23

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, 1971			Jan. 1, 1972		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	11	8	19	8	8	16
California	4	--	4	4	--	4
Colorado	4	--	4	4	--	4
Illinois	13	6	19	13	6	19
Indiana	21	4	25	18	7	25
Kentucky	2	--	2	2	--	2
Maryland	8	2	10	4	6	10
Michigan	9	--	9	8	1	9
Minnesota	1	1	2	1	1	2
New York	9	6	15	6	9	15
Ohio	27	17	44	22	21	43
Pennsylvania	33	22	55	26	29	55
Tennessee	--	--	--	--	--	--
Texas	2	--	2	1	1	2
Utah	3	--	3	2	1	3
West Virginia	3	1	4	4	--	4
Total	150	67	217	123	90	213
Ferroalloy blast furnaces	2	--	2	3	--	3
Grand total	152	67	219	126	90	216

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	Iron and manganiferous ores: 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
1970:																
Alabama	1,482	W	4,632	7,741	137	9	r 7,887	3,519	800	4,654	1.663	0.029	0.002	r 1.695	0.756	0.172
Illinois	W	--	10,270	r 11,771	203	337	12,311	4,551	1,439	7,388	r 1.593	.027	.046	r 1.666	.616	.195
Indiana	W	W	18,415	20,585	281	533	21,399	7,618	1,720	13,348	1.542	.021	.040	1.603	.571	.129
Ohio	3,921	861	19,095	r 23,242	775	1,440	r 25,457	10,101	3,177	r 15,411	r 1.508	r .050	r .093	r 1.652	r .655	r .206
Pennsylvania	5,544	r 3,783	r 22,968	r 31,541	884	1,714	r 34,139	13,132	2,866	20,793	r 1.517	r .043	.082	r 1.642	.632	.138
California, Colorado, Utah	r 3,456	W	W	r 8,656	68	148	r 8,872	3,097	860	5,150	r 1.681	.013	.029	r 1.723	.601	.167
Maryland, West Virginia, Kentucky, Texas	W	W	13,837	r 16,969	298	998	r 18,265	7,133	1,287	11,451	r 1.482	.026	.087	r 1.595	.623	.112
Michigan and Minnesota	923	W	10,714	11,317	214	260	r 11,791	4,701	1,437	7,550	1.499	.028	.034	1.562	.623	.190
New York	1,755	89	W	8,856	185	250	9,291	3,472	805	5,548	1.596	.033	.045	1.675	.626	.145
Total	r 21,507	r 10,219	r 112,421	r 140,678	3,045	5,689	r 149,412	57,324	[4] 14,391	r 91,293	r 1.541	.033	.062	r 1.637	r .628	r .158
1971:																
Alabama	810	W	4,140	6,480	124	9	6,613	3,001	792	3,946	1.642	0.031	0.002	1.676	0.761	0.201
Illinois	W	--	8,970	10,225	171	229	10,625	4,072	1,132	6,500	1.573	.026	.035	1.634	.626	.174
Indiana	W	W	17,950	19,392	329	670	20,391	7,014	1,532	12,695	1.528	.026	.053	1.606	.553	.121
Ohio	3,666	715	16,820	20,682	565	1,412	22,659	8,922	2,725	13,703	1.509	.041	.103	1.654	.651	.199
Pennsylvania	5,608	3,201	20,357	28,527	812	1,343	30,682	11,775	2,446	18,812	1.516	.043	.071	1.631	.626	.130
California, Colorado, Utah	2,301	W	W	7,492	59	132	7,683	2,738	715	4,492	1.668	.013	.029	1.710	.610	.159
Maryland, West Virginia, Kentucky, Texas	W	W	13,412	14,982	184	773	15,939	6,102	984	9,772	1.533	.019	.079	1.631	.624	.101
Michigan and Minnesota	497	W	10,660	10,924	227	133	11,284	4,540	1,300	7,283	1.500	.031	.018	1.549	.623	.178
New York	1,444	107	W	6,555	179	165	6,899	2,630	688	4,179	1.569	.043	.039	1.651	.629	.165
Total	17,542	7,836	102,675	125,259	2,650	4,866	132,775	50,794	[5] 12,314	81,382	1.539	.033	.060	1.632	.624	.151

r Revised.

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

[1] Net ores and agglomerates equal ores 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: 7,417 limestone, 6,235 dolomite, and 739 other fluxes excluding 4,679 limestone, 3,503 dolomite, and 175 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: 6,211 limestone, 7 burnt lime, 5,736 dolomite, and 360 other fluxes excluding 4,154 limestone, 3,166 dolomite, and 139 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]	Bessemer	Basic oxygen process	Electric	Total
1967	70,690	(3)	41,434	15,089	127,213
1968	65,836	(3)	48,812	16,814	131,462
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

[1] Excludes castings produced by foundries not covered by AISI.
[2] Basic and acid open hearth production data reported separately in previous years.
[3] Included with "Open hearth."
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			
1967	954	2,905	600	378	80,404	1,818	65,027
1968	958	2,514	684	337	79,948	1,676	67,281
1969	710	2,121	487	512	84,187	1,775	74,343
1970	502	1,889	465	476	r 81,797	1,641	66,451
1971	308	1,166	294	320	74,059	1,447	63,308

r Revised.
[1] Basic oxygen converter, open-hearth furnace, and electric furnace. Bessemer included in 1967 only.
[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	1969		1970		1971	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	r 48,610	r 54.1	r 51,730	r 59.8	52,023	66.2
Open hearth	r 37,976	r 42.2	r 32,204	r 37.2	23,574	30.0
Electric	332	.4	453	.5	825	1.1
Cupola	2,911	3.3	2,076	2.4	1,865	2.4
Air	92	.1	94	.1	60	.1
Other furnaces [2]	3	--	10	--	204	.3
Total	r 89,924	100.0	r 86,567	100.0	78,551	100.0

r Revised.
[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes vacuum melting furnaces and miscellaneous melting processes.

Table 10.—Average value of pig iron at blast furnaces in the United States, by State

(Per short ton)

State	1971
Alabama	$68.29
California, Colorado, Utah	71.46
Illinois	69.06
Indiana	70.31
New York	70.19
Ohio	73.87
Pennsylvania	68.48
Other States [1]	69.75
Average	70.23

[1] Includes Kentucky, Maryland, Michigan, Minnesota, Texas, and West Virginia.

Table 11.—Consumption of pig iron [1] in the United States, by State

(Thousand short tons)

State	1971
Alabama	3,445
Connecticut	18
Delaware	(2)
Georgia	8
Illinois	6,376
Indiana	12,776
Iowa	25
Kansas	2
Kentucky	1,611
Louisiana	(2)
Maine	(2)
Massachusetts	17
Michigan	7,185
Missouri	17
Montana	(2)
Nebraska	(2)
Nevada	(2)
New Jersey	55
New York	3,734
North Carolina	5
Ohio	13,401
Oklahoma	5
Oregon	(2)
Pennsylvania	19,387
Rhode Island	5
Tennessee	95
Texas	636
Vermont	4
Washington	(2)
Wisconsin	117
Undistributed [3]	12,254
Total	81,178

[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 12.—U.S. exports of major iron and steel products

Products	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 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.	5,880	$699	4,462	$729	8,643	$1,015	11,425	$1,721	2,153	$353
Blooms, billets, ingots, slabs, sheet bars, and roughly forged pieces	302,498	26,330	551,708	48,201	1,810,490	142,767	r 3,169,563	270,368	873,503	78,188
Coils for rerolling	60,486	34,446	50,432	26,987	421,531	61,911	340,630	49,903	14,347	7,646
Blanks for tubes and pipes, iron or steel	1,453	251	2,095	241	12,159	1,400	2,175	280	2,334	271
Total	370,317	61,726	608,697	76,158	2,252,823	207,093	r 3,523,793	322,272	892,337	86,458
Bars, rods, angles, shapes and sections:										
Wire rods	7,107	1,598	12,317	2,316	r 98,245	r 16,348	r 151,062	r 18,541	62,843	8,415
Bars, rods, and hollow-drill steel	78,857	26,193	100,200	28,251	215,674	51,797	216,362	48,415	129,796	38,516
Concrete reinforcing bars	21,577	2,904	26,097	3,903	86,762	11,592	r 92,534	r 12,134	40,540	6,089
Angles, shapes, and sections	113,789	18,454	121,899	20,757	170,424	29,261	r 212,405	r 37,554	163,941	31,093
Plates and sheets:										
Steel plates	15,622	8,517	15,584	7,878	25,441	12,603	27,011	14,021	23,353	12,062
Steel sheets	138,591	41,895	273,043	49,486	1,040,381	146,923	r 1,268,386	r 190,079	581,366	82,812
Black plate	19,854	1,895	27,867	3,097	49,723	6,789	r 67,931	r 9,133	85,202	13,527
Iron and steel plates, n.e.c.	254,410	53,725	209,269	43,628	403,715	66,152	r 292,803	r 56,835	161,921	37,492
Tinplate and terneplate	283,542	42,246	293,265	44,550	339,606	52,264	341,275	61,844	224,120	43,101
Tinplate circles, cobbles, strip and scroll	15,380	1,485	15,267	1,405	26,080	2,577	23,910	2,628	9,716	1,186
Hoop and strip	56,874	28,071	56,022	26,456	r 111,595	38,160	r 376,068	r 73,311	129,128	42,619
Total	r 1,005,603	226,983	1,150,830	231,727	r 2,567,646	r 434,466	r 3,069,747	r 524,495	1,611,926	316,912

See footnote at end of table.

Table 12.—U.S. exports of major iron and steel products—Continued

Products	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
MANUFACTURED										
Rails and railway track construction materials:										
Rails	21,617	$3,211	61,654	$8,908	56,105	$7,903	63,980	$10,143	50,291	$8,489
Joints and tie plates	8,605	1,820	11,052	2,149	8,323	1,585	7,976	1,620	12,613	2,563
Sleeper and track material of iron or steel, n.e.c.	2,126	1,304	16,820	5,603	8,708	3,507	9,873	4,104	4,599	2,073
Wire, cables, ropes, bands, and slings	49,099	25,971	63,710	28,960	r 82,480	r 37,172	72,868	r 38,479	62,746	38,282
Tubes, pipes, and fittings:										
Cast-iron pressure pipe and fittings	r 31,546	r 6,991	30,821	9,328	22,782	6,639	22,034	8,173	15,481	8,095
Cast-iron soil pipe and fittings	33,026	6,325	18,277	3,992	9,637	2,701	11,537	3,690	8,288	2,813
Steel tube and pipe fittings, unions, and flanges	17,189	21,261	20,044	25,953	18,344	27,397	r 22,262	r 33,214	21,707	36,679
Steel tube and pipe fittings, welded	13,324	20,258	9,878	15,185	11,641	18,708	12,840	19,469	10,546	18,306
Malleable iron tube and pipe fittings, n.e.c.	1,623	1,625	1,440	1,771	2,087	2,290	1,560	1,857	2,407	2,764
Electrical conduit fittings of iron or steel	10,655	8,040	12,123	6,806	12,317	7,965	10,453	7,971	7,289	8,880
Iron tube and pipe fittings n.e.c.	6,217	8,769	6,650	8,562	7,191	10,562	r 7,935	r 10,414	7,820	12,063
Seamless tubes and pipe	183,802	77,165	228,877	83,999	251,996	99,235	r 243,835	r 100,295	222,768	99,542
Welded, clinched or riveted tubes and pipe	70,602	30,982	93,738	29,122	73,767	28,992	r 100,721	r 40,579	111,564	44,709
Finished structural iron and steel	r 102,393	r 45,811	87,019	38,940	116,054	55,013	142,462	67,727	117,275	63,023
Castings and forgings	r 105,515	r 62,873	r 176,532	r 76,157	r 205,612	r 79,452	r 255,671	r 102,726	295,619	114,320
Storage tanks, lined or unlined	19,514	11,585	19,015	12,165	15,245	11,426	16,539	11,174	15,582	10,494
Nails, tacks, staples and spikes, n.e.c.	7,952	6,078	7,686	5,871	9,349	7,058	7,667	6,499	7,720	5,835
Bolts	19,948	18,122	24,230	20,327	27,753	23,829	26,069	23,634	23,837	23,348
Nuts	5,126	8,967	5,764	8,809	6,567	9,647	5,846	8,684	5,780	9,374
Screws, rivets, washers	14,140	21,246	18,417	23,445	22,003	26,546	21,271	27,622	19,939	27,342
Total	r 724,019	r 388,404	r 913,747	r 416,052	r 967,961	r 467,627	r 1,063,399	r 528,074	1,023,871	538,994
Grand total	r 2,099,939	r 677,113	r 2,673,274	r 723,937	r 5,788,430	r 1,109,186	r 7,656,939	r 1,374,841	3,528,134	942,364

r Revised.

Table 13.—U.S. imports for consumption of pig iron, by country

Country	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	674	$31	--	--	171	$10
Brazil	--	--	--	--	25,620	1,111
Canada	295,076	14,449	249,129	$13,720	270,048	15,402
Finland	69,843	2,422	--	--	--	--
Germany, West	36,484	1,436	112	9	--	--
Norway	2,811	107	--	--	--	--
South Africa, Republic of	--	--	--	--	10,481	441
Total	404,888	18,445	249,241	13,729	306,320	16,964

Table 14.—U.S. imports for consumption of major iron and steel products

Products	1967		1968		1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Iron products:										
Cast iron pipes and tubes	r 20,183	r $3,593	29,010	$5,594	26,108	$5,883	18,491	$5,534	12,356	$2,516
Malleable cast-iron fittings	7,124	2,763	10,054	3,839	8,287	3,568	9,690	4,229	11,962	6,164
Bars of wrought iron	306	93	478	173	617	153	428	123	226	65
Castings and forgings	r 6,537	r 2,497	10,117	3,572	24,311	6,283	15,819	5,446	12,975	5,219
Total	r 34,150	r 8,946	49,659	13,178	59,323	15,887	44,428	15,332	37,519	13,964
Iron and steel products:										
Ingots, blooms, billets, slabs, and sheet bars	220,289	31,298	298,678	42,359	195,176	37,514	170,647	29,917	274,411	37,191
Bars of steel:										
Concrete reinforcement bars	567,026	42,003	r 739,755	53,514	470,807	40,563	202,699	21,200	514,813	49,809
Solid and hollow steel bars	651,286	75,717	r 976,820	r 108,247	r 903,813	r 119,522	r 727,742	r 115,027	1,027,768	153,831
Hollow drill steel	5,014	1,953	3,708	1,351	5,412	2,036	4,212	1,687	2,392	1,088
Plates and sheets:										
Black plate	9,887	1,001	6,669	648	11,657	1,684	r 5,753	r 987	7,452	1,371
Steel plate	r 1,025,308	r 95,486	r 1,789,686	r 160,738	r 1,201,523	r 120,201	r 968,677	r 124,109	1,572,560	198,952
Steel sheets	r 4,213,336	r 438,076	r 7,327,008	r 761,900	4,891,047	559,808	5,307,553	716,425	7,830,910	1,080,955
Plates and sheets of iron or steel	299	343	229	250	809	692	250	404	417	550
Plates, sheets and strip of iron or steel	r 11,558	r 3,030	r 10,007	r 2,885	r 30,320	r 6,204	r 50,963	r 10,100	75,970	14,255
Strip of iron or steel	67,591	23,112	90,961	28,873	r 96,162	32,921	92,335	r 37,934	114,902	43,678
Tinplate and terneplate	156,351	27,112	227,663	39,156	300,664	51,339	327,725	59,066	417,691	80,595
Structural iron and steel	1,149,580	121,834	1,559,104	157,546	1,517,373	171,669	1,300,847	186,385	1,637,154	231,060
Angles, shapes, and sections	r 506,433	r 45,480	r 668,728	r 56,690	r 522,601	r 48,747	r 416,124	r 50,030	550,350	61,971
Wire rods of steel	1,076,472	r 101,865	1,600,929	150,534	1,260,890	129,803	1,055,570	r 131,810	1,538,288	187,607
Sheet piling	29,669	3,050	67,545	6,654	65,957	6,854	52,335	6,189	89,208	10,605
Pipes, tubes and fittings	r 1,103,854	r 174,767	r 1,664,777	r 258,370	r 1,702,536	r 267,062	r 1,976,749	r 341,441	1,888,942	340,425
Bail ties of iron or steel	16,247	2,138	24,467	3,124	23,881	3,193	15,353	2,279	21,047	3,307
Steel castings and forgings	r 17,413	r 7,874	r 13,193	r 6,013	r 18,539	r 8,352	r 14,039	r 6,660	12,958	5,275
Rails and railway track construction materials	r 36,401	r 5,520	r 53,200	r 7,308	r 67,581	r 10,630	r 72,306	r 11,323	68,863	11,034
Wire:										
Round wire	r 431,179	r 82,953	r 562,740	r 105,985	r 563,265	r 110,097	r 505,164	r 116,561	530,194	125,722
Other wire	145,869	26,769	163,729	30,739	146,127	29,021	143,726	33,875	135,737	33,464
Nails	216,061	31,587	287,873	44,876	301,817	51,184	244,993	47,259	293,562	55,134
Total	r 11,657,123	r 1,342,968	r 18,137,469	r 2,027,760	r 14,297,957	r 1,809,096	r 13,655,762	r 2,050,668	18,605,589	2,727,879
Advanced manufactures: Bolts, nuts, rivets and washers	139,543	47,432	147,952	49,607	172,904	58,795	181,559	73,718	170,966	67,235
Grand total	r 11,830,816	r 1,399,346	r 18,335,080	r 2,090,545	r 14,530,184	r 1,883,778	r 13,881,749	r 2,139,718	18,814,074	2,809,078

r Revised.

Table 15.—Pig iron [1]: World production by country

(Thousand short tons)

Country [2]	1967	1968	1969	1970	1971 p
North America:					
Canada	7,108	8,383	7,461	9,086	8,687
Mexico [3]	1,776	2,173	2,313	2,492	2,598
United States	r 86,799	88,767	95,003	91,293	81,382
South America:					
Argentina	657	633	r 648	899	947
Brazil	3,383	3,714	r 4,097	4,632	5,222
Chile	549	487	535	530	552
Colombia [4]	228	218	r 215	254	217
Peru [4]	34	122	194	94	99
Venezuela [4]	465	677	573	562	e 562
Europe:					
Austria	2,359	2,727	3,104	3,267	3,140
Belgium	9,813	11,411	12,454	11,951	11,467
Bulgaria	1,135	r 1,194	1,209	1,325	1,472
Czechoslovakia	7,470	[5] 7,629	[5] 7,726	[5] 8,320	[5] 8,775
Denmark	119	196	223	227	244
Finland	1,174	1,218	1,357	1,348	1,134
France	16,967	17,720	19,603	20,652	19,731
Germany, East [6]	2,783	2,572	2,313	2,198	2,235
Germany, West [7]	29,886	33,045	36,956	36,791	32,826
Greece [8]	e 300	e 300	320	331	321
Hungary	1,824	1,804	1,932	2,008	2,172
Italy	8,040	8,627	8,593	9,184	9,409
Luxembourg	4,365	4,749	r 5,363	5,302	5,057
Netherlands	2,853	3,110	r 3,813	3,962	4,144
Norway [8]	702	743	r 752	747	691
Poland	6,845	7,083	7,277	7,546	e 8,000
Portugal	313	310	370	340	e 390
Romania	2,708	3,298	3,833	4,641	4,830
Spain	2,953	3,063	3,674	4,591	5,321
Sweden [3]	2,771	2,919	2,949	3,079	3,037
Switzerland	26	24	28	31	35
U.S.S.R.	80,970	85,297	88,682	93,486	e 97,300
United Kingdom	16,801	18,218	18,185	19,297	16,823
Yugoslavia	1,297	1,324	1,321	1,405	1,669
Africa:					
Algeria e	11	11	66	77	77
Egypt, Arab Republic of	e 220	e 220	466	e 500	e 500
Rhodesia, Southern [4]	287	287	e 300	e 310	e 310
South Africa, Republic of	3,770	4,159	4,333	4,326	e 4,400
Tunisia	108	141	144	e 140	e 140
Asia:					
China, People's Republic of e [9]	15,400	20,900	22,000	24,300	30,000
India	7,618	7,883	8,114	7,754	7,234
Israel e	40	40	40	40	40
Japan	44,197	51,144	64,096	75,010	80,188
Korea, North e [9]	1,930	2,200	2,500	2,600	2,800
Korea, Republic of	26	51	46	54	25
Malaysia e	20	70	70	70	70
Taiwan	r 93	r 83	r 87	61	84
Thailand	7	19	12	12	15
Turkey	r 933	1,003	1,045	1,139	e 1,000
Oceania:					
Australia	5,574	6,142	6,731	6,777	6,755
New Zealand (all sponge iron)	--	--	NA	e 25	e 220
Total	385,707	418,108	453,126	475,066	474,347

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

[1] Table excludes all ferroalloy production except where otherwise noted.

[2] In addition to the countries listed, North Vietnam and Zaire (formerly Congo-Kinshasa) 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: 1967—359, 1968—410, 1969—444, 1970—679, 1971—743; Sweden: 1967—168, 1968—168, 1969—196, 1970—203, 1971—191.

[4] Includes ferroalloys, if any are produced.

[5] Includes blast furnace ferroalloys.

[6] May include ferroalloys.

[7] Includes blast furnace ferroalloys except ferromanganese and spiegeleisen.

[8] Includes blast furnace ferroalloys, if any are produced.

[9] Includes ferroalloy production.

Table 16.—Ferroalloys: World production by country [1] and furnace type

(Thousand short tons)

Country	1967	1968	1969	1970	1971 p
BLAST FURNACE [2]					
Europe:					
Belgium	--	21	14	3	--
Czechoslovakia	49	(3)	(3)	(3)	(3)
Denmark	8	8	7	10	8
France	355	412	472	536	491
Germany, West [4]	280	362	262	277	231
Hungary	11	13	--	7	8
Italy	20	18	17	24	20
Poland	128	140	147	151	e 220
Portugal	8	8	12	8	--
Romania	--	15	9	1	--
U.S.S.R.	1,496	1,552	1,305	1,239	e 1,100
United Kingdom	170	185	172	183	170
Africa:					
South Africa, Republic of	57	58	81	51	e 60
Asia: Korea, Republic of [5]	8	e 10	12	15	16
ELECTRIC FURNACE [6]					
North America:					
Canada [2]	168	167	204	210	213
Mexico	60	62	64	83	e 83
United States [2]	2,750	2,621	2,629	2,595	2,692
South America:					
Argentina	20	27	27	35	e 34
Brazil	65	r 73	81	99	e 98
Chile	11	11	13	13	e 13
Europe:					
Austria	6	6	7	6	6
Bulgaria	e 31	31	41	55	47
Czechoslovakia	107	111	107	115	134
Finland	--	9	29	36	39
France	289	301	341	374	386
Germany, West	177	230	277	297	258
Hungary	15	10	15	11	11
Italy	168	168	168	193	192
Norway	r 657	r 787	r 837	610	714
Poland	119	115	126	131	e 132
Spain	89	107	105	123	144
Sweden	230	r 254	272	257	e 250
Switzerland	2	7	7	e 10	25
Yugoslavia	87	94	99	112	128
Africa:					
South Africa, Republic of	338	326	386	389	e 430
Asia:					
India	167	186	221	236	235
Japan	1,042	1,175	1,430	1,835	2,083
Taiwan	2	2	2	6	8
Turkey	9	9	10	e 10	e 10
Oceania:					
Australia [2] [7]	96	71	87	87	e 86
Total	9,295	9,762	10,095	10,433	10,775

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, Norway, 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 United States included under electric furnace output.

3 Production not reported separately from that of pig iron, which is presented in the iron and steel chapter.

4 Blast furnace ferromanganese and spiegeleisen only; other blast furnace ferroalloys are included with pig iron production in the iron and steel chapter.

5 Includes electric furnace ferroalloys if any are produced.

6 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.

7 Year ended November 30 of that stated.

Table 17.—Raw steel [1]: World production, by country

(Thousand short tons)

Country [2]	1969	1970	1971 p
North America:			
Canada	10,307	12,346	12,130
Cuba e	60	60	60
Mexico	3,825	4,278	4,199
United States [3]	141,262	131,514	120,443
South America:			
Argentina	r 1,863	2,010	2,109
Brazil [4]	5,429	5,941	6,611
Chile	r 707	653	e 660
Colombia	r 300	342	e 360
Peru	r 214	104	e 210
Uruguay	15	18	e 18
Venezuela	r 926	1,022	e 1,045
Europe:			
Austria	4,328	4,496	4,365
Belgium	14,145	13,897	13,717
Bulgaria	1,670	1,984	2,147
Czechoslovakia	11,907	12,655	13,304
Denmark [5]	531	521	519
Finland	1,067	1,289	1,130
France	24,814	26,205	25,198
Germany, East	5,318	5,570	5,897
Germany, West	49,952	49,649	44,439
Greece	496	480	526
Hungary	3,342	3,428	3,428
Ireland	89	e 100	e 100
Italy	18,109	19,045	19,238
Luxembourg	6,086	6,021	5,777
Netherlands	5,204	5,558	6,537
Norway	936	959	951
Poland	12,446	13,002	14,041
Portugal	440	424	e 450
Romania	6,107	7,184	7,499
Spain	6,619	8,189	8,553
Sweden	5,866	6,058	5,810
Switzerland	551	578	586
U.S.S.R	r 121,618	127,746	133,380
United Kingdom	29,593	31,213	26,648
Yugoslavia	2,447	2,456	2,945
Africa:			
Algeria	20	e 20	e 20
Rhodesia, Southern e	r 154	165	165
South Africa, Republic of [6]	5,061	5,185	e 5,500
Tunisia	110	e 110	e 110
Uganda	23	22	30
United Arab Republic	540	e 550	e 550
Asia:			
Burma e	r 23	19	19
China, People's Republic of e	18,000	20,000	23,000
India [4]	r 7,028	6,722	6,559
Israel e	130	130	130
Japan	90,572	102,870	97,617
Korea, North e	2,200	2,400	2,600
Korea, Republic of	[4] 412	[4] 530	571
Lebanon e	20	20	20
Malaysia e	65	65	75
Pakistan e	110	110	NA
Philippines e	95	95	95
Singapore	--	--	136
Taiwan	299	324	432
Thailand	10	7	132
Turkey	1,290	1,446	1,237
Oceania:			
Australia	7,735	7,520	7,425
New Zealand	e 75	e 75	220
Total	r 632,561	655,380	641,673

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

[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): 1969—1,906; 1970—1,723; 1971—1,583.

[4] Ingots only.

[5] Apparently excludes shipyard production of steel castings.

[6] Revised to exclude iron castings.

Iron and Steel Scrap

By Harold J. Polta [1]

Domestic consumption of iron and steel scrap the first half of 1971 was well above that of the first half of 1970, and nearly equaled that of 1969 when consumption reached a record high. However, the decline in steel production that followed labor contract negotiations in the steel industry in July, resulted in a greatly reduced demand for scrap during the last 6 months of the year. This, together with large declines in scrap export trade, had the scrap processing industry operating considerably below 1970 levels. Prices were well below those of the year before.

Concern about the quality of our environment and emphasis on conservation of natural resources remained high. Industry cooperated with environmental groups in setting up can collection centers, and an increasing number of States passed legislation designed to encourage the recycling of junked autos. However, both consumers and processors of scrap apparently agreed that to increase recycling will require inceasing demand for ferrous scrap. Research by the Bureau of Mines and others was directed toward improving the quality of scrap and finding ways to use greater quantities of low-quality scrap in steelmaking.

[1] Mining engineer, Division of Ferrous Metals.

Table 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Thousand short tons and thousand dollars)

	1970	1971
Stocks Dec. 31:		
Scrap at consumer plants	7,668	8,494
Pig iron at consumer and supplier plants	2,082	1,779
Total	9,750	10,273
Consumption:		
Scrap	r 85,559	82,567
Pig iron	90,724	81,215
Exports: [1]		
Scrap (excludes rerolling material)	r 10,111	6,082
Value	r $431,910	$206,420
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	301	283
Value	$11,200	$11,259

r Revised.
[1] 1965–69 included ships, boats, and other vessels for breaking up (for scrapping).

Legislation and Government Programs.—The U.S. Department of Commerce removed controls on exports of certain nickel-containing commodities to free-world countries in midyear. After removal of these controls, U.S. companies were no longer required to obtain permission from the Department to export iron and steel scrap containing nickel, nickel alloy scrap, and certain other nickel products to Western Europe, South America, Japan, and other free-world nations.

In line with the general policy of improving foreign relations, the United States relaxed restrictions on exports of "consumer grades of iron and steel scrap" to Communist Bloc countries including the Peoples Republic of China and the U.S.S.R. Other items allowed to be exported under general license included most stainless and nickel alloy, nickel cobalt, and cobalt-base-alloy grades of scrap. However, restrictions on trade with North Vietnam, North Korea, Cuba, and Southern Rhodesia were not relaxed. Suspension of tariffs on iron and steel scrap were continued to June 30, 1973, by Public Law 91–25.

AVAILABLE SUPPLY

The 83.2 million tons of iron and steel scrap reported available for consumption at consumers' plants in 1971 consisted of 49.2 million tons of home, and 34.0 million tons of purchased scrap (net receipts). Home scrap production, by consumers, was down 6.5 percent from that in 1970, and 12.6 percent below the record high reported in 1969. Net receipts of scrap were less than 1 percent below those of 1970 but 8 percent below the record high of 1969.

CONSUMPTION

Consumers reported consumption of 82.6 million tons of iron and steel scrap in 1971. This was 3.5 percent less than in 1970 and about 13 percent less than that reported for the record year 1969.

STOCKS

Consumers' stocks reported on hand December 31, 1971, were 8.5 million tons, up more than 10 percent from the year before.

PRICES

Iron and steel scrap prices rose sharply at the beginning of 1971, but then declined almost continuously the rest of the year. The American Metal Market weekly composite price of No. 1 heavy melting scrap dropped from $41 in January to $30 in December. By the end of 1971, the price had declined almost 35 percent from the high established early in 1969. The decline coincided with the decrease in scrap exports resulting from the worldwide recession in the steel industry.

FOREIGN TRADE

Exports of iron and steel scrap stayed below the record highs of 1970 the entire year. The 1971 total, 6.1 million short tons (excluding rerolling material and ships, boats, and other vessels for scrapping) was 40 percent below the record 10.1-million-ton total exported in 1970. The principal destination of U.S. scrap again was Japan which received 29 percent of the total exported. However, the 1.7 million tons exported to Japan were 3.5 million tons below those of 1970. Next largest destinations for U.S. scrap were Canada (16 percent), and Spain (10 percent).

No. 1 heavy melting scrap exports declined 50 percent from those the year before, but exports of scrap produced from relatively lower grade material remained comparatively high. Exports of shredded scrap declined only 12 percent, and those of No. 2 bundles, 29 percent.

WORLD REVIEW

Massive stocks of ferrous scrap were reported in the United Kingdom at the end of 1971. Total stocks held by the steel industry, the iron foundries, and merchants were said to total over 2.4 million tons. Reason for the large stocks was a 13-percent decline in British steel production. Nearly all export controls were relaxed,

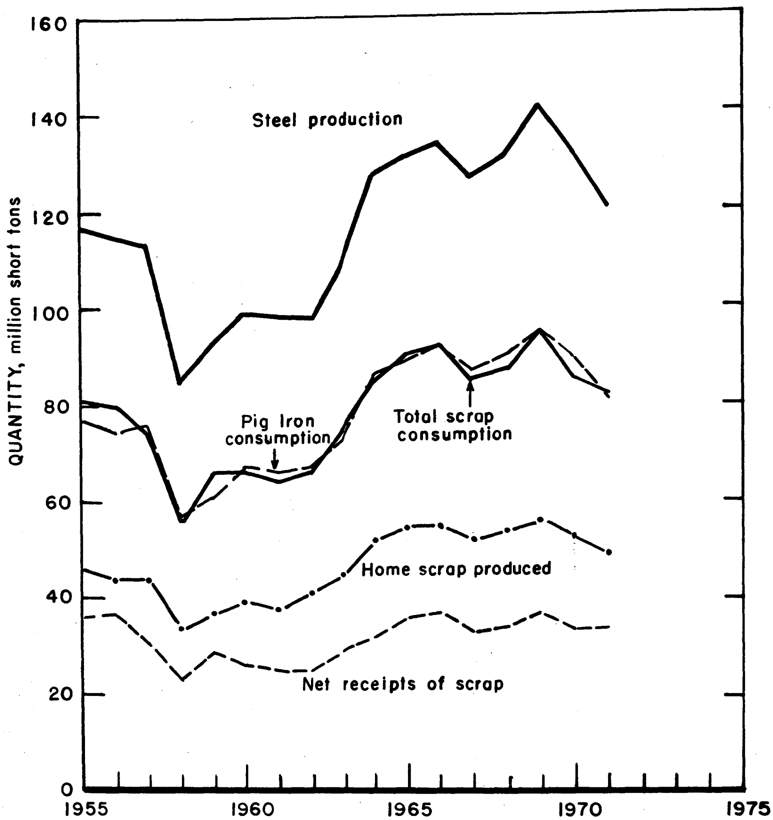

Figure 1.—Steel production (AISI); total iron and steel scrap consumption; pig iron consumption; home scrap production; and net scrap receipts.

and exports increased to over 1 million tons, an increase of 150 percent over 1970 exports.

Steel production in West Germany declined more than 10 percent from that of 1970, but purchases of domestic scrap declined only about 8 percent. Imports of scrap were down sharply, the lowest since 1966. Prices declined in line with the decreased demand. Germany had three shredders in operation at the start of the year —at Nuremberg, Bremen, and North Rhine-Westphalia. The much larger shredder under construction at Eppingen/Baden was scheduled for production late in 1971. It has a capacity of shredding 70,000 automobiles per year. Another 10 to 15 large shredders were either planned or under construction.

The scrap situation in France paralleled that in other free-world countries. With decreased steel production, particularly in the second half of the year, demand for scrap was low and prices declined.

Operation of Sweden's first shredder started in April at Halmstad. The shredder was installed only after much study, including field trips to operating shredders in the United States, West Germany, Britain, and France. During 1970, approximately 140,000 automobiles were scrapped in Sweden. Estimates are that by 1975, 200,000 will be scrapped. Capacity of the Halmstad shredder is about 50,000 cars per year; therefore, an additional shredder installation is planned. It is scheduled to be in operation by 1972. Because there has been a shortage of steel scrap in Sweden for many years, there is a prohibition on the exportation of all qualities of nonalloyed steel scrap. In spite of the recession in the steel industry, all collected domestic steel scrap could be marketed, and prices remained firm. Demand for stainless steel scrap also remained firm, but prices dropped considerably. Cast iron scrap was most affected by the recession. Demand was light and prices were low.

A 40,000-ton-per-year shredder is reported due for operation in Finland in 1972. Plans are to set up collecting points throughout the country from which scrap will be sent to the new shredder for processing. Approximately 70,000 motor vehicles are scrapped every year; the new plant will be able to handle 80,000 to 100,000 vehicles. Finnish scrap requirements are estimated to be 350,000 tons per year, of which 200,000 tons come from domestic sources.

Reports indicate that up to 40 million tons of ferrous scrap are "procured" in the U.S.S.R. annually. For many years the U.S.S.R. has exported scrap in considerable quantities, but in the past 5 years, exports are said to have trebled. Principal exports are to East Germany, Finland, Japan, West Germany, Spain, Austria, Egypt, France, Sweden and Italy.

TECHNOLOGY

Concern about our environment and increased emphasis on recyling of materials had an increasing impact on all segments of the iron and steel scrap industry. The scrap processing industry, consumers of scrap, and Government were all actively searching for ways to increase consumption of iron and steel scrap.

Scrap processors continued to improve scrap quality through the use of shredders so that 1971 reported domestic consumption of shredded scrap was 97 percent above that of 1970. Formal recognition of the importance of this relatively new form of ferrous scrap was given in April when the Institute of Scrap Iron and Steel (ISIS) approved specifications for shredded scrap. The development and use of auto hulk flatteners to reduce the volume of a junked automobile has greatly increased the number of hulks that can be transported on a carrier, and has extended the economic haul distance for junked automobiles. Through the ISIS, scrap processors were cooperating with the Department of Health, Education, and Welfare in financing at Battelle Memorial Institute a research project entitled, "A Study to Identify Opportunities for Increased Recycling of Ferrous Waste."

Following a test program by National Steel Corp., which proved scrap cans are suitable for primary steelmaking, the sponsors of the project, the American Iron and Steel Institute (AISI) and the Carbonated Beverage Container Manufacturers Association (CBCMA) established can collection centers at locations throughout the country. However, representatives of steel companies indicated they did not feel collection centers themselves are the answer to the Nation's solid waste problem. The steel industry feels the ultimate solution will require an efficient system of municipal solid waste management.

The number of communities that were using mineral resource conservation directed trash disposal was growing.[2] Atlanta, Ga. was magnetically separating cans from garbage, selling about 80 tons of steel cans per week for $13.50 per ton, whereas the cost of burying would have been $8.42 per ton. Chicago, Ill., was selling municipal incinerator residue (principally iron and steel from cans) at the rate of 36,000 tons per year for over $100,000. Oakland, Calif., was magnetically separating steel cans from its sanitary land fill and selling them for $2 per ton. Franklin, Ohio, in an experimental plant, was reclaiming cans magnetically from slurried waste and selling cans at a reported profit of $8 per ton, thereby providing 10 percent of the plant's revenue. Other municipalities testing the feasibility of mineral resource reclamation from garbage included Pittsburgh, Pa., San Francisco, Calif., Sacramento, Calif., and Madison, Wis. Stamford, Conn., developed plans for a reclamation plant based on the Bureau of Mines experimental plant at College Park, Md., which recovers ferrous scrap and other waste products from incinerator residues.

A significant portion of Bureau of Mines

[2] American Metal Market. Steelmaker's View: Scrap Processors Can Help Save Big "Tin" Can Market. V. 79, No. 11, Jan. 17, 1972, p. 15.

research was being directed toward finding ways to increase consumption of iron and steel scrap. At its Twin Cities Metallurgy Research Center, the Bureau was investigating the feasibility of producing commercially acceptable foundry iron and synthetic pig iron from commercial and subcommercial scrap. Included in this project were studies on cupola operating pressures, wind rates, and the effect of impurities on grey iron. Another project was researching the production of ductile and malleable iron from shredded automobile scrap with or without the addition of prereduced pellets. Other metallurgists and scientists were hoping to develop ways to remove and recover contaminants, particularly copper and zinc, from oxidized ferrous scrap through a pelletization-chlorination process.

The College Park, Md., Metallurgy Research Center was continuing operation and modification of its pilot plant for recovering metals and minerals from incinerator residues. Objectives were to increase throughput and compile reliable engineering data. Another project was directed toward completing a pilot plant for processing raw refuse using a modification of a horizontal air-classification system designed previously.

Research at the Bureau's Albany, Oreg., facility included efforts to develop methods for preheating and continuously charging ferrous scrap to electric furnaces. At Salt Lake City, studies were continuing on ways to improve the smokeless automobile incinerator developed previously. Other projects had as their objective the recovery of nonferrous metals from shredded scrap and an evaluation of methods for dissembling military hardware and household appliances.

In addition to its in-house research programs, the Bureau of Mines made solid waste research grants to many colleges and universities. Information Circular 8529, "Bureau of Mines Research and Accomplishments in Utilization of Solid Wastes," published in 1971, lists all Bureau solid waste related projects and publications.

Table 2.—Consumers stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1971, by grade

(Thousand short tons)

Grades of scrap	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
MANUFACTURERS OF STEEL INGOTS AND CASTINGS					
Carbon steel:					
Low-phosphorous plate and punchings	480	10	462	2	66
Cut structural and plate	401	--	389	1	53
No. 1 heavy melting steel	7,625	18,556	24,178	2,100	2,781
No. 2 heavy melting steel	2,068	1,047	3,061	72	421
No. 1 and electric furnace bundles	4,941	720	5,559	84	797
No. 2 and all other bundles	2,237	519	2,709	81	276
Turnings and borings	1,377	399	1,632	115	195
Slag scrap (Fe content)	1,072	1,955	2,942	93	115
Shredded or fragmentized	1,198	--	1,172	5	81
All other carbon steel scrap	3,123	12,408	13,666	1,080	1,216
Stainless steel	328	469	768	40	86
Alloy steel (except stainless)	385	2,088	2,340	114	319
Cast iron (includes borings)	2,109	4,044	5,068	1,148	981
Other grades of scrap	330	393	673	47	33
U.S. total	27,674	42,608	64,619	4,982	7,420
Pig iron	3,775	80,918	78,689	6,102	1,504
MANUFACTURERS OF STEEL CASTINGS					
Carbon steel:					
Low-phosphorous plate and punchings	487	153	643	10	60
Cut structural and plate	155	9	166	--	11
No. 1 heavy melting steel	144	88	241	12	14
No. 2 heavy melting steel	1	1	2	--	--
No. 1 and electric furnace bundles	75	--	70	1	11
No. 2 and all other bundles	18	--	19	--	3
Turnings and borings	53	18	66	6	7
Slag scrap (Fe content)	--	4	3	--	--
Shredded or fragmentized	62	--	61	--	5
All other carbon steel scrap	517	321	830	7	63
Stainless steel	175	21	193	1	7
Alloy steel (except stainless)	53	73	117	11	27
Cast iron (includes borings)	166	120	277	14	36
Other grades of scrap	43	62	99	14	6
U.S. total	1,949	870	2,787	76	250
Pig iron	70	--	72	3	7

Table 2.—Consumers stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1971, by grade—Continued

(Thousand short tons)

Grades of scrap	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Carbon steel:					
Low-phosphorous plate and punchings	807	46	833	14	41
Cut structural and plate	749	64	794	7	62
No. 1 heavy melting steel	209	77	255	33	12
No. 2 heavy melting steel	201	17	216	9	23
No. 1 and electric furnace bundles	347	--	347	--	13
No. 2 and all other bundles	443	7	461	--	48
Turnings and borings	602	37	614	30	56
Slag scrap (Fe content)	10	8	18	1	--
Shredded or fragmentized	419	--	421	--	26
All other carbon steel scrap	1,621	157	1,742	25	139
Stainless steel	4	--	4	--	4
Alloy steel (except stainless)	98	10	114	1	26
Cast iron (includes borings)	3,805	5,029	8,751	140	349
Other grades of scrap	379	239	591	16	25
U.S. total	9,694	5,691	15,161	276	824
Pig iron	2,464	--	2,454	7	268
TOTAL—ALL TYPES OF MANUFACTURES					
Carbon steel:					
Low-phosphorous plate and punchings	1,774	209	1,937	26	166
Cut structural and plate	1,305	73	1,349	8	126
No. 1 heavy melting steel	7,978	18,721	24,674	2,145	2,807
No. 2 heavy melting steel	2,270	1,065	3,278	81	444
No. 1 and electric furnace bundles	5,363	720	5,976	84	822
No. 2 and all other bundles	2,698	526	3,189	81	327
Turnings and borings	2,032	454	2,313	151	258
Slag scrap (Fe content)	1,082	1,967	2,963	94	115
Shredded or fragmentized	1,679	--	1,654	5	112
All other carbon steel scrap	5,261	12,886	16,238	1,112	1,418
Stainless steel	507	490	966	42	97
Alloy steel (except stainless)	536	2,171	2,571	126	372
Cast iron (includes borings)	6,080	9,193	14,096	1,302	1,366
Other grades of scrap	752	694	1,363	77	64
U.S. total	39,317	49,169	82,567	5,334	8,494
Pig iron	6,309	80,918	81,215	6,112	1,779

Table 3.—Consumption of iron and steel scrap and pig iron [1] in the United States in 1971, 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]	3,708	--	--	--	--	--	3,708	--
Basic oxygen converter [5]	20,058	52,023	--	--	--	--	20,058	52,023
Open-hearth furnace	18,572	23,551	260	22	--	--	18,832	23,573
Electric furnace	20,150	670	2,210	28	2,058	126	24,418	825
Cupola furnace	1,738	146	294	14	12,774	1,705	14,806	1,865
Air furnace	30	5	23	5	132	50	185	60
Other furnaces [6]	363	201	--	--	197	3	560	204
U.S. total	64,619	76,597	2,787	69	15,161	1,884	82,567	78,550

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes only those castings made by companies that produce 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.

Table 4.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1971 Scrap	1971 Pig iron
Basic oxygen converter	27.9	72.1
Open-hearth furnace	44.4	55.6
Electric furnace	96.7	3.2
Cupola furnace	88.8	11.2
Air furnace	75.4	24.6

Table 5.—Iron and steel scrap supply [1] available for consumption in 1971, by State

(Thousand short tons)

State	Receipts	Production	Total new supply	Shipments [2]	New supply available for for consumption
Alabama	1,587	2,025	3,612	53	3,559
Arizona	W	W	W	W	W
Arkansas	W	--	W	--	W
California	1,516	1,400	2,916	125	2,791
Colorado	W	W	W	W	W
Connecticut	69	45	114	5	109
Delaware	W	W	W	(3)	W
Florida	W	W	W	W	W
Georgia	W	W	W	W	W
Illinois	4,664	4,042	8,706	373	8,333
Indiana	2,291	7,482	9,773	969	8,804
Iowa	409	155	564	1	563
Kansas	75	45	120	1	119
Kentucky	W	W	W	W	W
Louisiana	W	W	W	W	W
Maine	W	W	W	--	W
Maryland	W	W	W	W	W
Massachusetts	33	43	76	2	74
Michigan	4,462	4,332	8,794	162	8,632
Minnesota	463	185	648	8	640
Mississippi	W	W	W	W	W
Missouri	819	256	1,075	16	1,059
Montana	W	(3)	W	--	W
Nebraska	W	W	W	W	W
Nevada	W	--	W	--	W
New Hampshire	W	W	W	--	W
New Jersey	502	127	629	9	620
New York	1,034	1,666	2,700	252	2,448
North Carolina	W	W	W	W	W
Ohio	6,653	8,493	15,146	1,248	13,898
Oklahoma	W	W	W	--	W
Oregon	W	W	W	W	W
Pennsylvania	6,614	11,192	17,806	1,605	16,201
Rhode Island	W	W	W	W	W
South Carolina	W	W	W	(3)	W
Tennessee	448	207	655	9	646
Texas	1,840	1,143	2,983	30	2,953
Utah	W	W	W	W	W
Vermont	9	6	15	1	14
Virginia	W	W	W	W	W
Washington	458	104	562	10	552
West Virginia	W	W	W	W	W
Wisconsin	424	374	798	30	768
Undistributed	4,947	5,847	10,794	425	10,369
U.S. total	39,317	49,169	88,486	5,334	83,152

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

[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.

[3] Less than ½ unit.

Table 6.—Consumption of iron and steel scrap and pig iron [1] by States, by type of manufacturers in 1971

(Thousand short tons)

State	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
Alabama	2,106	W	190	W	1,097	W	3,393	W
Arizona	155	--	84	--	65	--	304	--
Arkansas	--	--	W	--	--	--	W	--
California	2,413	W	121	W	241	W	2,775	W
Colorado	W	W	W	W	W	--	W	W
Connecticut	61	--	[(4)]	--	51	18	112	18
Delaware	W	--	W	W	--	--	W	W
Florida	W	W	--	--	W	W	W	W
Georgia	W	--	W	W	W	8	W	8
Illinois	6,587	6,111	402	3	1,173	262	8,162	6,376
Indiana	7,990	12,620	141	2	632	154	8,763	12,776
Iowa	--	--	35	--	539	25	574	25
Kansas	--	--	99	1	17	1	116	2
Kentucky	1,156	1,583	--	--	222	28	1,378	1,611
Louisiana	--	--	15	W	--	--	15	W
Maine	--	--	--	--	W	W	W	W
Maryland	W	W	W	--	W	W	W	W
Massachusetts	--	--	7	[(4)]	68	17	75	17
Michigan	4,482	6,764	105	1	3,920	420	8,507	7,185
Minnesota	490	W	57	W	73	W	620	W
Mississippi	W	--	--	--	--	--	W	--
Missouri	W	--	W	3	W	14	W	17
Montana	--	--	--	--	W	W	W	W
Nebraska	--	--	W	W	W	W	W	W
Nevada	--	--	W	W	--	--	W	W
New Hampshire	--	--	W	W	W	W	W	W
New Jersey	184	--	27	[(4)]	412	55	623	55
New York	1,605	W	133	W	752	W	2,490	W
North Carolina	W	--	--	--	W	5	W	5
Ohio	11,091	12,928	342	14	2,197	459	13,630	13,401
Oklahoma	W	--	W	[(4)]	W	5	W	5
Oregon	114	--	54	W	6	W	174	W
Pennsylvania	15,039	19,273	320	27	660	87	16,019	19,387
Rhode Island	65	--	--	--	55	5	120	5
South Carolina	287	--	--	--	48	W	335	W
Tennessee	47	--	17	1	579	94	643	95
Texas	2,323	660	44	1	650	12	3,017	673
Utah	W	W	W	W	W	W	W	W
Vermont	--	--	--	--	14	4	14	4
Virginia	--	--	183	W	450	W	633	W
Washington	W	--	W	[(4)]	W	--	W	[(4)]
West Virginia	W	W	W	W	W	W	W	W
Wisconsin	--	--	197	6	573	111	770	117
Undistributed	8,424	18,750	214	13	667	670	9,305	19,433
U.S. total	64,619	78,689	2,787	72	15,161	2,454	82,567	81,215

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[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.
[4] Less than 1/2 unit.

Table 7.—Consumption of iron and steel scrap and pig iron [1] in the United States in 1971, by State, by type of furnace

(Thousand short tons)

State	Blast furnace	Basic oxygen converter		Open-hearth furnace		Electric furnace		Cupola furnace		Air furnace		Other furnaces [2]	
	Scrap	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Alabama	184	432	W	1,202	W	499	W	1,021	W	48	--	7	W
Arizona	--	--	--	--	--	W	--	--	--	--	--	W	--
Arkansas	--	--	--	--	--	W	--	--	--	--	--	--	--
California	49	357	W	1,202	W	908	W	251	W	--	--	7	--
Colorado	W	W	W	W	W	W	(3)	W	W	--	--	--	--
Connecticut	--	--	--	--	--	88	8	24	10	--	--	--	--
Delaware	--	--	--	--	--	W	(3)	--	--	--	--	--	--
Florida	--	--	--	--	--	W	W	--	--	--	--	--	--
Georgia	--	--	--	--	--	W	(3)	W	8	--	--	W	--
Illinois	191	1,916	4,946	372	904	4,713	35	928	64	3	4	38	11
Indiana	254	3,626	9,396	3,524	2,892	738	7	604	139	15	9	2	--
Iowa	--	--	--	--	--	194	(3)	380	25	--	--	--	--
Kansas	--	--	--	--	--	99	(3)	17	2	--	--	--	--
Kentucky	11	510	W	--	--	662	--	157	W	--	--	37	--
Louisiana	--	--	--	--	--	W	--	W	--	--	--	--	--
Maine	--	--	--	--	--	--	--	W	W	--	--	--	--
Maryland	W	W	W	W	W	W	W	W	W	--	--	W	--
Massachusetts	--	--	--	--	--	16	(3)	56	14	4	2	--	--
Michigan	226	2,966	6,910	--	--	995	24	4,313	360	4	1	2	--
Minnesota	1	--	--	279	W	273	W	67	W	--	--	--	(3)
Mississippi	--	--	--	--	--	W	--	--	--	--	--	--	--
Missouri	--	--	--	W	--	W	(3)	W	14	--	--	--	--
Montana	--	--	--	--	--	--	--	W	--	--	--	W	--
Nebraska	--	--	--	--	--	W	--	W	--	--	--	--	--
Nevada	--	--	--	--	--	W	--	--	--	--	--	--	--
New Hampshire	--	--	--	--	--	W	--	--	--	W	W	--	--
New Jersey	--	--	--	--	--	191	1	414	51	1	1	17	W
New York	224	990	W	261	W	262	W	685	W	(3)	--	70	--
North Carolina	--	--	--	--	--	--	(3)	W	5	--	--	--	--
Ohio	1,157	3,156	8,817	3,270	3,879	3,598	123	2,401	160	32	16	17	12
Oklahoma	--	--	--	--	--	W	3	W	2	--	--	--	--
Oregon	--	--	--	--	--	170	(3)	4	(3)	--	--	--	--
Pennsylvania	984	3,666	9,265	5,528	8,181	4,823	110	816	84	40	10	163	--
Rhode Island	--	--	--	--	--	103	1	18	4	--	--	--	--
South Carolina	--	--	--	--	--	W	--	W	W	W	--	--	--
Tennessee	--	--	--	--	--	52	11	592	84	--	--	--	--
Texas	139	--	--	761	599	1,534	266	582	38	--	--	1	--
Utah	W	--	--	W	W	W	W	W	W	--	--	W	W
Vermont	--	--	--	--	--	--	(3)	13	4	--	--	--	--
Virginia	--	--	--	--	--	181	--	452	W	--	--	--	--
Washington	--	--	--	--	--	W	(3)	W	(3)	--	--	--	--
West Virginia	W	W	W	W	W	W	W	W	W	W	W	W	--
Wisconsin	--	--	--	32	5	328	13	392	89	17	11	--	--
Undistributed	288	2,439	12,690	2,401	7,113	3,991	223	619	708	21	6	199	181
U.S. total	3,708	20,058	52,024	18,832	23,573	24,418	825	14,806	1,865	185	60	560	204

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

[1] Excludes molten pig iron used for ingot molds and direct castings.

[2] Includes vacuum melting furnaces and miscellaneous melting processes.

[3] Less than ½ unit.

Table 8.—Consumer stocks of iron and steel scrap, by grade, and pig iron, Dec. 31, 1971, by State

(Thousand short tons)

State	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
Alabama	279	--	1	110	4	394	242
Arizona	W	--	--	W	W	W	--
Arkansas	(1)	--	--	--	--	(1)	--
California	272	(1)	5	43	4	324	21
Colorado	45	(1)	(1)	2	1	48	11
Connecticut	3	2	(1)	5	--	10	2
Delaware	W	--	--	W	W	W	(1)
Florida	W	--	--	W	--	W	W
Georgia	69	--	--	1	--	70	1
Illinois	872	6	17	51	1	947	99
Indiana	947	12	14	183	5	1,161	31
Iowa	41	(1)	1	7	--	49	2
Kansas	7	--	--	1	--	8	(1)
Kentucky	113	1	16	3	16	149	7
Louisiana	W	--	--	--	--	W	W
Maine	W	--	--	W	--	W	(1)
Maryland	80	11	11	73	(1)	176	11
Massachusetts	1	--	(1)	2	--	3	2
Michigan	339	5	1	110	3	458	176
Minnesota	151	--	2	17	1	171	4
Mississippi	W	--	--	--	--	W	--
Missouri	76	(1)	1	21	2	100	7
Montana	--	--	--	W	W	W	(1)
Nebraska	W	--	--	W	--	W	(1)
Nevada	W	--	--	--	--	W	(1)
New Hampshire	W	--	--	--	--	(1)	(1)
New Jersey	34	(1)	3	13	(1)	50	4
New York	210	12	10	109	(1)	341	328
North Carolina	5	--	--	1	--	6	1
Ohio	1,150	8	74	140	2	1,374	462
Oklahoma	39	--	--	1	(1)	40	1
Oregon	8	5	1	--	--	14	(1)
Pennsylvania	1,220	34	179	360	5	1,798	224
Rhode Island	4	--	(1)	2	(1)	6	1
South Carolina	26	--	--	1	5	32	(1)
Tennessee	17	--	(1)	9	1	27	6
Texas	232	(1)	18	19	1	270	34
Utah	W	--	W	W	--	W	W
Vermont	(1)	--	--	1	--	1	(1)
Virginia	17	--	--	16	--	33	7
Washington	104	(1)	6	22	1	133	1
West Virginia	19	(1)	4	3	--	26	3
Wisconsin	20	(1)	(1)	11	1	32	33
Undistributed	195	--	8	29	11	243	58
U.S. total	6,595	97	372	1,366	64	8,494	1,779

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 9.—Average monthly price and composite price for No. 1 heavy melting scrap in 1971

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	43.25	41.25	37.50	40.67
February	42.50	40.50	37.50	40.17
March	36.10	38.30	35.30	36.57
April	33.75	36.50	32.00	34.09
May	33.90	36.30	32.50	34.23
June	30.75	35.50	32.00	32.75
July	29.50	35.50	31.50	32.17
August	29.30	35.50	31.50	32.10
September	32.50	35.50	31.50	33.17
October	32.00	34.25	31.00	32.42
November	29.10	32.90	30.05	30.68
December	28.17	31.83	30.17	30.06
Average:				
1971	33.40	36.15	32.71	34.09
1970	41.86	41.43	39.90	41.06

[1] Composite price, Chicago, Pittsburgh, Philadelphia.

Source: Iron Age, Jan. 6, 1972.

Table 10.—U.S. exports and imports for consumption of iron and steel scrap by class

(Thousand short tons and thousand dollars)

Class	1967		1968		1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	2,762	$89,365	2,482	$72,286	3,452	$114,646	r 3,654	r $158,483	1,827	$64,514
No. 2 heavy melting scrap	1,151	33,064	783	20,384	1,009	29,760	r 1,140	r 45,516	645	20,297
No. 1 baled steel scrap	392	12,536	269	7,151	593	19,679	377	16,290	233	8,460
No. 2 baled steel scrap	1,511	33,272	969	18,999	1,038	22,038	1,381	41,902	987	22,519
Stainless steel scrap	124	33,334	113	26,305	76	22,868	87	30,926	44	12,518
Shredded steel scrap [1]	--	--	--	--	--	--	1,165	49,344	1,026	36,568
Borings, shovelings, and turnings	462	9,009	439	8,359	767	13,135	r 619	r 15,311	390	8,663
Other steel scrap [2]	624	21,640	973	30,548	1,361	46,930	r 881	r 44,423	465	19,030
Iron scrap	447	12,777	416	10,868	627	20,481	r 807	r 29,715	465	13,851
Total	7,473	244,997	6,444	194,900	8,923	289,537	r 10,111	r 431,910	6,082	206,420
Ships, boats, and other vessels (for scrapping)	34	306	120	2,105	114	2,319	531	11,474	396	6,824
Total	7,507	r 245,303	r 6,564	r 197,005	r 9,037	r 291,856	r 10,642	r 443,384	6,478	213,244
Rerolling material	162	5,934	127	5,844	254	13,170	251	15,464	175	8,978
Grand total	7,669	r 251,237	r 6,691	r 202,849	r 9,291	r 305,026	r 10,893	r 458,848	6,653	222,222
Imports:										
Iron and steel scrap	216	8,181	276	10,784	311	12,571	279	10,609	263	10,713
Tinplate scrap	14	381	18	541	24	917	22	591	20	546
Total	230	8,562	294	11,325	335	13,488	301	11,200	283	11,259

r Revised.
[1] Separately classified Jan. 1, 1970, formerly part of other steel scrap.
[2] Includes terneplate and tinplate.

Table 11.—U.S. exports of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1967		1968		1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	22	$725	(1)	$21	(1)	$3	6	$370	63	$1,757
Belgium-Luxembourg	2	198	21	769	33	1,844	21	3,563	8	947
Canada	530	14,684	516	12,009	616	15,286	707	21,525	887	26,204
Egypt	64	1,938	30	668	27	689	(1)	463	--	--
France	14	487	15	1,633	47	2,868	57	2,785	8	298
Germany, West	1	211	58	2,952	93	5,345	45	2,069	13	1,152
Greece	--	--	9	194	--	--	--	--	37	1,228
Hong Kong	(1)	211	(1)	272	1	181	6	652	26	1,023
Italy	204	5,347	729	20,364	879	25,781	491	22,657	590	22,599
Japan	5,300	173,259	3,383	92,098	4,204	126,254	5,208	208,601	1,744	54,369
Korea, Republic of (South)	307	10,773	304	10,004	553	20,347	667	30,971	324	11,799
Mexico	747	25,748	525	18,074	580	20,210	821	35,368	555	20,027
Pakistan	(1)	(1)	22	457	(1)	40	(1)	11	52	1,639
Spain	85	1,609	306	6,939	1,034	29,052	r 1,154	r 45,725	610	20,354
Sweden	28	4,200	105	16,068	204	19,766	r 161	r 24,712	20	4,437
Taiwan	85	2,973	157	4,604	95	3,658	151	7,097	387	12,584
Thailand	12	380	47	1,323	61	1,950	45	1,950	39	1,464
Turkey	29	770	77	1,940	79	2,013	72	3,530	73	2,465
United Kingdom	1	130	3	268	310	10,514	251	10,909	335	12,785
Venezuela	18	516	30	783	58	1,683	179	5,587	212	5,244
Yugoslavia	--	--	65	1,876	11	450	22	1,006	56	2,271
Other	24	838	42	1,584	38	1,603	r 47	r 2,359	43	1,774
Total	7,473	244,997	6,444	194,900	8,923	289,537	r 10,111	r 431,910	6,082	206,420

r Revised.
[1] Less than ½ unit.

Table 12.—U.S. exports of rerolling material (scrap), by country

(Thousand short tons and thousand dollars)

Country	1967		1968		1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	1	$55	(1)	$28	(1)	$8	5	$208	1	$46
Japan	18	817	10	343	15	588	13	584	5	190
Korea, Republic of (South)	92	3,846	101	4,728	174	8,318	187	11,737	83	4,562
Mexico	9	425	9	447	22	1,103	33	2,036	27	1,530
Taiwan	16	686	7	298	3	156	(1)	10	44	2,023
Thailand	--	--	--	--	12	707	6	398	--	--
Venezuela	26	105	--	--	2	65	2	99	2	105
Yugoslavia	--	--	--	--	--	--	--	--	11	419
Other	--	--	--	--	26	2,225	5	392	2	103
Total	162	5,934	127	5,844	254	13,170	251	15,464	175	8,978

[1] Less than ½ unit.

Table 13.—U.S. exports of ships, boats, and other vessels for scrapping

(Thousand short tons and thousand dollars)

Country	1967		1968		1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Bahamas	--	--	8	$137	5	$78	--	--	--	--
Canada	12	$116	7	97	3	20	18	$338	30	$493
Denmark	7	130	--	--	--	--	--	--	--	--
Germany, West	--	--	--	--	--	--	15	197	5	77
Hong Kong	--	--	8	275	12	210	--	--	--	--
Italy	13	54	--	--	--	--	48	913	--	--
Japan	--	--	3	125	--	--	6	100	--	--
Mexico	--	--	--	--	3	51	--	--	--	--
Netherlands	--	--	--	--	--	--	15	275	--	--
Spain	--	--	51	725	70	1,098	357	7,637	255	4,788
Taiwan	--	--	38	734	20	849	58	1,607	106	1,463
Other	2	6	5	12	1	13	14	407	(1)	3
Total	34	306	120	2,105	114	2,319	531	11,474	396	6,824

[1] Less than ½ unit.

Table 14.—U.S. imports for consumption of iron and steel scrap, by country

Country	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	--	--	10	$3
Canada	294,122	$10,906	261,093	10,038
Japan	968	25	--	--
Mexico	4,332	101	16,766	360
South Africa, Republic of	--	--	26	12
Sweden	1,358	114	1,102	106
United Kingdom	414	49	4,336	736
Other	99	5	98	4
Total	301,293	11,200	283,431	11,259

Iron Oxide Pigments

By Henry E. Stipp [1]

Demand for iron oxide pigments increased moderately in 1971, spurred by a substantial increase in automobile sales and record new housing construction. Sales of finished iron oxide pigments were valued at $31.3 million, and imports of iron oxide pigments were valued at $6.2 million, indicating a $36 million domestic market. Consumption of pigment-grade iron oxides in the production of ferrites was substantial. The ferrite industry reportedly was more than a $200 million industry and was said to be growing at more than 10 percent per year. The future of iron oxide pigments was expected to be excellent, owing to a projected increase in the sale of household furnishings, durable goods, and construction materials.

DOMESTIC PRODUCTION

Mine production of crude iron oxide pigments decreased substantially for the third consecutive year. Figures for mine output were withheld in 1971 to avoid disclosing confidential company data. Four companies operating mines in four States reported production of crude iron oxide pigments. Cleveland-Cliffs Iron Co. produced the largest quantity from mines in Michigan.

Production of finished iron oxide pigments (as indicated by sales) in 1971 increased 3.5 percent to 128,308 short tons, compared with 123,988 short tons in 1970. Thirteen companies operated 18 establishments in 10 States in 1971. Charles Pfizer & Co., Inc., was the major producer, with plants in Pennsylvania, Illinois, and California.

Domestic production of iron oxide pigments was inadequate to meet demand and had to be supplemented with imported material.

Table 1.—Salient iron oxide pigments statistics in the United States

	1967	1968	1969	1970	1971
Mine production ---- short tons--	39,900	57,600	40,600	38,600	W
Crude pigments sold or used ---- do----	41,800	57,600	40,800	39,200	W
Value ---- thousands--	$326	$457	$362	$442	$414
Finished pigments sold ---- short tons--	127,300	132,400	142,900	124,000	128,300
Value ---- thousands--	$27,000	$31,000	$32,000	$28,000	$31,000
Exports ---- short tons--	3,000	3,000	4,000	5,000	4,000
Value ---- thousands--	$1,000	$1,000	$1,000	$2,000	$2,000
Imports for consumption ---- short tons--	23,000	30,000	33,000	33,000	36,000
Value ---- thousands--	$3,000	$4,000	$5,000	$6,000	$6,000

W Withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

The 5.7 percent increase in the consumption of iron oxide pigments in 1971 compared with 1970 was probably the result of increased economic activity, particularly in the durable goods (automotive) and construction materials fields. Inventories were increased during the first three quarters of the year in anticipation of the dock

[1] Physical scientist, Division of Ferrous Metals.

strikes. At yearend, some categories of iron oxide pigments were in short supply, owing to inventory depletion due to the dock strikes.

Iron oxide was used as a pigment in paints, rubber, plastics, concrete products, paper, magnetic ink, and fertilizers. It is used also in ferrite applications such as television components, filters in radio equipment, computer memory cores, door latches and seals, small electric motors, and inductor and microwave devices. Iron oxide material is used also in miscellaneous applications such as abrasives, welding rod coatings, soil conditioners, foundry sands, and automobile brake linings.

Data are not collected by the Bureau of Mines on specific uses of iron oxide pigments, and the figures given in table 2 do not necessarily reflect all sales of iron oxide pigment material for uses except as pigment.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Natural:				
Brown:				
Iron oxide (metallic) [1]	r 11,823	r $2,058	13,453	$2,109
Umbers:				
Burnt	4,258	1,014	4,441	1,136
Raw	1,087	262	1,196	309
Red:				
Iron oxide [2]	r 26,847	r 1,813	27,518	1,938
Sienna, burnt	963	352	903	401
Yellow:				
Ocher [3]	4,718	312	10,181	2,088
Sienna, raw	619	201	787	277
Total natural	r 50,315	r 6,012	58,479	8,258
Manufactured:				
Black: Magnetic	r 6,262	r 1,379	3,692	2,384
Brown: Iron oxide	r 4,656	r 1,731	6,272	2,284
Red:				
Pure red iron oxides:				
Calcined copperas	14,199	4,602	20,540	6,696
Other chemical processes	[4] r 14,461	r 3,786	11,492	2,861
Venetian red	592	124	467	106
Yellow: Iron oxide	25,075	8,004	22,469	7,643
Total manufactured	r 65,245	r 19,626	64,932	21,974
Unspecified including mixtures of natural and manufactured red iron oxides	8,428	2,559	4,897	1,105
Grand total	123,988	28,197	128,308	31,337

r Revised.
[1] Includes black magnetite and vandyke brown.
[2] Includes pyrite cinder.
[3] Includes yellow iron oxide.
[4] Includes other manufactured red iron oxide.

PRICES

Price increases ranging from one-fourth cent to 2 cents per pound were posted on most items during the first half of 1971. In the fourth quarter of the year, price increases were prohibited unless specifically authorized by the Federal Price Commission. Demand for iron oxide pigments, especially the yellow type, was strong in the fourth quarter of the year, owing mainly to the effects of the coastal dock strikes. Inventories were depleted and a shortage of some grades of iron oxide pigments resulted. The buildup of inventories earlier in the year was retarded by the shutdown of two domestic plants in midyear.

Table 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise noted, as of December 31, 1971 [1]

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Pure	$0.1575	$0.1900	Domestic primers	$0.0725	$0.1050
Synthetic	.1600	.1875	Persian Gulf	.1300	.1375
Brown:			Pure synthetic	.1800	.1850
Pure, synthetic	.1875	.2200	Spanish, ex dock, New York [2]	.1100	.1175
Metallic	.0775	.1025	Yellow:		
Umber, American, burnt	.1125	.1450	Ocher, domestic	.0550	.0575
Umber, American, raw	.1150	.1450	Ocher, French type	.1000	.1150
Vandyke, American [2]	.1450	.1550	Pure, light lemon	.1600	.1725
Sienna, American, burnt	.1325	.2850	Other shades	.1500	.1625

[1] Low and high range covers prices for car lots and less than car lots, at the works.
[2] Barrels.

Source: Oil, Paint and Drug Reporter and American Paint Journal.

FOREIGN TRADE

Despite the adverse effects of dock strikes, the 10-percent tariff surcharge, and monetary revisions, total imports of iron oxide pigments into the United States in 1971 increased 11.7 percent to 36,496 short tons compared with 32,684 short tons in 1970. The value of iron oxide pigments imports in 1971 increased 6.9 percent to almost $6.2 million contrasted with about $5.8 million in 1970. Manufactured iron oxide pigments made up the major portion of total imports. Crude and refined umber constituted the bulk of natural iron oxide pigments imports. West Germany, Canada, and the United Kingdom supplied the bulk of manufactured iron oxide pigments, while Spain provided the major supply of natural pigment imports.

Exports of iron oxide pigments from the United States in 1971 decreased 1.3 percent to 3,984 short tons, contrasted with 4,565 short tons in 1970. However, the value of exports of iron oxide pigments increased 0.4 percent to $1.7 million compared with $1.6 million in 1970. Canada was the destination of the major quantity of iron oxide pigments exports in 1971.

Table 4.—U.S. exports of iron oxide and hydroxides, by countries, 1971

Destination	Pigment grade		Other grades	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	45	$22	45	$28
Australia	277	145	163	106
Belgium-Luxembourg	80	27	48	28
Brazil	126	77	81	44
Canada	1,742	545	2,043	828
Colombia	28	11	67	33
France	267	137	357	259
Germany:				
East	--	--	119	57
West	47	32	614	227
Guatemala	31	14	10	4
India	10	8	502	370
Italy	36	17	342	414
Japan	50	45	837	685
Mexico	75	49	100	48
Netherlands	--	--	266	323
Netherlands Antilles	1	1	191	96
New Zealand	27	13	--	--
Panama	5	4	10	6
Philippines	36	15	3	2
South Africa, Republic of	4	3	30	19
Sweden	17	8	8	3
United Kingdom	308	187	623	494
Venezuela	172	75	28	18
Vietnam, South	440	169	--	--
Other	160	76	74	40
Total	3,984	1,680	6,561	4,132

Table 5.—U.S. imports for consumption of selected iron oxide pigments

Kinds	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Natural:				
Ocher, crude and refined	62	$4	--	--
Siennas, crude and refined	1,051	115	1,427	$125
Umber, crude and refined	4,883	171	4,681	228
Vandyke brown	435	50	358	39
Other [1]	2,115	155	1,794	171
Total	8,546	495	8,260	563
Manufactured (synthetic)	24,138	5,264	28,236	5,592
Grand total	32,684	5,759	36,496	6,155

[1] Classified by the Bureau of the Census as "Natural iron-oxide and iron-hydroxide pigments, n.s.p.f."

Table 6.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, n.s.p.f., by countries

Country	Natural				Synthetic			
	1970		1971		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Austria	--	--	14	$2	--	--	--	--
Belgium-Luxembourg	--	--	--	--	15	$2	16	$3
Canada	10	$10	--	--	7,742	1,383	9,210	1,476
Cyprus	--	--	2	(1)	--	--	--	--
France	(1)	1	97	15	20	4	--	--
Germany:								
East	--	--	--	--	18	3	36	6
West	13	10	72	54	14,797	3,119	17,147	3,686
Italy	--	--	(1)	(1)	--	--	2	(1)
Jamaica	(1)	1	--	--	--	--	--	--
Japan	1	2	1	1	183	535	115	106
Netherlands	--	--	1	1	28	17	21	29
Portugal	22	1	--	--	--	--	--	--
Spain	1,848	109	1,598	92	5	1	85	5
Sweden	--	--	8	2	--	--	--	--
Switzerland	--	--	1	4	1	(1)	--	--
United Kingdom	221	21	--	--	1,329	200	1,604	281
Total	2,115	155	1,794	171	24,138	5,264	28,236	5,592

[1] Less than ½ unit.

TECHNOLOGY

Natural iron oxide pigments reportedly have been replaced in many applications by synthetic iron oxide pigments.[2] However, the natural pigments are still being used, and some grades are assured an expanding market in future years. In competition with other pigments, iron oxide will continue to be used because of its cheapness, permanence, and availability.

The development of alkyd and polyester resins formulated with black iron oxide pigments and carbon black was reported to be a significant step in the process of applying paint by electrocoating.[3] These materials electrodeposited on a metal surface act as conductive primers, enabling a second coat to be deposited. Normally, only one coat of paint can be applied by this method;

[2] Industrial Minerals. Iron Oxide Pigments. No. 50, November 1971, pp. 9–19.

[3] American Paint Journal. A Review of the Paint Industry for 1970. V. 56, No. 1, July 26, 1971, pp. 55–59.

therefore, it has been used mainly for primers and undercoatings.

A Soviet patent (No. 220,478) covered powder coatings that can be made to adhere to a surface more securely by incorporating in them a powdered iron oxide or iron.[4] After application of the coating, the object is magnetized, attracting the ferromagnetic powder and increasing the adhesion of the coating. East German patent 66,240 also described paints that are made magnetic by incorporating powders of ferrous materials.

A possible source of ferric iron oxide was described in a U.S. patent.[5] Bayer process red mud was reacted with sulfur dioxide to precipitate ferric iron oxide.

Iron oxide-based cassette recording systems reportedly are almost as good as chromium dioxide cassettes and are comparable to regular audio-tape recording systems.[6] However, both chromium and iron oxide systems may soon face market competition from metal powder systems which offer very low tape speed and greater miniaturization.

A nonmagnetic, black iron oxide pigment, which has high temperature resistance and is nonfloating and flocculating, was introduced recently in West Germany.[7] It has good dispersibility. The pigment can be used for electrocoating paints as well as decorative and silicone paints.

[4] American Paint Journal. V. 56, No. 12, Oct. 11, 1971, p. 71.

[5] Tsai, J. H., Chemical Precipitation. U.S. Pat. 3,574,537, Apr. 13, 1971, 2 pp.

[6] Chemical and Engineering News. Du Pont Challenged on Magnetic Tape. Feb. 21, 1972, p. 12.

[7] American Paint Journal. V. 56, No. 11, Oct. 4, 1971, p. 71.

Kyanite and Related Minerals

By J. Robert Wells [1]

Kyanite, sillimanite, andalusite, dumortierite, and topaz are members of a group of related anhydrous aluminum silicate minerals that, in common with synthetic mullite, can be used as materials for the manufacture of specialized refractories of the high-alumina type. Industrial utilization of dumortierite and topaz for this purpose has not been reported in recent years.

India, the United States, and the Republic of South Africa, with some jockeying for first place, are customarily the world leaders in reported production of kyanite-group materials. In the absence of definite information, however, it seems likely that the U.S.S.R. should be ranked high among kyanite-group producers.

Although domestic kyanite production edged slightly upwards in 1971 and attained the highest point in history, other indications, at least for the short-term future, were less encouraging. Total value of 1971 shipments of all nonclay refractories fell 6 percent below the 1970 figure, while refractories specifically made of kyanite and related materials declined even further, reaching only 90 percent of the previous total. Domestic production of synthetic mullite in 1971, although only fractionally off from the year before in terms of tonnage, was conspicuously lower in reported total value, presumably reflecting slackness in demand for higher-unit-value materials.

In marked contrast to other, less favorable international-trade balances in 1971, the United States exported kyanite-mullite with a total value more than 32 times that of the year's kyanite-group imports.

Legislation and Government Programs.—Kyanite-mullite was removed in 1970 from the list of strategic materials for stockpiling, and at that time approximately 4,800 short tons was listed on Government inventory. On August 11, 1971, the 92d Congress approved Public Law 92–116 authorizing the Administrator of General Services to dispose of the entire holding. The General Services Administration issued an invitation on November 23, 1971, for sealed bids for the as-is sale of part of the material involved, specifically 282 short tons of kyanite, natural ore, lump, of Indian origin, drawn from three separate lots, for each of which a chemical analysis was stated, and 2,004 short tons of synthetic mullite, lump, originally produced by the Carborundum Co. No acceptable bids in response to this offering had been received by December 15, 1971, the specified opening date.

The Office of Minerals Exploration offers to grant Government loans up to 50 percent of approved costs for the exploration of eligible kyanite deposits, but no loans for that purpose were made in 1971.

According to provisions of the Tax Reform Act of 1969, the depletion rates allowed on kyanite production are 22 percent for domestic operations and 14 percent for foreign.

DOMESTIC PRODUCTION

Kyanite was produced in the United States in 1971 from three open-pit mines, two in Virginia and one in Georgia. In addition, a comparatively minor quantity of kyanite-sillimanite concentrate was recovered as a coproduct in the process of extracting titanium and zirconium minerals from a beach-sand deposit in Florida. Kyanite Mining Corp. operated the Wills mine in Buckingham County, Va., and the Baker mine in Prince Edward County, Va.

[1] Physical scientist, Division of Nonmetallic Minerals.

Aluminum Silicates, Inc., operated the Graves Mountain mine in Lincoln County, Ga. E. I. du Pont de Nemours & Co., Inc., operated the Trail Ridge mine in Clay County, Fla.

Domestic kyanite output in 1971, as measured by the quantity sold or used, was 2 percent higher in tonnage than in 1970 and represented an increase of 6 percent in total value, establishing new all-time highs in both respects. The increase, even though moderate, was notable in that it was achieved in spite of continued inactivity at a formerly important source in South Carolina. Specific kyanite production statistics for 1971 (as well as for all previous years since 1949) are withheld because the predominating position of the only two major producers would make publication even of national totals equivalent in effect to a disclosure of each company's confidential data.

Synthetic mullite, produced in 1971 by seven companies at operations in six States, amounted to only slightly less in tonnage than in 1970 but substantially less in total value. Sharp decreases in value reported in four States more than outweighed advances in the other two.

Leading producers were Mullite Corp. of America, in Sumter County, Ga., Charles Taylor & Sons, Inc., in Greenup County, Ky., and Harbison-Walker Refractories Co., in Henry County, Ala.

Table 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1967	40,288	$4,811
1968	36,014	5,758
1969	48,588	6,847
1970	55,516	8,840
1971	55,077	4,945

CONSUMPTION AND USES

Kyanite and related minerals, without notable departure from the customary end-use pattern, were consumed in 1971, mostly in the manufacture of refractories in the high-alumina or mullite class and in lesser quantities as ingredients in some ceramic compositions. Imported Indian kyanite was calcined in its natural lump form and then usually separated into designated particle-size ranges for use chiefly as a grog. Domestic kyanite already ground to about minus 35 mesh, as required by the flotation process used to eliminate the accompanying quartz gangue, was marketed in the raw form or after heat treatment for conversion to mullite, sometimes after further particle-size reduction. In the minus 35 to minus 48-mesh range, the mineral was employed 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 the making of kiln furniture, insulating brick, firebrick, and other refractory shapes of a wide variety of types. Material in the smaller size ranges, minus 200 mesh for example, was used especially in body mixes for sanitary porcelains, wall tile, precision casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1971, listed the following prices (2 to 12 percent above December 1970 quotations) for kyanite, f.o.b. Georgia, bags (bulk shipments $2.00 less per ton):

	Per short ton
35 mesh	$58
48 mesh	62
100 mesh	65
200 mesh	73
325 mesh	Nominal

Prices and price ranges quoted for kyanite-group minerals by Industrial Minerals (London), December 1971, were as follows (after conversion from pounds sterling per long ton to dollars per short ton):

	Per short ton
Andalusite, Transvaal, c.i.f.	$51–$56
Kyanite, Indian, c.i.f.	65– 79
Sillimanite, Indian, natural, f.o.b.	83
Calcined sillimanite, f.o.b. Calcutta	94

FOREIGN TRADE

In 1971, exports of kyanite-mullite from the United States reached their highest level in history, almost one-third more (in terms of both quantity and total value) than the former record figure of 1970. U.S. kyanite-group imports in 1971, although up about 15 percent from those of the previous year, represented no significant departure from the established tenor. Outweighed more than 20 to 1 by exports, the imports amounted to less than half the previous decade's annual average.

Tariff regulations applicable throughout 1971 provided for duty-free importation of kyanite, sillimanite, andalusite, and dumortierite. The duty on mullite, which amounted to 10 percent ad valorem in 1970, was reduced to 9 percent ad valorem on January 1, 1971, and a further reduction was scheduled for 1972. A 10-percent ad valorem surcharge (not to exceed the statutory limit), imposed August 16, 1971, on all dutiable imports, was removed on December 20, 1971.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1969		1970		1971	
	Short tons	Value	Short tons	Value	Short tons	Value
Exports:						
Argentina	19	$1,462	245	$18,375	257	$20,404
Australia	692	49,438	715	55,642	565	45,434
Belgium-Luxembourg	487	34,480	739	48,004	221	18,658
Canada	4,342	306,801	6,765	443,911	5,698	412,310
China, Republic of (Taiwan)	589	20,750	309	8,823	--	--
Colombia	209	9,381	--	--	661	37,791
France	157	26,045	285	34,240	717	80,584
Germany, West	2,559	168,145	2,707	170,246	1,502	92,571
Italy	2,845	211,864	2,996	229,425	9,961	533,850
Japan	2,338	151,762	2,168	167,869	2,166	180,319
Mexico	1,498	105,796	2,435	164,591	1,877	128,057
Netherlands	22	634	--	--	2,635	187,840
Philippines	20	2,190	75	5,877	170	17,635
South Africa, Republic of	77	6,319	41	6,044	157	8,230
Sweden	1,124	64,673	1,217	72,775	2,609	163,405
Thailand	--	--	61	3,800	10	834
United Kingdom	1,476	85,989	2,213	122,757	1,461	103,652
Venezuela	740	67,923	780	46,437	583	41,597
Other	502	39,733	273	23,217	304	24,096
Total	19,696	1,353,385	24,024	1,622,033	31,554	2,097,267
Imports:						
Canada	306	17,921	--	--	--	--
France	--	--	1	290	1	1,612
India	1,167	48,439	1,178	55,264	1,301	60,743
Mozambique	277	9,921	--	--	--	--
South Africa, Republic of	338	11,928	--	--	41	2,891
Total	2,088	88,209	1,179	55,554	1,343	65,246

WORLD REVIEW

Although in many cases only limited quantitative information has been published, significant production of kyanite-group minerals in recent years has been reported in Australia, France, India, Malawi, Mozambique, Rhodesia, Republic of South Africa, South Korea, Spain, Territory of South-West Africa, and the United States.[2] Presumably, a number of the more industrialized Communist countries also produce and consume substantial quantities of kyanite minerals, but no data are available.

Argentina.—A second blast furnace complex, incorporating four blast preheaters designed for exceptionally high operating temperatures, is being constructed by the Sociedad Mixta Siderúrgia Argentina (SOMISA) for the General Savio Steel Works at San Nicolás, Buenos Aires Prov-

[2] Thomas, I. A. Sillimanite Minerals. Mining Annual Review (London), 1971 Edition, June 1971, pp. 112–113.

ince. A contract to supply mullite refractories with a total value in excess of $1 million for the new furnace was awarded to Chas. Taylor Sons Co. of Cincinnati, Ohio.

France.—Commercial extraction of andalusite from schists at Glomel, Brittany, launched in 1970, was scheduled for expansion to 13,000 short tons per year by the end of 1971.

India.—Production of lump kyanite in India during 1970, the last year for which final data are available, amounted to 131,171 short tons, with a total value of $3.4 million, compared with a revised figure of 73,066 short tons and $2.1 million in 1969. It was stated that this expanded level of production, the highest on record, was achieved as a result of the Indian Government's policy of stimulating output of the mineral in anticipation of a significant increase in demand, both for domestic consumption and for overseas markets. Exports of Indian kyanite in 1970 totaled 74,983 short tons, valued at $4.0 million, in the neighborhood of one and one-half times the corresponding figures for 1969. Principal recipients of the exported mineral were Japan, 20 percent of the total; Italy, 17 percent; United Kingdom, 12 percent; Federal Republic of Germany, 9 percent; and Belgium, 7 percent. The remaining 35 percent was distributed among 10 other countries, with approximately 2 percent of the total coming to the United States. The 1970 output of sillimanite was 5,029 short tons, of which 2,135 short tons was exported—58 percent to Japan, 26 percent to the Federal Republic of Germany, and 16 percent to Belgium.

Malawi.—Active production of kyanite from the Kapiridimba ore body was resumed after more than 10 years of suspension, making Malawi the only present world source of lump kyanite other than India.

South Africa, Republic of.—Output of kyanite-group minerals in 1970 consisted of 46,872 short tons of andalusite and 35,181 short tons of sillimanite, according to the Quarterly Information Circular, October–December 1970, published by the Republic's Department of Mines. Exports of andalusite, with a declared value of $0.9 million, accounted for just over half of the total 1970 production, and exports of sillimanite, amounting to 88 percent of the year's production, were valued at $2.0 million. As tabulated in the January–September 1971 issue of the Circular, production of andalusite in those 9 months was 15 percent greater than in the corresponding period of 1970, but the output of sillimanite was 44 percent less. Exports of andalusite during that period were practically on a level, in both quantity and value, with those in the same months of 1970, while sillimanite exports fell by about 25 percent in tonnage and 21 percent in total value. The Republic has no current production of kyanite, but active exploration has been undertaken of deposits existing in the northern part of Cape Province.

United Kingdom.—A new kiln of the tunnel type, 150 meters in length, was completed and placed in operation at Parkandillick, Cornwall, by English Clays, Lovering Pochin & Co., Ltd. This recent addition, supplementing two other furnaces already in service, doubled the capacity of the English Clays plant (now the largest of its kind in existence), which produces a high-performance alumino-silicate refractory material by the prolonged heat treatment of china clay (up to 1,525° C in a 60-hour cycle). The product, trade-named "Molochite" and consisting essentially of acicular crystals of mullite embedded in amorphous fused silica, is increasingly in demand (often in excess of available supply) for use in a number of specialized refractories applications including the manufacture of blast furnace stack linings, kiln furniture for the ceramics industry, and erosion-resistant surfaces for jet plane turbine blades.[3]

Continental Ore Co., Ltd., of London and Sheffield, was named exclusive sales agent in the United Kingdom for the extensive list of refractory materials, including mullite and raw or calcined kyanite, that are produced in the United States by C–E Minerals Division of Combustion Engineering, Inc.

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[3] Industrial Minerals (London). Molochite: English China Clays Doubles Capacity to 80,000 Tons a Year. No. 50, November 1971, pp. 20–21.

TECHNOLOGY

Two papers presented at the November 1971 meeting of the National Institute of Ceramic Engineers in Anaheim, Calif., dealt with aspects of kyanite-mullite refractories technology. Abstracts of those papers were published in an industrial journal.[4]

Two reports were published summarizing results of research conducted by the Bureau of Mines on the extractive metallurgy of kyanite and other specified minerals.[5]

A journal article, with some attention to both theoretical and practical considerations, reviewed techniques and equipment types for reducing mine-run mineral materials to the particle-size ranges in which they can serve the needs of industry, or, conversely, for agglomerating those too finely divided for advantageous utilization. Kyanite was one of the minerals for which grindability indices and other grinding information were cited.[6] Subsequent articles by the same author summarized details of various processes that are applicable for the separation and concentration of specific industrial minerals, one of which was kyanite. Procedures discussed in relation to kyanite ore treatment included gravity separation by tabling, electromagnetic separation, and froth flotation.[7]

Kyanite can be used as an alternative ingredient to replace tabular alumina and alpha quartz in a patented composition for the production of fused alumina refractories.[8] Calcined kyanite, mixed with asbestos, iron powder, lead, lead sulfide, petroleum coke, and other substances, is used in the manufacture of composite friction elements, according to a recent foreign patent.[9] Kyanite, tabular alumina, calcined alumina, kaolin, and asbestos or glass fiber are the materials specified in a patent to be compounded with water and phosphoric acid for the manufacture of alumina refractories of the ramming-mix type that are highly resistant to abrasion and to temperatures in excess of 2000° F.[10]

Mullite and various types of mullite refractories can be produced by firing a dry mixture of aluminum chlorohydroxide and silica in a process for which a patent was issued.[11] A method was patented according to which granular mullite or other specified granular materials can be compacted by high-pressure impact compression to form molded shapes suitable for firing to produce very dense, highly refractory articles.[12]

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[4] Prior, H. David, and Arthur J. Metzger. A Bond for Mullite Refractories (abstract). Ceram. Bull., v. 50, No. 9, September 1971, p. 802.

Smith, Peter C., and Robert E. Moore. High Temperature Compressive Creep of Mullite (abstract). Ceram. Bull., v. 50, No. 9, September 1971, pp. 803–804.

[5] Davis, E. G., and G. V. Sullivan. Recovery of Heavy Minerals From Sand and Gravel Operations in the Southeastern United States. BuMines Rept. of Inv. 7517, 1971, 25 pp.

Llewellyn, Thomas O., and James S. Browning. Continuous Heavy Liquid Concentration of Kyanite. BuMines Rept. of Inv. 7481, 1971, 11 pp.

[6] Jones, G. K. Size Reduction and Size Enlargement. Industrial Minerals (London), No. 47, August 1971, pp. 33–43.

[7] Jones, G. K. Concentration of Minerals by Sizes and Gravity. Separating Minerals by Froth Flotation, Electrical Properties, and Other Methods. Industrial Minerals (London), No. 49, October 1971, pp. 43–50; No. 51, December 1971, pp. 39–41.

[8] Drever, J. R., P. D. Zimmerman, and A. B. Brink (assigned to Amsted Industries, Chicago, Ill.). Composition for Making Refractory Articles. U.S. Pat. 3,567,473, Mar. 2, 1971.

[9] Griffith, A. M. (assigned to Abex Corp.). British Pat. 1,236,218, June 23, 1971.

[10] Salazar, P. V. (assigned to Nalco Chemical Co.). Canadian Pat. 879,143, Aug. 24, 1971.

[11] Albert, R. E. (assigned to E. I. du Pont de Nemours & Co., Wilmington, Del.). Process for the Preparation of Mullite Bonded Refractory Materials. U.S. Pat. 3,615,778, Oct. 26, 1971.

[12] Star, S., J. A. Waterman, and A. M. Daniel (assigned to Israel Mining Industries, Institute for Research & Development). British Pat. 1,217,267, Dec. 31, 1970.

Lead

By J. Patrick Ryan [1]

World production of lead in 1971 declined from the record level of 1970, but as lead consumption increased an improved supply-demand relationship was achieved. Free world mine production decreased about 3 percent as production gains in Canada, the United States, and Mexico were not sufficient to offset losses in other countries. An increase of about 2 percent in metal consumption was accompanied by a significant decline in metal inventories, particularly in the United States.

Free world producer stocks of lead declined about 79,000 tons during the year to about 224,000 tons at yearend. The improved supply-demand relationship was the principal factor tending to stabilize market price. A modest increase in the New York price of lead was achieved in the second half of the year. The London Metal Exchange (LME) quotation remained relatively stable during the first 7 months of 1971, but declined sharply following imposition of the surcharge on U.S. imports on August 15, 1971. After the duty surcharge was removed in December the LME price began to rise.

The domestic lead industry achieved increases in both mine production and consumption of lead, but production of primary refined metal declined owing to the sharp reduction in imports of crude materials for processing in domestic plants. Mine production increased 1 percent to 578,600 tons as gains in Missouri, Idaho, and Colorado more than offset the decline in Utah's output. Primary lead production from both domestic and foreign sources was nearly 2 percent less than the record high level achieved in 1970. Domestic mines contributed 88 percent of the total primary metal. Secondary lead output of 596,800 tons, representing about 40 percent of the market supply, was only slightly less than the 1970 output. The domestic supply of lead—primary, secondary, and imports—amounted to 1.46 million tons, 6,000 tons less than in 1970.

Demand for lead for use in transportation continued to grow as requirements for the major component, batteries, increased 15 percent; however, antiknock requirements declined 5 percent below the record level of 1970. Ammunition requirements increased substantially, but the quantity of lead used in pigments decreased. Total consumption of lead was 1.43 million tons, 71,000 tons more than in 1970. Battery use amounted to 47 percent of the total and gasoline additives, 18 percent.

Primary metal stocks declined in every month during 1971 except January and July. From an inventory of 97,900 tons at the beginning of the year metal stocks were reduced to 51,800 tons at yearend. Commercial sales from the Government stockpile again were insignificant, with only 12 tons sold and shipped. Transfers to Government plant uses amounted to 9,600 tons. The available domestic supply from all sources indicated an apparent consumption of 85,000 tons of lead in addition to the reported consumption of 1.43 million tons.

The world price of lead, as indicated by the LME monthly average, in terms of U.S. currency, ranged between 11.92 cents and 12.23 cents per pound during the first 6 months, then declined to 10.04 cents in November, and moved up to 10.47 cents in December. The average for the year was 11.52 cents. The domestic price for common lead at New York held at 13.50 cents per pound until June 23, when a price range of 14 to 14½ cents was established which held through mid-December, when a split

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price of 14.0 to 14.3 cents was established for delivery anywhere in the United States. The New York price averaged 13.89 cents for the year.

At yearend, International Smelting and Refining Co. closed its custom lead smelter at Tooele, Utah, and U.S. Smelting, Refining and Mining Co. closed down its U.S. and Lark mine and Midvale mill.

Legislation and Government Programs.— The program of the Office of Minerals Exploration, Geological Survey, U.S. Department of the Interior, continued in effect but activity was minimal. Lead was withdrawn from the list of eligible metals in June 1962 and there was virtually no activity in connection with any previous certified projects involving lead.

Sales of Government surplus lead from the strategic stockpile to commercial users under Public Law 91–46 dropped to 12 tons from 22 tons sold in 1970. Lead authorized for sale on an off-the-shelf basis to commercial users was 77,290 tons at yearend 1971. Transfers for Government use in 1971 under Public Law 89–9 amounted to 9,572 tons used primarily at Government-owned ammunition plants. The remaining tonnage in the authorization was 21,683 at yearend. Actual drawdown of Government stock during 1971 was 13,180 tons, leaving a total of 1,127,440 tons remaining in the stockpile, of which 597,440 tons was in excess of the 530,000-ton stockpile objective.

In February legislation was introduced in the Congress to dispose of 498,000 tons of surplus lead in Government stocks. Hearings were held but further action was delayed pending determination of methods of disposal.

A bill (H.R. 8587) to provide an adequate supply of lead and zinc for consumption in the United States from domestic and foreign sources was introduced in May and referred to the Committee on Ways and Means. The proposed legislation was designed to implement, with respect to lead and zinc, the National Mining and Minerals policy (Public Law 91–631), but no further action was taken.

The International Lead and Zinc Study Group convened in Torremolinos, Spain, Nov. 2–6, 1971, to review the current situation and outlook for 1972 for lead and zinc. The forecasts for 1971 production and consumption of lead made at the 14th Session were reduced and a supply surplus of 53,000 tons was anticipated. For 1972, lead mine production was forecast to increase by 107,000 tons (4 percent) and lead metal production was forecast to increase 151,000 tons (5 percent) over 1971 levels. Lead metal consumption was predicted to exceed the 1971 level by 63,000 tons, 2 percent more than in 1971. The Study Group also discussed trade liberalization and the need to adopt policies designed to promote the orderly development of the lead and zinc industry throughout the world. Special groups were designated to continue investigations of specific supply-demand problems identified in the discussions and to submit recommendations for their alleviation to the Standing Committee.

The International Lead-Zinc Research Organization continued to sponsor a broad program of research on lead and lead compounds and to publish information on their applications including batteries, architectural uses, and cable sheathing. The Organization also described research on properties including corrosion resistance of lead and its alloys, preparation and uses of lead compounds, lead pigments in paints, and lead compounds in ceramics.

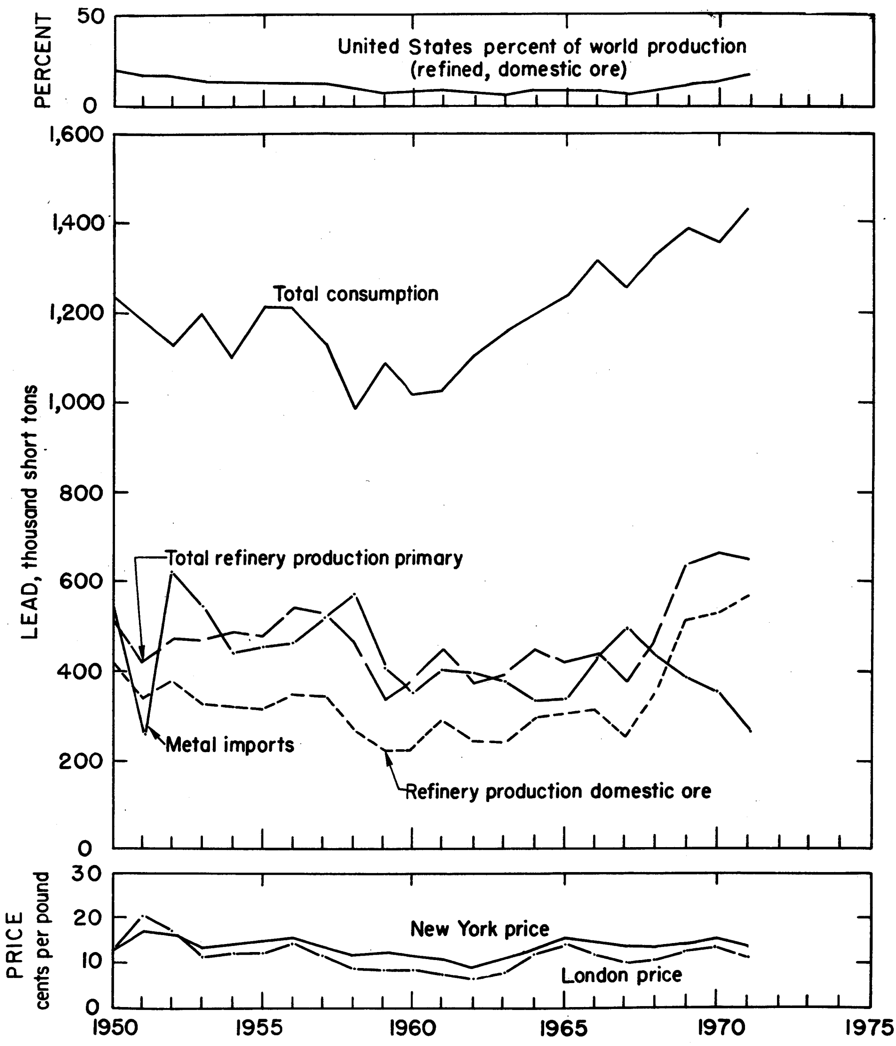

Figure 1.—Trends in the lead industry in the United States.

Table 1.—Salient lead statistics

(Short tons unless otherwise specified)

	1967	1968	1969	1970	1971
United States:					
Production:					
Domestic ores, recoverable lead content	316,931	359,156	509,013	571,767	578,550
Value ____ thousands	$88,741	$94,903	$151,635	$178,609	$159,679
Primary lead (refined):					
From domestic ores and base bullion	258,507	349,039	513,931	528,086	573,022
From foreign ores and base bullion	121,387	118,271	124,724	138,644	76,993
Antimonial lead (primary lead content)	9,083	19,494	16,250	11,655	16,116
Secondary lead (lead content)	553,772	550,879	603,905	597,390	596,797
Imports, general:					
Lead in ore and matte	124,067	87,836	109,252	112,406	65,998
Lead in base bullion	569	8	1,993	296	41
Lead in pigs, bars, and old	373,887	344,601	285,342	251,480	198,970
Exports of lead materials excluding scrap	6,536	8,281	4,968	7,747	5,925
Stocks December 31 (lead content):					
At primary smelters and refineries	125,479	90,427	101,860	192,985	121,660
At consumer plants	105,786	78,900	126,404	133,502	125,577
Consumption of metal, primary and secondary	1,260,516	1,328,790	1,389,358	1,360,552	1,431,514
Price: New York, common lead, average, cents per pound	14.00	13.21	14.93	15.69	13.89
World:					
Production:					
Mine	3,159,343	3,314,992	3,566,061	3,725,699	3,751,797
Smelter	3,182,316	3,250,514	3,553,458	3,622,306	3,492,274
Price: London, common lead, average, cents per pound	10.28	10.88	13.09	13.76	11.52

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of recoverable lead, continuing the rising trend since 1967, increased slightly to 578,500 tons in 1971, the greatest annual output since 1929. Monthly production reached a maximum of 56,100 tons in December, the largest monthly lead output in more than 30 years. Production from Missouri mines increased 7,900 tons to 429,600 tons, representing 74 percent of the total domestic lead in ore. Idaho, the second largest producer, provided 12 percent; Utah, 7 percent; and Colorado, 4 percent. These four States combined supplied 97 percent of domestic mine output. Although total production in Missouri increased slightly in 1971 only one mining company, Missouri Lead Operating Co., reported a production gain; the other three mine operators, St. Joe Minerals Corp., Cominco American Inc., and Ozark Lead Co. reduced output during the year.

The Buick mine of Missouri Lead Operating Co. was the leading lead producer, having displaced the Fletcher mine of St. Joe Minerals Corp. as first-ranking mine. The six leading mines, all in Missouri, contributed 72 percent of the total domestic mine production. The 10 leading mines produced 85 percent, and the 25 leading mines contributed 98 percent.

Although production of lead concentrate by St. Joe Minerals Corp. decreased 5 percent to 303,190 tons, the company reported a gain of nearly 8 percent in lead and lead alloy production to 222,213 tons in 1971. Development of the new Brushy Creek mine continued during the year. The new facilities scheduled for initial production in 1973 will have a capacity of 70,000 tons of lead concentrate per year.[2]

In the second full year of operations of the Buick mine by Missouri Lead Operating Co., a joint venture of American Metal Climax Inc. and Homestake Mining Co., ore milled increased over 40 percent to 1.34 million tons, from which 124,049 tons of lead concentrate was produced. The company reported improvements in ore extraction and processing methods and increased labor efficiency and productivity. Ore reserves at yearend were approximately 61 million tons with an average grade of 4.7 percent lead and 1.7 percent zinc.[3]

[2] St. Joe Minerals Corp. 1971 Annual Report. Pp. 13, 16.

[3] Homestake Mining Co. Ninety-Fourth Annual Report. 1971, pp. 5–6.

According to the Annual Report of Kennecott Copper Corp.[4] the Ozark Lead Co. produced 55,300 tons of lead, compared with 66,900 tons in 1970. The loss in production was largely attributed to a labor strike at ASARCO's Glover, Mo. smelter which buys Ozark's lead concentrate. After settlement of the 7-month strike in April 1971 Ozark continued to operate on a reduced scale as the smelter processed the inventory of concentrates that had accumulated during the strike. Ozark also achieved increased productivity during 1971 from less than 30 to more than 45 tons per man-shift, and operated the entire year without a lost-time injury.

The Magmont mine at Bixby, Mo., jointly owned by Cominco American Inc. and Dresser Industries Inc., increased lead ore production 14 percent to 1.04 million tons, but owing to a lower grade of ore extracted the lead content of concentrate produced declined approximately 15 percent.

Production in Idaho, the second largest State in lead output, increased 5,400 tons compared with 1970. Production gains at the Lucky Friday, Dayrock, and Star mines together more than offset the loss in output at the Bunker Hill mine. Although total tonnage mined at the Bunker Hill mine increased during the year the average grade of ore decreased. Hecla Mining Co. reported[5] ore production of 246,100 tons at the Star-Morning mine owned jointly by Hecla (30 percent) and Bunker Hill (70 percent), about 30,000 tons more than in 1970. Hecla's share of the 1971 production was 73,800 tons yielding 3,800 tons of lead. The company continued deep-level development below the 7,500-foot level and improved production facilities during the year. Hecla's Lucky Friday mine produced 213,390 tons of ore yielding 23,500 tons of lead, about 4,400 tons more than in 1970. Ore reserves at yearend totaled 552,000 tons compared with 624,000 tons in 1970.

In Utah, lead output declined about 16 percent in 1971. The Mayflower mine operated by Hecla Mining Co. produced 124,350 tons of ore yielding 4,860 tons of lead, slightly less than in 1970. Ore reserves at yearend were estimated at 183,000 tons, 57,000 less than in 1970. The company reported that development work has been curtailed and that continued production is rapidly depleting ore reserves. U.S. Smelting Refining and Mining Co. closed its U.S. and Lark mine and Midvale mill late in the year as operations became uneconomic.

The Tintic Division of Kennecott Copper Corp. reported decreased output. Adverse mining conditions at the Burgin mine retarded mining in some areas. The company reported the discovery of additional reserves in the Trixie area and stated that development work in the Ball Park area indicated moderately high-grade reserves. The critical shortage of skilled miners continued to constrain mine development and output.

In Colorado lead output increased nearly 18 percent owing largely to new production at the Leadville Unit, an ASARCO-managed joint venture with Newmont Mining Corp. at Leadville, Colo., and increased output by the Idarado Mining Co. The Leadville Unit began production in April and full production capacity of 20,000 tons of ore per month is expected to be achieved during the second quarter of 1972. Ore reserves were estimated at 2.72 million tons averaging 5.16 percent lead and 9.94 percent zinc.[6] Idarado Mining Co. milled 391,300 tons of ore averaging 2.29-percent lead and 3.75-percent zinc, an increase of about 12 percent in tons milled and a corresponding increase in lead produced. Rico Argentine Mining Co., Homestake Mining Co. and Standard Metals Corp. also operated mines in Colorado that supplied lead concentrates during the year. Emperius Mining Co. closed its Commodore mine at Creede early in the year.

SMELTER AND REFINERY PRODUCTION

Reversing the gains of the preceding 3 years, primary refined lead output in 1971 was nearly 3 percent less than in 1970. Increased availability of domestic concentrates failed to offset the sharp decline in metal recovered from imported ores and concentrates. Production from domestic primary sources increased 45,000 tons during the year, despite losses resulting from a shutdown of the ASARCO Glover smelter during the first 4 months by a labor strike. The 650,000 tons of primary refined lead produced in 1971 was the second largest total output since 1929. Nearly 88 percent

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[4] Kennecott Copper Corp. 1971 Annual Report. P. 22.

[5] Hecla Mining Co. 1971 Annual Report. Pp. 7, 8, 13.

[6] Newmont Mining Corp. 1971 Annual Report. Pp. 11, 13.

of the total lead production was derived from domestic ores compared with 79 percent in 1970. An additional 1,200 tons was refined from scrap. Antimonial lead production declined for the third consecutive year with only 18,500 tons of lead recovered, of which 12,200 tons originated from domestic ores, 3,900 tons from foreign ores, and 2,400 tons from scrap. The antimony content of the lead increased slightly to 6.0 percent.

The Herculaneum smelter of St. Joe Minerals Corp. produced 222,213 tons of lead metal and alloys from 303,190 tons of concentrate. Lead output increased nearly 26,000 tons although concentrate production was 15,200 tons less than in 1970. The company began construction of a $4.5 million facility which will double the smelter's gas cleaning capacity and made major alterations to its sulfuric acid plant to improve sulfur dioxide recovery.[7]

ASARCO's smelter and refinery at Glover, Mo., resumed operations in April after a settlement of a 7-month strike. Lead output was 66,500 tons compared with 59,200 tons in 1970. The East Helena, Mont., smelter operated at full capacity during the year processing crude ores and concentrates from approximately 50 domestic mines and from mines in Canada, Peru, and Australia. The El Paso lead smelter processed ores and concentrates from about 40 domestic mines and 23 foreign sources, chiefly in Peru, Canada, and Mexico. The company's Omaha refinery, which processed lead bullion from the East Helena and El Paso smelters, operated below capacity in 1971 because bullion shipments from the El Paso smelter were interrupted by a 7-week labor strike which began July 1. Production of refined lead dropped 8,500 tons below the 1970 level to 122,500 tons.[8]

International Smelting & Refining Co., a subsidiary of The Anaconda Company, processed lead concentrates at its Tooele, Utah, custom smelter and produced approximately 38,200 tons of lead in bullion, of which about 16,400 tons came from Anaconda operations and the remainder from outside sources under contract. About 30 percent of Anaconda's total production was derived from zinc plant operations at Great Falls, Mont. The lead bullion was refined by the United States Lead Refinery, Inc., in East Chicago, Ind. The Tooele smelter was shut down at yearend essentially because operations had become uneconomic.[9]

Missouri Lead Operating Co. smelter at Buick, Mo., owned jointly by AMAX and Homestake Mining Co. produced 109,000 tons of refined lead, slightly less than in 1970. The small drop in output resulted from a brief shutdown to rectify operating problems. Of the total lead production, 52,000 tons came from AMAX-Homestake mining operations and 57,000 tons was processed on toll for others.[10] A major modification in the sinter plant designed to improve production efficiency and hygiene was nearly completed at yearend.

The Bunker Hill smelter-refinery of Gulf Resources & Chemical Corp. at Kellogg, Idaho, produced a record of 129,000 tons of lead, about 6,000 tons more than in 1970. The new updraft sintering equipment installed late last year was brought up to full capacity and pollution control facilities, including a new sulfuric acid plant, came on-stream. Resolution of problems relating to the changeover in smelting practice and labor disputes adversely affected production during part of the year, but by September operations stabilized and record production was achieved.[11]

RAW MATERIAL SOURCE

The 578,500 tons of recoverable lead in concentrates delivered by domestic mines to smelters in 1971 constituted about 86 percent of the 669,700 tons of primary refined and antimonial lead, compared with 83 percent in 1970 and 79 percent in 1969. Lead in imported concentrates smelted during the year amounted to 80,900 tons, a drop of 43 percent below the level of 1970. The quantity of lead recovered from lead scrap processed at primary plants also dropped sharply to 3,600 tons compared with 12,000 tons in 1970. Raw material stocks at the beginning of the year at primary plants totaled 174,300 tons, of which 71,500 tons was in process and 2,600 tons was in secondary materials. Total stocks trended upward to a high of 188,800 tons at the end of April and generally declined thereafter to a low of 160,300 tons at the end of November. At yearend stocks of primary materials awaiting processing con-

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[7] Pages 13 and 16 of work cited in footnote 2.
[8] American Smelting and Refining Co. 1971 Annual Report. P. 9.
[9] The Anaconda Company. 1971 Annual Report. P. 11.
[10] AMAX. 1971 Annual Report. P. 23.
[11] Gulf Resources & Chemical Corp. 1971 Annual Report. Pp. 2, 6.

tained 79,300 tons, material in process 84,400 tons, and secondary materials 1,800 tons, making a total of 165,500 tons.

Scrap materials consumed in 1971 totaled 784,700 tons compared with 786,200 in 1970. New scrap in the form of purchased drosses and residues from a wide variety of sources aggregated 143,400 tons, about 18 percent of the total input. The remainder, old scrap, was predominantly battery scrap with small amounts of cable lead, type metal, solder, babbitt, and soft and hard lead. The scrap processed was essentially all from domestic sources. General imports of reclaimed scrap was 3,400 tons (lead content) mainly from Australia, Canada, and Mexico. Of this amount 2,500 tons was entered for consumption during the year. Exports of scrap by the United States in 1971 amounted to 9,600 tons, more than double the 4,200 tons exported in 1970. Stocks of scrap at smelters trended slightly downward during the first three quarters of the year, reaching a low of 63,700 tons at the end of September, but rising thereafter to 76,200 tons at yearend, compared with 73,200 at the start of the year.

CONSUMPTION AND USES

Lead consumption in 1971 increased about 5 percent to a record of 1.43 million tons. Monthly requirements for lead were higher than those of 1970 in every month except July. All major products except pigments and antiknock additives required greater amounts of lead. The 86,400-ton increase in battery lead more than offset the decreases in lead in pigments and antiknock compounds. The high rate of growth in battery lead requirements continued with an increase of 15 percent in 1971. Much of this gain was attributed to the increasing numbers of off-the-road vehicles using batteries for starting, lighting, ignition, and propulsion. A total of more than 49.3 million automotive batteries were produced in 1971, about 20 percent of which were required for new car production. The growth in recent years in antiknock additives was reversed in 1971 as requirements declined 5 percent from the 1970 level in part reflecting the impact of proposed regulations reducing the use of lead alkyl antiknock additives in gasoline. The average lead content of regular gasolines fell from 2.43 grams per gallon in mid-1970 to 2.22 grams a year later. In metal products other than batteries increases in lead use of 20 percent and 31 percent, respectively, were recorded in ammunition and sheet lead; calking lead and type metal requirements were down 13 and 15 percent, respectively. Quantitative changes in lead used in other metal products and for miscellaneous purposes were relatively small.

Except in July, requirements of lead exceeded 100,000 tons during each month. The high occurred in September, and the low, as usual, in July. The daily average of 3,922 tons was 194 tons more than in 1970. Soft refined lead represented 65 percent of the total consumption, antimonial lead 29 percent, and lead in other alloys, mainly solder and bearing metals, accounted for 5 percent. Lead in copper-base scrap, 1 percent, is recovered from old material which is subsequently returned as marketable brass and bronze.

The domestic supply of lead metal from all sources—production, imports for consumption, stock changes, and stockpile shipments—totaled 85,000 tons more than reported consumption and exports, about the same as in 1970. The unaccounted-for supply in 1971, amounting to 6 percent of the reported consumption, compares with an annual average of 65,100 tons for the 1963–71 period. The difference in totals is presumed to be in unreported consumption and stock buildup, especially by small users and dealers who do not report to the Bureau of Mines.

The annual growth rate in lead consumption during the 10-year period 1962–71 averaged about 2.9 percent, owing largely to the increased demand from the transportation sector for batteries and gasoline additives, which showed a growth of 6.0 percent per year and accounted for approximately 66 percent of the total domestic consumption in 1971 but only 53 percent in 1962. Ammunition also showed significant growth but most other lead-consuming products showed little or no growth during the period. The communication and construction use of lead in cable covering, type metal, calking, plumbing, and sheet declined in tonnage. Also, lead used in paints and pigments decreased moderately, but in some miscellaneous uses, including weights and ballast, galvanizing, and plating, modest gains were recorded. In 1962 the use of lead in products in terms of percent of the total was as follows: Ammunition, 4 percent; batteries, 38 percent; other metal products, 30 percent; pigments, 9 percent; chemicals, including antiknock compounds, 16 percent; and miscellaneous and other unclassified uses, 3 percent. During 1971 the comparative percentages were as follows: Ammunition, 6 percent; batteries, 47 percent; other metal products, 20 percent; pigments, 6 percent; chemicals, including antiknock compounds, 18 percent; and miscellaneous and other unclassified uses, 3 percent.

LEAD PIGMENTS

Lead requirements for the production of lead oxides and pigments in 1971 totaled 427,100 tons, about 11 percent more than in 1970. Virtually all of the lead used was derived from refined pig lead. The quantity of lead used in making white and red lead pigments increased about 10 percent and comprised only 7 percent of the total lead consumed in this category. White lead requirements in 1971 were about one-half of the quantity used in 1962. Red lead use in 1971 was only slightly less than in 1962. Litharge production and shipments increased slightly in 1971 compared with 1970 and were substantially greater than 10 years ago. Most of the litharge is used in battery manufacture and is included in "Other." This category, comprising 81 percent of the total shipments, has increased from 77,400 tons in 1962 to 120,000 tons in 1971. Litharge requirements for ceramic glazes amounting to about 16 percent of the total remained relatively stable.

Shipments of both white lead and red lead were again less than production, indicating lower demand for lead-base paints, but shipments of litharge continued to exceed production for the seventh consecutive year in 1971, indicating continued drawdown of stock.

Prices.—Lead pigment prices remained essentially stable during the year despite an upward trend in the price of lead during the second half of the year. The price of basic carbonate white lead remained unchanged at 21.5 cents per pound in carload lots, freight allowed. The price of red lead, 95 percent red lead oxide (Pb_3O_4) in carload lots, at works, also remained unchanged at 17.75 cents, and commercial-grade litharge, powdered, in carload lots, at works, was unchanged at 18 cents.

The value of shipments of white lead, red lead, and litharge amounted to $57.1 million, an average of $325 per ton in 1971 compared with $60.7 million and $348 per ton, respectively, in 1970.

Foreign Trade.—Exports of pigment-grade lead oxides totaled 1,955 tons valued at $833,000 and exports of lead oxides other than pigment grade amounted to 510 tons valued at $510,600. Shipments went to about 50 countries. Canada, South Vietnam, Republic of South Africa, Italy, the United Kingdom, Belgium, and Japan were the leading importers of pigment-grade lead oxide, accounting for 64 percent of the total. West Germany, Japan, and Canada received nearly 80 percent of the non-pigment-grade oxide exported.

Imports for consumption of lead oxides and compounds decreased 4 percent in quantity to 21,700 tons and 19 percent in value to $4.7 million. Litharge, which comprised 68 percent of total imports, increased 7 percent, but imports of red lead dropped 29 percent. Mexico supplied nearly all of the 14,700 tons of litharge and 87 percent of the 4,900 tons of red lead imported. Canada and West European countries provided most of the remaining tonnage of these oxides imported. Imports of lead nitrate amounted to 370 tons; lead acetate, 21 tons; white lead 1,231 tons; lead sulfate, 113 tons; lead suboxide, 40 tons; and other lead compounds, 250 tons.

STOCKS

Inventories of refined and antimonial lead at primary smelters and refineries declined steadily through the year as shipments exceeded production in all but 2 months. Metal stocks totaling 97,900 tons at the start of the year were reduced to

52,100 tons at yearend. Stocks of base bullion increased about 2,000 tons during the year, but ore and matte stocks decreased about 28,000 tons.

Stocks of lead in all forms at consumer and secondary smelting plants declined about 8,000 tons during the year to 125,600 tons at yearend, of which 82,900 tons was located at consumer plants. Refined soft lead constituted 65 percent of the inventory compared with 62 percent of the total in 1970.

PRICES

Increased lead consumption combined with a decline in free world mine and smelter production and reduction of inventories improved the free world lead supply-demand relationship and brought an increase in prices in the United States in the second half of the year. The LME lead price also remained relatively stable in the first half of the year but thereafter trended steadily down to mid-November, then moved upward through December. The average LME spot quotation ranged from 11.9 cents per pound (U.S. equivalent) in January to 12.2 cents in early June, then declined steadily to 10.0 cents in November, and moved up to 10.5 cents in December. The decline in the LME price largely reflected monetary adjustments between major world currencies. Following removal of the 10-percent surcharge on U.S. imports on December 20 the LME price began to rise, reflecting more stabilized conditions in world trade and currency realignments.

The domestic market price of refined lead at New York remained unchanged at 13.5 cents per pound until June 23, when the three leading producers established a price range of 14 to 14.5 cents which held to December 9, when St. Joe Minerals Corp. lowered its price to 14.3 cents per pound delivered to customer plants in the United States. On December 13, American Smelting and Refining Co. announced a delivered price of 14.0 cents. The split price of 14 to 14.3 cents per pound delivered to consumers at any location in the United States remained unchanged to yearend. The average New York price of common-grade refined lead in 1971 based on sales reported to Metals Week by producers and their agents was 13.89 cents per pound. This compares with an average price of 15.69 cents in 1970. The LME price of lead, 99.97-percent-lead basis, in terms of U.S. currency, averaged 11.52 cents per pound, compared with 13.76 cents in 1970.

FOREIGN TRADE

Exports of lead materials during 1971 aggregated nearly 15,500 tons valued at $5.3 million, compared with 12,000 tons valued at $5.8 million in 1970. Wrought and unwrought metal exports constituted 38 percent of the total exported; the remaining 62 percent was contained in scrap materials, most of which was shipped to Canada, Belgium-Luxembourg, and West Germany.

General imports of lead materials continued to decline in tonnage for the fourth consecutive year in 1971. The total of 265,000 tons was about 99,200 tons less than in 1970 and marked the lowest level of imports since 1951. Shipping interruptions caused by dock strikes at U.S. ports and foreign concern regarding the 10-percent ad valorem surcharge on dutiable imports effective between August 16 and December 20 were contributing factors to the import decline. Receipts of lead in ores and other crude materials were about 46,700 tons less than in 1970, and metal receipts decreased to 195,600 tons, compared with 244,600 tons in 1970. Nearly all the metal was entered duty-paid for consumption. Delivery of lead in ores, however, exceeded lead ores entered duty-paid for consumption by 22,100 tons, indicating a buildup of lead ores in bond for the second consecutive year. Canada continued to be the leading supplier of lead in ore with 33 percent of the total, followed by Peru, Honduras, and Australia. Canada was also the leading metal supplier with 29 percent of the total, followed by Australia, 24 percent; Peru, 19 percent; Mexico, 15 percent; The Republic of South Africa, 7 percent; and Yugoslavia, 4 percent. The decline trend in both lead ore and metal imports in recent years reflects growing availability of domestic ores for smelting and increasing self sufficiency in the domestic lead industry.

WORLD REVIEW

Free world mine production of lead, depending on the reporting base, reporting source, and scope of estimating, ranged from 2.79 million tons based on data compiled by the Bureau of Mines, through the International Lead and Zinc Study Group total of 2.65 million tons, to the American Bureau of Metal Statistics (ABMS) total of 2.69 million tons. Bureau of Mines data, which indicate the basis used insofar as possible, depend largely on Government information, as do those of the Study Group, although a somewhat different basis is used by the Study Group. ABMS relies largely on company and industry association sources. The Bureau of Mines estimated production in Communist countries, excluding Yugoslavia, at 0.96 million tons and the world total at 3.75 million tons, an alltime record. Smelter output of lead is reported by the Bureau of Mines as primary output, insofar as possible, whereas the Lead Zinc Study Group reports metal output from both primary and secondary sources. Free world smelter production in 1971 thus ranged from the Study Group preliminary total of 3.34 million tons, through the ABMS total of 2.86 million tons, to the Bureau of Mines total of 2.55 million tons. In addition the Bureau of Mines estimated 0.94 million tons of metal produced in Communist countries (excluding Yugoslavia) to provide a world total of 3.49 million tons of primary lead. The ABMS estimate for the same Communist countries was 1.06 million tons for a world total smelter production of 3.92 million tons of lead.

The United States maintained its rank as the leader in mine production of lead in 1971 accounting for approximately 15 percent 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 65 percent of the world total. Free world output decreased about 1 percent as production gains from mines in the United States, Canada, and Peru failed to offset losses in Mexico and Australia. The North America area increase was about 2 percent, and the 1.2 million tons produced represented 43 percent of the free world total and 32 percent 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 Japan, Australia, West Germany, Canada, Mexico, France, and Yugoslavia. These nine countries each produced more than 100,000 tons and together accounted for 69 percent of the world total. The North America area accounted for 38 percent of the free world metal output and 28 percent of the estimated world output (excluding U.S. secondary production). The decrease in free world primary metal output amounting to 6 percent was shared by all the principal metal-producing countries except Japan where output gained 3 percent. Secondary metal production in the free world was estimated at 850,000 tons, of which the United States accounted for about 597,000 tons. This secondary output is included in the smelter output of some countries, particularly France, Japan, and West Germany.

According to preliminary data compiled by the Lead and Zinc Study Group, free world consumption of lead metal, including primary and secondary, amounted to 3.5 million tons, about 2 percent or 74,000 tons more than in 1970. Western Hemisphere countries accounted for most of the increase. The Lead and Zinc Study Group free world comparative statistics on metal production and consumption indicate a supply deficit of 3,000 tons in 1971, and a surplus of 249,000 tons in 1970. This was reflected in a gain in producers stocks of 118,000 tons in 1970 and a decline of 79,000 tons in 1971.

Argentina.—Compañía Minera Aguilar, S.A., a subsidiary of St. Joe Minerals Corp., completed its first full year's operation in 1971 with its expanded and modernized facilities and established a record production of 52,274 tons of lead concentrate containing 39,990 tons of lead, compared with 46,662 tons of concentrate and 35,700 tons of lead in 1970.[12]

Australia.—Mine production of lead declined 11 percent from the record level of 1970 to 439,493 tons in 1971. The production drop reflected lower demand and prices which caused major mine operators to reduce ore output. Lead bullion production at Mount Isa Mines, Ltd., Cockle

[12] Page 13 of work cited in footnote 2.

Creek, and Port Pirie smelters dropped from 188,430 to 176,795 tons. Production of primary refined lead at Port Pirie was 179,928 tons, about 9 percent less than in 1970. A miners strike at Broken Hill which disrupted the normal flow of concentrates to the Port Pirie smelter was the principal factor reducing refined lead output.

E Z Industries, Ltd. (Electrolytic Zinc Co. of Australia Ltd.) continued to expand its mines, mills and ancillary facilities in Tasmania. During fiscal year 1971 the company milled 307,300 tons of ore, producing 13,722 tons of lead concentrate, a 12-percent decline in ore milled and a 6-percent decline in output of lead concentrate compared with operating data for the corresponding period of 1970. Loss of operating time due to labor disputes was the principal factor in reducing mine and mill production in 1971. The grade of ore milled averaged 15.4 percent zinc, 5.1 percent lead, 0.7 percent copper, and 6.1 ounces per ton silver. Lead concentrate grade averaged 58.3 percent lead, 18.1 percent zinc, and 25.7 ounces of silver per ton. The company reported ore reserves totaling 9.4 million tons, slightly more than in 1970.[13]

Operations of North Broken Hill Ltd. were interrupted during labor negotiations in April. Total tonnage of ore mined during the fiscal year ending June 30 declined to 489,895 tons, about 26,826 tons less than in fiscal year 1970. The grade of ore mined averaged 12.6 percent lead, 10.0 percent zinc, and 6.9 ounces of silver per ton. About 80,630 tons of lead concentrate was produced, containing 59,748 tons of lead and 3.14 million ounces of silver. The company reported ore reserves at June 30, 1971, totaled 4.5 million tons, the same as a year earlier.[14]

Canada.—Mine production of lead contained in ores and concentrates increased 8 percent in 1971 to 426,800 tons, a new record output. Most of the increase was attributed to expanded production by Anvil Mining Corp. Ltd. in the Yukon Territory. Greater output by Brunswick Mining and Smelting Corp. Ltd. in New Brunswick also contributed to the production gain. In June, Venus Mines Ltd. in the Yukon Territory and Copperline Mines Ltd. in British Columbia suspended operations which began in October 1970 at their respective lead-zinc-silver mines. Cominco Ltd. closed its Bluebell lead-zinc-silver mine in British Columbia in December. Canada maintained its position as the third largest mine producer of lead in the non-communist world, exceeded only by the United States and Australia.

Cominco Ltd. operated the Sullivan and Bluebell mines in British Columbia and the Pine Point mine in the Northwest Territories. The company also operated the Trail smelter and refinery treating both company and custom ores. Cominco reported production at the Sullivan mine of 1.98 million tons of ore averaging 11.3 percent combined lead and zinc; production at the Bluebell mine was 0.26 million tons of ore with a combined average grade of 9.7 percent lead and zinc; and at Pine Point production was 1.04 million tons averaging 8.5 percent lead and zinc. Lead production from all sources totaled 191,000 tons compared with 219,000 tons in 1970. Ore reserves at the Sullivan mine totaled 65.0 million tons containing 7.0 million tons of lead and zinc; and at Pine Point reserves totaled 41.9 million tons containing 3.5 million tons lead and zinc.[15]

Anvil Mining Corp. reported that lead-zinc ore production reached a level of 7,000 tons per day in 1971 following completion of a 20-percent expansion of milling capacity. Ore mined averaged 11.7 percent lead and zinc combined. Anvil shipped concentrates containing 92,000 tons of lead to customers in Japan and West Germany. At the request of Japanese smelting interests the company agreed to reduce and defer concentrate shipments to Japan in 1972.

Brunswick Mining and Smelting Corp. Ltd. reported that tonnage milled at its No. 12 concentrator totaled 1,567,000 tons averaging 8.11 percent zinc, 3.25 percent lead, 0.30 percent copper, and 2.44 ounces of silver per ton. In addition 625,000 tons of ore from No. 6 mine were treated in the No. 12 mill. Lead concentrates production was 117,000 tons. The company's No. 6 concentrator was shut down about 3½ months, during which it was converted to make separate lead and zinc concentrates instead of bulk concentrates in accord with plans to convert from zinc-lead smelting

[13] E Z Industries Ltd. 1971 Annual Report. Pp. 6–7.
[14] North Broken Hill Ltd. 1971 Annual Report. Pp. 4, 12.
[15] Cominco Ltd. 66th Annual Report. 1971, pp. 21.

to lead smelting. Tonnage milled during the year at No. 6 concentrator was 847,000 averaging 5.76 percent zinc, 2.11 percent lead, 0.36 percent copper, and 1.86 ounces of silver per ton. About 73,000 tons of zinc-lead concentrates and 7,800 tons of lead concentrates were produced. The smelter processed 149,985 tons of concentrates and produced 74,230 tons of ISF metal, 44,770 tons SHG zinc and 22,417 CG lead.

Zinc-lead ore reserves totaled 78.8 million tons at yearend, about 3.8 million less than at yearend 1970. Lead content of the reserves totaled about 2.4 million tons.[16]

Heath Steele Mines Ltd. treated 972,000 tons of lead-zinc-copper ore at its mill in New Brunswick and produced 45,000 tons of lead concentrate along with zinc and copper concentrates. Mill feed tonnage and grade were down slightly but were offset by higher recoveries of metals in the concentrates.[17]

At the Buchans mine of ASARCO in Newfoundland, lead production dropped to 10,000 tons, less than one-half the output in 1970, because of a 21-week labor strike and subsequent manpower shortage. Byproduct lead from Hudson Bay Mining and Smelting Co. Ltd., and Ecstall Mining Ltd., a subsidiary of Texas Gulf Sulphur Co., and United Keno Hill Mines Ltd. together contributed about 11,800 tons of Canada's total lead output.

Mattabi Mines Ltd. at Sturgeon Lake, Ontario, owned 60 percent by Mattagami Lake Mines Ltd. continued its $40 million construction program during the year. The concentrator is scheduled to commence production at a rate of 3,000 tons per day in June 1972 on ore from its open pit mine. Ore reserves are estimated at 12.9 million tons averaging 7.60 percent zinc, 0.91 percent copper, 0.84 percent lead, and 3.13 ounces silver per ton. Drilling exploration of a second ore body by Mattagami some 4 miles east of the Mattabi mine has outlined ore reserves to date of 826,000 tons of ore averaging 9.19 percent zinc, 1.22 percent copper, 1.33 percent lead, 0.015 ounce gold per ton, and 5.24 ounces silver per ton.

Output of primary refined lead in 1971 from Canada's two primary lead refineries at Trail, British Columbia, and Belladune, New Brunswick, was estimated at 185,000 tons compared with 204,600 tons in 1970.

Exports of lead in ores and concentrates principally to Japan, West Germany, the United States, and Belgium totaled 199,318 tons. Refined metal exports totaling 136,884 tons went mostly to the United States, the United Kingdom, and India.

Honduras.—New York and Honduras Rosario Mining Co. reported that ore production at its El Mochito mine in 1971 reached a record of 311,936 tons. Ore milled increased 15 percent to 311,310 tons containing 7.34 percent lead, 8.51 percent zinc, 12.3 ounces silver per ton, and 0.011 ounce gold per ton. The increase in tonnage resulting from completion of an expansion program was accompanied by improved metallurgy and a slight decline in mine operating costs. However, these improvements were more than offset by decreased silver prices, lower grade ore mined, increased smelter charges, and the imposition of a surcharge on imports of lead and zinc concentrates into the United States. Also, 1971 was the first full year of the production tax imposed by the mining code of Honduras enacted in August 1970. After increasing for 6 consecutive years, ore reserves declined slightly in 1971 to a total of about 2.08 million tons at yearend, however, average grade increased to 10.87 percent lead, 11.70 percent zinc, 12.6 ounces silver, and 0.009 ounce gold.[18]

India.—Lead concentrates produced at the Zawar mine of Hindustan Zinc Ltd., the country's only operating mine, totaled 4,455 tons in 1971. The concentrates were shipped 1,200 miles to the company's Tundoo lead smelter near Dhanbad, Bihar. Smelter output was about 1,700 tons, only 29 percent of capacity, compared with 2,050 tons in 1970. Zawar mine ore reserves were reported to total 182 million tons ranging in metal content from 0.5 to 2.5 percent lead and 3.5 to 7.0 percent zinc. Expansion plans announced in 1970 and later revised indicated that the Zawar mine output was to be increased from 800 tons to 2,000 tons per day by yearend 1972.

According to the Planning Commission and India's lead consumers, lead demand in 1971 increased to about 88,000 tons whereas lead availability was only 54,400 tons, a shortfall of 33,600 tons.

Ireland.—Tara Exploration and Development Co., Ltd., reported that explora-

[16] Brunswick Mining and Smelting Corp. Ltd. 19th Annual Report. 1971, pp. 5–7.
[17] Page 23 of work cited in footnote 10.
[18] New York and Honduras Rosario Mining Co. 1971 Annual Report. Pp. 4–5.

tion of its Navan lead-zinc ore body has disclosed reserves of 51.9 million tons, of which 21.4 million tons was "well established ore," 5.8 million tons was "indicated ore," and 24.7 million tons was termed "potential ore." The average grade of ore ranged from 2.38 percent lead and 11.51 percent zinc in the "well established" and "indicated" ore to 2.62 percent lead and 10.06 percent zinc in the "potential" category. Investigations to date indicate that ore reserves are sufficient to support an annual output of about 400,000 tons of 56-percent zinc concentrate and 70,000 tons of 62-percent lead concentrate. Tara plans to construct jetty- and vessel-loading facilities in conjunction with its mine and processing plant to handle shipments to West European ports.

Mexico.—Asarco Mexicana, S.A., 49 percent owned by ASARCO, reported normal operations at its mines and plants during 1971 except for startup problems at the Chihuahua lead smelter's new updraft sintering plant. The company produced 73,400 tons of refined lead, about 10,000 tons less than in 1970. The new 350-ton-per-day mill at the San Antonio mine of the Santa Eulalia unit was completed and major mine development work continued at the Santa Barbara and Taxco mines. The Fresnillo Company produced 1.15 million tons of lead-zinc-copper-silver ore from its five operating mines and recovered 41,612 tons of lead. Combined ore reserves of all mining units at yearend were 4.83 million tons averaging 4.4 percent lead, 4.8 percent zinc, 0.38 percent copper, and 4.96 ounces silver per ton This represents a decline of about 7 percent from yearend 1970.

Nicaragua.—Neptune Gold Mining Co., a subsidiary of ASARCO, placed the Vesubio mine operation on stream in September and made the first 2,500-ton shipment of lead-zinc concentrates to the ASARCO Corpus Christi, Tex., refinery. ASARCO reported metal production of 600 tons of lead and 3,800 tons of zinc in 1971. Ore reserves at Vesubio totaled 1.2 million tons averaging 12.58 percent zinc, 2.16 percent lead, and 0.28 percent copper. The concentrator has a rated capacity of 500 tons per day and will produce 2,800 tons of zinc concentrates and 500 tons of lead concentrates per month.[19]

Peru.—Cerro Corp. reported that productive operations at its Cerro-Peru subsidiary were interrupted by numerous labor strikes which reduced lead output about 5 percent to 75,000 tons. About 40 percent of the lead was derived from purchased ores. The company stated that strikes caused the loss of 375,000 man-days of production during 1971.[20]

Yugoslavia.—Energoinvest Corp. plans to expand its ore mining and milling facilities at the Srebrenica combine to treat 400,000 tons per year and bring annual metal output to 31,500 tons of lead and 18,500 tons of zinc. Ore reserves in the Srebrenica region were estimated at 20 million tons. Trepca Corp. was preparing to open lead mines at Kriva, Feja, and Podveroui that will ultimately increase present productive capacity to 500,000 tons of ore per year.

TECHNOLOGY

Lead-related research efforts continued to be directed to developing technology and equipment for controlling motor vehicle exhaust emissions compatible with the use of leaded gasoline so as to meet new emission standards for lead and other airborne pollutants scheduled to become effective by 1975. Significant progress was reported by manufacturers of lead alkyls in the development and testing of new catalytic, thermal, and filtering devices that may substantially cut automotive air pollution without eliminating lead alkyls.

Research scientists of Electrolytic Zinc Co. of Australia Ltd. (EZ) developed a new hydrometallurgical process for extracting lead from zinc plant residues using aqueous solutions containing ammonia and ammonium sulfate to dissolve lead compounds insoluble in conventional solvents. The process may facilitate recovery of lead.

Lead Industries Association Inc. (LIA) reported the development of a lead-acid-type battery with improved characteristics for motive power use in electric vehicles such as golf carts. According to LIA there is still potential for improving the capacity rating of the lead-acid battery as the theoretical energy density of the battery is several times greater than the best pres-

[19] Pages 9, 10, and 16 of work cited in footnote 8.

[20] Cerro Corp. Annual Report. 1971, p. 9.

ent capacity rating of about 20 watt hours per pound.

The International Lead Zinc Research Organization, Inc., (ILZRO) continued to sponsor and direct research and development programs in the general areas of metallurgy and chemistry and to publish the results of individual projects in its Research Digest. The organization with 34 member companies in 14 countries conducted some 20 lead research programs relating to existing uses as well as new products. According to ILZRO[21] research has been a prime factor in maintaining and expanding markets for lead in various architectural applications. Programs in this general area include (1) development of equipment to produce screen-reinforced lead sheet, (2) development of confirmed procedures for ensuring good service from paint systems on lead surfaces, (3) designing and demonstrating uses for lead in industrialized housing, and (4) development of lead preforms for caulked joints in cast iron drainpipe. Research was completed on a program to develop suitable lead-plastic composites, including adhesive technology and identification of optimum conditions for forming the laminates. The results of this program indicated that lead-plastic composites would be suited for making fuel tanks and military packages as well as for construction and industrial applications.

Three ongoing industry research programs, focused on expanding the cable sheathing market for lead, dealt with developing and forming lead-plastic cable sheathing and improving methods for splicing cable joints. Two research programs were directed toward improving the performance of lead-acid batteries including new designs suitable for use in electric vehicles and tests on casting lead-calcium grids containing 0.03 to 0.06 percent calcium.

A final report was completed by ILZRO covering the results of its tests evaluating several different lead-air cells to determine the basic operating characteristics and to identify the primary limitations of the lead-air concept. The report (LE-156)[22] concluded that exploitation of the lead-air battery must await improved cathode catalysts or air electrode redox systems and the identification or development of materials for the cathode which will withstand corrosion in an acid electrolyte under anodic oxygen evolution conditions. Fundamental and developmental research has been directed towards synthesis of new organolead compounds and improved methods of producing them for protecting wood against marine borers and other destructive agents.

Industrial research on lead in paints and pigments and ceramics was conducted to expand markets in these areas. The market potential for magnetic lead ferrites as substitutes for field windings in small motors has created much interest and has encouraged the lead industry to conduct programs relating to development of manufacturing techniques for lead ferrites and to development of lead-based glasses for conversion into magnetic lead ferrites. Another ceramics program included investigation of the fundamental properties of leaded-glass systems to develop basic information for use in such applications as color television tubes and porcelain enamels for steel and aluminum radiation shielding and for paint pigments.

The Zinc Development Association and the Lead Development Association of London (ZDA/LDA) review all current world literature on the metals and their products including published research work and provide an abstracting service to lead and zinc users throughout the world. Lead Abstracts, published bimonthly in 1971, may be obtained from Lead Industries Association Inc., 292 Madison Avenue, New York, N.Y. 10017. Some 1500 abstracts were listed in the 1971 editions.

Cominco Ltd. reported that construction at Trail, British Columbia, of a pilot plant to test the company's unique oxygen smelting process was nearing completion at year-end. This plant will have a daily capacity of 60 tons of lead bullion and will establish the design data for a full-size plant.

[21] International Lead Zinc Research Organization, Inc. Lead Research Digest, No. 28, Autumn 1971. 38 pp.

[22] Christopher, H. A. and Moran, P. J., Lead-Air Battery, Gen. Elec. Co.

Table 2.—Mine production of recoverable lead in the United States, by State

(Short tons)

State	1967	1968	1969	1970	1971
Alaska	--	W	2	--	--
Arizona	4,771	1,704	217	285	859
California	1,735	4,001	2,518	1,772	2,284
Colorado	21,923	19,778	21,767	21,855	25,746
Idaho	61,387	54,790	65,597	61,211	66,610
Illinois	2,384	1,467	791	1,532	1,238
Kansas	1,031	1,227	395	80	--
Kentucky	845	W	--	--	--
Missouri	152,649	212,611	355,452	421,764	429,634
Montana	898	1,870	1,753	996	615
Nevada	1,500	863	1,420	364	111
New Mexico	1,827	1,363	2,368	3,550	2,971
New York	1,653	1,396	1,686	1,280	877
Oklahoma	2,727	2,387	605	797	--
Oregon	--	W	(1)	(1)	--
South Dakota	--	--	1	3	--
Utah	53,813	45,205	41,332	45,377	38,270
Virginia	3,430	3,573	3,358	3,356	3,386
Washington	2,762	5,655	8,649	6,784	5,177
Wisconsin	1,596	1,126	1,102	761	752
Other States	--	140	--	--	20
Total	316,931	359,156	509,013	571,767	578,550

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1] Less than ½ unit.

Table 3.—Production of lead and zinc in the United States in 1971, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(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
Arizona	3,250	124	69	--	--	--	5	1	1
California	(1)	(1)	(1)	(1)	(1)	(1)	[1] 89,042	[1] 2,284	[1] 3,003
Colorado	143	46	--	311,099	3,612	32,239	425,701	12,306	16,034
Idaho	274,716	28,479	2,506	973	22	69	780,970	36,848	41,854
Maine	--	--	--	--	--	--	--	--	--
Missouri	8,624,668	429,634	48,215	--	--	--	--	--	--
Montana	6,190	373	12	4,027	30	265	217	10	6
Nevada	197	10	2	74	3	10	532	81	54
New Jersey	--	--	--	172,179	--	29,977	--	--	--
New Mexico	--	--	--	--	--	--	119,021	2,971	13,473
New York	--	--	--	171,533	--	15,585	606,978	877	47,835
Oklahoma	--	--	--	--	--	--	--	--	--
Pennsylvania	--	--	--	628,408	--	27,438	--	--	--
Tennessee	--	--	--	4,244,715	--	111,991	--	--	--
Utah	(2)	(2)	(2)	--	--	--	[2] 363,216	[2] 33,462	[2] 22,974
Virginia	--	--	--	614,721	3,386	16,829	--	--	--
Washington	621	25	--	425	--	8	252,492	5,151	5,774
Wisconsin	--	--	--	413,760	752	10,645	--	--	--
Other States	--	--	--	281,955	486	11,190	--	--	--
Total	8,909,785	458,691	50,804	6,843,869	8,291	256,246	2,638,174	93,991	151,008
Percent of total lead-zinc	--	79	10	--	2	51	--	16	30

	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
Arizona	95,034	102	7,672	37,661,651	632	19	37,759,940	859	7,761
California	--	--	--	--	--	--	89,042	2,284	3,003
Colorado	391,250	8,037	11,515	99,622	1,745	1,393	1,227,815	25,746	61,181
Idaho	--	--	--	304,652	1,261	649	1,361,311	66,610	45,078
Maine	179,751	--	5,850	--	--	--	179,751	--	5,850
Missouri	--	--	--	--	--	--	8,624,668	429,634	48,215
Montana	--	--	--	25,474	202	78	35,908	615	361
Nevada	--	--	--	838	17	5	1,641	111	71
New Jersey	--	--	--	--	--	--	172,179	--	29,977
New Mexico	--	--	--	1,101,859	--	486	1,220,880	2,971	13,959
New York	--	--	--	--	--	--	778,511	877	63,420
Oklahoma	--	--	--	220,104	--	(4)	220,104	--	(4)
Pennsylvania	--	--	--	--	--	--	628,408	--	27,438
Tennessee	1,703,575	--	7,304	--	--	--	5,948,290	--	119,295
Utah	124,354	4,790	2,727	2,594	18	--	490,164	38,270	25,701
Virginia	--	--	--	--	--	--	614,721	3,386	16,829
Washington	--	--	--	71,118	1	--	324,656	5,177	5,782
Wisconsin	--	--	--	--	--	--	413,760	752	10,645
Other States	--	--	--	--	772	6,787	281,955	1,258	17,977
Total	2,493,964	12,929	35,068	39,487,912	4,648	9,417	60,373,704	578,550	502,543
Percent of total lead-zinc	--	2	7	--	1	2	--	100	100

[1] Lead and zinc ores combined with lead-zinc ore to avoid disclosing individual company confidential data.
[2] Lead and lead-zinc ores 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.
[4] Less than ½ unit.

Table 4.—Mine production of recoverable lead in the United States, by month

(Short tons)

Month	1970	1971	Month	1970	1971
January	47,151	45,171	August	47,435	48,171
February	46,333	41,875	September	47,940	51,020
March	51,771	52,848	October	46,167	48,717
April	49,098	47,615	November	47,840	49,263
May	49,640	45,994	December	45,842	56,099
June	46,797	46,101			
July	45,753	45,676	Total	571,767	578,550

Table 5.—Twenty-five leading lead-producing mines in the United States in 1971, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Buick	Iron, Mo	Missouri Lead Operating Co	Lead ore.
2	Fletcher	Reynolds, Mo	St. Joe Minerals Corp	Do.
3	Magmont	Iron, Mo	Cominco American, Inc	Do.
4	Viburnum	Crawford, Iron, and Washington, Mo	St. Joe Minerals Corp	Do.
5	Ozark	Reynolds, Mo	Ozark Lead Co	Do.
6	Federal	St. Francois, Mo	St. Joe Minerals Corp	Do.
7	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore and lead-zinc tailings.
8	Lucky Friday	do	Hecla Mining Co	Lead ore.
9	U.S. and Lark	Salt Lake, Utah	U.S. Smelting, Refining and Mining Co	Lead-zinc ore.
10	Indian Creek	Washington, Mo	St. Joe Minerals Corp	Lead ore.
11	Star Unit	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
12	Burgin	Utah, Utah	Kennecott Copper Corp	Lead and lead-zinc ores.
13	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
14	Dayrock	Shoshone, Idaho	Day Mines, Inc	Lead ore.
15	Pend Oreille	Pend Oreille, Wash	Pend Oreille Mines and Metals Co	Lead-zinc ore.
16	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
17	Leadville	Lake, Colo	American Smelting and Refining Co	Lead-zinc ore.
18	Eagle	Eagle, Colo	The New Jersey Zinc Co	Zinc ore.
19	Austinville and Ivanhoe	Wythe, Va	do	Do.
20	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
21	Ground Hog	Grant, N. Mex	American Smelting and Refining Co	Do.
22	Darwin	Inyo, Calif	Darwin Mines	Lead-zinc and lead ores.
23	Ophir	Tooele, Utah	U.S. Smelting, Refining and Mining Co	Lead-zinc ore.
24	Camp Bird	Ouray, Colo	Federal Resources Corp	Do.
25	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1967	1968	1969	1970	1971
Refined lead:					
From primary sources:					
Domestic ores and base bullion	258,507	349,039	513,931	528,086	573,022
Foreign ores and base bullion	121,387	118,271	124,724	138,644	76,993
Total	379,894	467,310	638,655	666,730	650,015
From secondary sources	2,538	2,259	4,966	4,367	1,223
Grand total	382,432	469,569	643,621	671,097	651,238
Calculated value of primary refined lead (thousands) [1]	$106,370	$123,463	$190,702	$209,220	$180,574

[1] Value based on average quoted price, New York, 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		Lead content by difference (short tons)			
		Short tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1967	18,608	1,717	9.2	5,449	3,634	7,808	16,891
1968	28,363	2,007	7.1	15,788	3,706	6,862	26,356
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

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1971

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	2,944	48,768	--	48,875	48,875	2,837
Hard lead	2,245	27,855	--	27,165	27,165	2,935
Cable lead	1,267	29,264	--	29,406	29,406	1,125
Battery-lead plates	37,204	492,819	--	486,792	486,792	43,231
Mixed common babbitt	435	3,014	--	3,150	3,150	299
Solder and tinny lead	400	11,366	--	11,464	11,464	302
Type metals	1,587	25,965	--	25,813	25,813	1,739
Drosses and residues	26,903	140,081	143,382	--	143,382	23,602
Total	72,985	779,132	143,382	632,665	776,047	76,070
Foundries and other manufacturers:						
Soft lead	45	36	--	50	50	31
Hard lead	17	86	--	89	89	14
Cable lead	47	16	--	49	49	14
Battery-lead plates	--	--	--	--	--	--
Mixed common babbitt	69	8,496	--	8,515	8,515	50
Solder and tinny lead	--	--	--	--	--	--
Type metals	--	--	--	--	--	--
Drosses and residues	--	--	--	--	--	--
Total	r 178	8,634	--	8,703	8,703	109
All consumers:						
Soft lead	2,989	48,804	--	48,925	48,925	2,868
Hard lead	2,262	27,941	--	27,254	27,254	2,949
Cable lead	1,314	29,280	--	29,455	29,455	1,139
Battery-lead plates	r 37,204	492,819	--	486,792	486,792	43,231
Mixed common babbitt	504	11,510	--	11,665	11,665	349
Solder and tinny lead	400	11,366	--	11,464	11,464	302
Type metals	1,587	25,965	--	25,813	25,813	1,739
Drosses and residues	r 26,903	140,081	143,382	--	143,382	23,602
Grand total	r 73,163	787,766	143,382	641,368	784,750	76,179

r Revised.

Table 9.—Secondary metal recovered [1] from lead and tin scrap in the United States in 1971, by type of product

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	122,988	--	--	--	122,988
Remelt lead	27,146	--	--	--	27,146
Total	150,134	--	--	--	150,134
Refined pig tin	--	2,523	--	--	2,523
Remelt tin	--	80	--	--	80
Total	--	2,603	--	--	2,603
Lead and tin alloys:					
Antimonial lead	342,712	707	15,839	483	359,741
Common babbitt	15,477	823	1,467	59	17,826
Genuine babbitt	40	184	11	3	238
Solder	34,935	6,140	587	104	41,766
Type metals	23,375	1,346	2,900	1	27,622
Cable lead	14,230	2	98	--	14,330
Miscellaneous alloys	795	105	15	60	975
Total	431,564	9,307	20,917	710	462,498
Tin content of chemical products	--	685	--	--	685
Grand total	581,698	12,595	20,917	710	615,920

[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)

	1967	1968	1969	1970	1971
As metal:					
At primary plants	2,538	2,259	4,966	4,367	1,223
At other plants	147,806	136,607	149,344	154,800	148,911
Total	150,344	138,866	154,310	159,167	150,134
In antimonial lead:					
At primary plants	7,808	6,862	6,409	7,599	2,379
At other plants	280,911	301,701	336,066	340,759	340,333
Total	288,719	308,563	342,475	348,358	342,712
In other alloys	114,709	103,450	107,120	89,865	103,951
Grand total:					
Quantity	553,772	550,879	603,905	597,390	596,797
Value (thousands) [1]	$155,056	$145,542	$180,326	$187,461	$165,790

[1] Value based on average quoted price, New York.

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1970	1971	Form of recovery	1970	1971
New scrap:			As soft lead:		
Lead-base	86,753	102,693	At primary plants	4,367	1,223
Copper-base	4,144	3,859	At other plants	154,800	148,911
Tin-base	307	464	Total	159,167	150,134
Total	91,204	107,016	In antimonial lead [1]	348,358	342,712
Old scrap:			In other lead alloys	77,159	88,053
Battery-lead plates	350,273	333,007	In copper-base alloys	12,690	15,858
All other lead-base	139,365	142,239	In tin-base alloys	16	40
Copper-base	16,546	14,532			
Tin-base	2	3	Total	438,223	446,663
Total	506,186	489,781	Grand total	597,390	596,797
Grand total	597,390	596,797			

[1] Includes 7,599 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1970 and 2,379 in 1971.

Table 12.—Lead consumption in the United States, by product

(Short tons)

Product	1970	1971	Product	1970	1971
Metal products:			Pigments—Continued:		
Ammunition	72,726	87,567	Pigment colors	14,407	13,916
Bearing metals	16,328	16,285	Other [1]	1,178	773
Brass and bronze	18,927	20,044			
Cable covering	50,772	52,920	Total	98,736	81,258
Calking lead	34,608	29,993			
Casting metals	7,498	7,281	Chemicals:		
Collapsible tubes	10,913	10,041	Gasoline antiknock additives	278,505	264,240
Foil	5,521	4,417			
Pipes, traps, and bends	17,888	18,174	Miscellaneous chemicals	623	401
Sheet lead	21,050	27,607			
Solder	69,707	70,013	Total	279,128	264,641
Storage batteries:					
Battery grids, posts, etc	283,451	322,236	Miscellaneous uses:		
Battery oxides	310,002	357,567	Annealing	4,161	4,068
Terne metal	1,038	1,409	Galvanizing	1,792	1,395
Type metal	24,476	20,812	Lead plating	400	582
			Weights and ballast	16,184	17,453
Total	944,905	1,046,366	Total	22,537	23,498
Pigments:			Other, unclassified uses	15,246	15,751
White lead	5,936	4,731			
Red lead and litharge	77,215	61,838	Grand total [2]	1,360,552	1,431,514

[1] Includes lead content of leaded zinc oxide and other pigments.
[2] Includes lead that went directly from scrap to fabricated products.

Table 13.—Lead consumption in the United States, by month [1]

(Short tons)

Month	1970	1971	Month	1970	1971
January	118,444	118,676	August	110,486	123,174
February	110,497	113,197	September	114,215	130,568
March	120,832	126,579	October	115,419	127,763
April	117,797	120,660	November	103,401	121,126
May	117,547	120,104	December	114,889	117,346
June	116,137	116,548			
July	100,888	95,773	Total	1,360,552	1,431,514

[1] Includes lead that 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 1971, by class of product and type of material [1]

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	190,475	93,569	67,394	15,125	366,563
Storage batteries	364,835	314,968	--	--	679,803
Pigments	81,258	--	--	--	81,258
Chemicals	264,414	227	--	--	264,641
Miscellaneous	9,846	13,603	49	--	23,498
Unclassified	14,239	697	815	--	15,751
Total	925,067	423,064	68,258	15,125	1,431,514

[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 1971, by State [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	83,780	35,833	7,659	790	128,062
Colorado	1,127	2,889	97	--	4,113
Connecticut	16,978	8,879	--	1,085	26,942
District of Columbia	129	--	--	--	129
Florida	4,073	7,117	--	--	11,190
Georgia	52,990	17,697	1,191	--	71,878
Illinois	89,835	50,341	12,845	2,244	155,265
Indiana	85,192	47,578	3,626	489	136,885
Kansas	13,002	10,776	52	312	24,142
Kentucky	8,929	11,381	1	--	20,311
Maryland	1,059	18,190	3,531	17	22,797
Massachusetts	2,259	720	17	282	3,278
Michigan	17,440	17,334	1,919	362	37,055
Missouri	34,832	9,055	1,444	603	45,934
Nebraska	4,766	1,012	1,207	1,268	8,253
New Jersey	125,706	21,970	6,865	675	155,216
New York	43,029	1,184	11,936	949	57,098
Ohio	9,694	2,530	5,063	1,474	18,761
Pennsylvania	66,650	45,393	6,135	2,664	120,842
Rhode Island	1,347	196	2	--	1,545
Tennessee	167	16,015	247	138	16,567
Virginia	753	1,287	1,606	541	4,187
Washington	12,950	415	505	--	13,870
West Virginia	17,021	3,942	--	--	20,963
Wisconsin	6,142	6,216	40	277	12,675
Alabama and Mississippi	2,297	4,829	--	412	7,538
Arkansas and Oklahoma	4,907	3,737	57	--	8,701
Hawaii and Oregon	337	6,613	--	--	6,950
Iowa and Minnesota	4,189	11,338	1,020	--	16,547
Louisiana and Texas	200,194	42,479	1,193	401	244,267
Montana and Idaho	692	--	--	--	692
New Hampshire, Maine, Vermont, Delaware	8,876	10,813	--	142	19,831
North and South Carolina	3,691	5,305	--	--	8,996
Utah, Nevada, Arizona	34	--	--	--	34
Total	925,067	423,064	68,258	15,125	1,431,514

[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	1970 Production (short tons)	1970 Shipments Short tons	1970 Shipments Value[2] Total	1970 Shipments Value[2] Average per ton	1971 Production (short tons)	1971 Shipments Short tons	1971 Shipments Value[2] Total	1971 Shipments Value[2] Average per ton
White lead:								
Dry	6,497	7,287	$3,037,038	$417	7,505	5,466	$2,348,721	$430
In oil[3]	2,878	1,351	863,942	639	1,297	1,315	868,893	661
Total	9,375	8,638	3,900,980	452	8,802	6,781	3,217,614	474
Red lead	20,316	19,444	7,585,560	390	23,548	20,989	7,587,104	361
Litharge	132,529	146,343	49,206,528	336	138,271	147,844	46,301,521	313
Black oxide	247,862	--	--	--	283,032	--	--	--

[1] Except for 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	1970 Lead in pigments produced from— Ore Domestic	1970 Ore Foreign	1970 Pig lead	1970 Total lead in pigments	1971 Lead in pigments produced from— Ore Domestic	1971 Ore Foreign	1971 Pig lead	1971 Total lead in pigments
White lead	--	--	7,500	7,500	--	--	7,042	7,042
Red lead	--	--	18,416	18,416	--	--	21,346	21,346
Litharge	--	--	123,252	123,252	--	--	128,592	128,592
Black oxide	--	--	236,514	236,514	--	--	270,097	270,097
Leaded zinc oxide	304	211	--	515	W	W	--	W
Total	304	211	385,682	386,197	W	W	427,077	427,077

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes lead in basic lead sulfate.

Table 18.—Distribution of white lead (dry and in oil) shipments,[1] by industry

(Short tons)

Industry	1967	1968	1969	1970	1971
Paints	6,968	6,681	5,969	4,460	4,396
Ceramics	96	124	67	26	34
Other	5,064	4,829	4,323	4,152	2,351
Total	12,128	11,634	10,359	8,638	6,781

[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	1967	1968	1969	1970	1971
Paints	13,318	11,347	9,191	7,848	8,717
Storage batteries	W	W	9,302	W	W
Other	12,423	12,464	3,684	11,596	12,272
Total	25,741	23,811	22,177	19,444	20,989

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

Table 20.—Distribution of litharge shipments, by industry

(Short tons)

Industry	1967	1968	1969	1970	1971
Ceramics	19,491	24,123	21,570	24,578	24,337
Insecticides	W	W	W	W	W
Oil refining	1,835	1,849	1,603	2,016	1,413
Rubber	1,928	1,986	1,794	1,663	2,081
Varnish	1,228	W	W	W	W
Other	75,500	103,220	110,752	118,086	120,013
Total	99,982	131,178	135,719	146,343	147,844

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	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
White lead	1,105	$431	1,231	$379
Red lead	6,909	1,827	4,899	1,134
Litharge	13,703	3,278	14,704	2,940
Other lead pigments	219	54	202	56
Other lead compounds	655	255	633	225
Total	22,591	5,845	21,669	4,734

Table 22.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1967	1968	1969	1970	1971
Refined pig lead	18,243	11,490	21,283	90,866	46,762
Lead in antimonial lead	5,119	3,852	4,448	6,988	5,318
Lead in base bullion	16,622	11,471	12,726	11,710	13,803
Lead in ore and matte	85,495	63,614	63,403	83,421	55,777
Total	125,479	90,427	101,860	192,985	121,660

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
1967	59,837	35,879	8,919	1,151	105,786
1968	43,933	25,009	9,184	774	78,900
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

Table 24.—Average monthly and yearly quoted prices of lead at St. Louis, New York and London [1]

(Cents per pound)

Month	1970 St. Louis	1970 New York	1970 London [2]	1971 St. Louis	1971 New York	1971 London [2]
January	16.30	16.50	14.72	13.30	13.50	11.92
February	16.30	16.50	15.18	13.30	13.50	12.14
March	16.30	16.50	15.24	13.30	13.50	12.21
April	16.30	16.50	14.59	13.30	13.50	12.23
May	16.30	16.50	14.22	13.30	13.50	12.08
June	16.30	16.50	13.95	13.50	13.70	12.11
July	15.48	15.68	13.56	14.05	14.25	11.96
August	14.92	15.12	12.87	14.05	14.25	11.71
September	14.55	14.75	12.82	14.05	14.25	10.83
October	14.55	14.75	12.85	14.05	14.25	10.39
November	14.55	14.75	12.64	14.05	14.25	10.04
December	13.99	14.19	12.49	--	14.19	10.47
Average	15.49	15.69	13.76	[3] 13.66	13.89	11.52

[1] St. Louis: Metal Statistics, 1972. New York: Metal Statistics, 1972. London: Metals Week.
[2] Based on monthly rates of exchange by Federal Reserve Board.
[3] Eleven-month average.

Table 25.—U.S. exports of lead, by country [1]

Destination	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Unwrought lead and lead alloys:				
Canada	804	$295	911	$340
Chile	--	--	10	3
Dominican Republic	95	54	41	18
India	770	249	--	--
Jamaica	9	7	17	6
Japan	15	8	612	177
Korea, Republic of	39	14	5	3
Mexico	81	43	83	36
Netherlands	19	7	8	7
Pakistan	53	19	--	--
Philippines	87	49	74	44
Spain	1,791	519	12	6
Sweden	176	136	221	169
Taiwan	141	68	1,102	301
Thailand	--	--	220	56
United Kingdom	211	64	46	31
Venezuela	375	134	21	23
Vietnam, South	29	10	186	56
Other	274	178	200	119
Total	4,969	1,854	3,769	1,395
Wrought lead and lead alloys:				
Belgium-Luxembourg	12	14	6	7
Canada	316	344	229	219
Chile	110	63	111	86
Colombia	38	25	86	44
Dominican Republic	45	36	129	70
Germany, West	31	32	32	27
Italy	58	54	38	38
Jamaica	22	19	121	108
Japan	58	149	96	162
Korea, Republic of	62	28	83	20
Mexico	171	142	43	42
Netherlands	423	759	433	982
Pakistan	94	64	3	2
Philippines	27	30	66	39
Sweden	112	101	44	38
Taiwan	47	26	32	30
Turkey	366	240	2	3
United Kingdom	106	172	61	81
Venezuela	176	130	143	99
Vietnam, South	33	15	2	3
Other	471	460	396	394
Total	2,778	2,903	2,156	2,494
Scrap:				
Belgium-Luxembourg	702	127	1,131	188
Brazil	--	--	169	20
Canada	781	180	4,852	700
Germany, West	250	33	1,099	183
Italy	983	216	749	82
Japan	192	93	337	32
Netherlands	314	63	456	51
Philippines	--	--	218	28
South Africa, Republic of	110	22	53	7
United Kingdom	659	268	429	95
Venezuela	106	17	--	--
Other	117	37	80	24
Total	4,214	1,056	9,573	1,410

[1] In addition foreign lead was reexported as follows: unwrought lead and lead alloys 1970, 283 tons ($95,256); 1971, 8 tons ($2,724). Wrought lead and lead alloys 1970, 150 tons ($54,026); 1971, 23 tons ($9,224).

Table 26.—U.S. imports[1] of lead, by country

Country	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Ore, flue dust, and matte, (lead content):						
Argentina	90	$13	31	$5	227	$42
Australia	20,335	4,556	29,360	6,468	8,893	1,656
Bolivia	3,605	724	3,041	561	--	--
Canada	48,606	10,299	41,337	9,223	21,885	4,217
Colombia	345	22	464	62	211	42
Guatemala	--	--	68	13	1,075	93
Honduras	12,988	2,606	15,054	2,539	15,121	1,543
Mexico	301	46	440	101	146	27
Peru	22,582	4,933	21,337	5,117	18,393	3,579
South Africa, Republic of	365	35	--	--	--	--
Other	35	9	1,274	246	47	53
Total	109,252	23,243	112,406	24,335	65,998	11,252
Base bullion (lead content):						
Australia	1,979	693	--	--	--	--
Canada	1	2	--	--	--	--
Mexico	13	4	170	40	14	4
United Kingdom	--	--	126	93	27	12
Total	1,993	699	296	133	41	16
Pigs and bars (lead content):						
Australia	60,791	14,417	51,705	13,902	46,044	10,107
Belgium-Luxembourg	1,315	465	680	396	153	100
Burma	150	36	341	132	--	--
Canada	44,457	11,409	63,753	19,107	56,821	14,015
Denmark	114	136	140	64	281	119
France	5,627	1,258	1,255	357	--	--
Germany, West	1,289	723	703	2,037	173	411
Mexico	57,451	13,973	38,368	10,156	29,645	6,725
Netherlands	14	34	174	150	198	75
Peru	57,249	15,687	52,473	16,292	36,372	9,500
South Africa, Republic of	12,558	3,706	12,984	4,164	13,519	4,083
United Kingdom	8,664	3,752	2,928	1,508	3,677	1,227
Yugoslavia	27,862	6,272	18,765	4,930	8,704	2,258
Other	839	225	354	202	--	--
Total	278,380	72,093	244,623	73,397	195,587	48,620
Reclaimed scrap, etc. (lead content):						
Australia	36	15	3,638	1,098	1,741	423
Austria	--	--	--	--	100	27
Canada	4,866	1,222	2,075	661	889	228
Dominican Republic	236	29	--	--	--	--
Mexico	1,253	191	1,056	141	642	85
Netherlands Antilles	45	9	--	--	--	--
Panama	420	69	84	21	--	--
Other	106	23	4	(2)	11	2
Total	6,962	1,558	6,857	1,921	3,383	765
Grand total	396,587	97,593	364,182	99,786	265,009	60,653

[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 27.—U.S. imports for consumption [1] of lead, by country

Country	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Ore, flue dust, and matte, (lead content):						
Argentina	26	$6	31	$5	290	$57
Australia	24,003	5,004	6,726	1,539	11,382	2,538
Bolivia	4,308	770	1,914	358	9	(2)
Canada	44,764	8,967	23,436	4,474	36,406	8,209
Chile	1,679	322	--	--	--	--
Colombia	--	--	301	19	227	43
Honduras	13,992	2,871	1,087	192	18,803	3,798
Mexico	555	95	121	23	385	57
Peru	21,794	4,023	8,228	1,595	20,634	4,607
South Africa, Republic of	413	43	--	--	--	--
Other	3,752	596	762	155	48	53
Total	115,286	22,697	42,606	8,360	88,184	19,362
Base bullion (lead content):						
Australia	1,979	693	876	238	--	--
Canada	1	2	--	--	--	--
Mexico	13	4	175	117	14	4
United Kingdom	--	--	126	93	27	12
Total	1,993	699	1,177	448	41	16
Pigs and bars (lead content):						
Australia	60,791	14,417	51,705	13,902	43,045	9,512
Belgium-Luxembourg	1,814	476	680	396	153	100
Burma	150	36	341	132	--	--
Canada	44,457	11,409	63,753	19,107	56,820	14,015
Denmark	108	136	140	64	281	119
France	5,627	1,258	1,255	357	--	--
Germany, West	1,289	723	703	2,037	173	411
Mexico	57,451	13,973	38,368	10,156	29,645	6,725
Netherlands	14	34	174	150	198	75
Peru	57,249	15,687	52,473	16,292	36,372	9,500
South Africa, Republic of	12,558	3,706	12,984	4,164	13,519	4,083
United Kingdom	8,664	3,752	2,928	1,508	3,660	1,223
Yugoslavia	27,862	6,272	18,765	4,930	8,704	2,258
Other	839	225	354	202	--	--
Total	278,873	72,104	244,623	73,397	192,570	48,021
Reclaimed scrap, etc. (lead content):						
Australia	79	27	352	116	976	264
Canada	4,515	1,147	1,394	495	889	228
Dominican Republic	236	29	--	--	--	--
Mexico	1,253	191	1,056	141	642	85
Netherlands Antilles	45	9	19	4	--	--
Panama	420	69	84	21	--	--
Spain	7	1	37	11	--	--
United Kingdom	28	18	23	7	--	--
Other	99	22	16	3	11	2
Total	6,682	1,513	2,981	798	2,518	579
Sheets, pipe, and shot:						
Belgium-Luxembourg	121	34	45	17	20	8
Canada	190	79	320	169	82	37
Germany, West	7	3	--	--	--	--
Netherlands	49	15	87	33	73	23
United Kingdom	30	10	35	13	62	18
Yugoslavia	121	33	26	9	--	--
Total	518	174	513	241	237	86
Grand total	403,352	97,187	291,900	83,244	283,550	68,064

[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Less than ½ unit.

Table 28.—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		
1969	115	$22,697	2	$699	279	$72,104	7	$1,513	(2)	$174	$369	$97,556
1970	43	8,360	1	448	245	73,397	3	798	1	241	448	83,692
1971	88	19,362	(2)	16	193	48,021	3	579	(2)	86	316	68,380

1 Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
2 Less than ½ unit.

Table 29.—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 (short tons)	Value (thousands)
1969	2,134	667	$3,822
1970	1,429	836	2,364
1971	1,261	496	2,802

Table 30.—Lead: World mine production, by country

(Short tons)

Country [1]	1969	1970	1971 p
North America:			
Canada	r 332,903	393,742	426,800
Guatemala	r 330	550	e 550
Honduras	r 15,256	17,598	19,805
Mexico [2]	188,377	194,665	172,900
United States [3]	509,013	571,767	578,550
South America:			
Argentina	42,651	39,228	42,000
Bolivia	27,230	27,995	25,491
Brazil	30,416	30,400	31,296
Chile	917	885	970
Colombia	r 226	323	226
Peru [4]	170,354	172,809	195,712
Europe:			
Austria [3]	7,503	6,617	8,504
Bulgaria	100,500	105,300	e 110,000
Czechoslovakia	7,310	6,260	e 20,000
Finland	5,019	5,517	5,224
France	33,290	31,769	32,800
Germany, East e	11,000	11,000	10,600
Germany, West	43,335	44,653	45,306
Greece	r 9,552	10,171	11,570
Hungary e	1,100	1,910	1,910
Ireland	r 64,691	69,306	50,486
Italy	r 40,785	38,801	33,083
Norway	r 3,845	3,450	3,411
Poland	60,000	63,100	e 72,000
Portugal	1,986	1,717	1,558
Romania e	r 44,000	42,000	42,000
Spain	79,090	80,154	76,613
Sweden	r 86,249	81,130	85,649
U.S.S.R. e	485,000	485,000	496,000
United Kingdom	3,300	4,400	e 4,400
Yugoslavia	130,122	139,655	138,031
Africa:			
Algeria	r 8,771	7,200	6,800
Congo (Brazzaville) e	550	88	88
Morocco	77,832	80,538	81,647
South-West Africa [5]	72,588	77,034	73,524
Tunisia	r 25,164	24,838	e 23,000
Zambia (refined)	r 25,361	30,093	30,500
Asia:			
Burma e	r 10,800	10,600	10,500
China, People's Republic of e	110,000	110,000	119,000
India	2,239	2,053	1,706
Indonesia	NA	e 220	e 220
Iran [6]	23,920	25,287	e 26,600
Japan [7]	69,953	70,996	77,808
Korea, North e	77,000	77,000	88,000
Korea, Republic of	18,163	17,655	18,236
Pakistan e	--	3	9
Philippines	74	15	--
Thailand	r 1,982	1,421	2,588
Turkey	e 7,900	e 12,000	7,260
Oceania:			
Australia	497,416	495,928	439,493
New Zealand [8]	r 998	858	1,373
Total	r 3,566,061	3,725,699	3,751,797

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

[1] In addition to the countries listed, Pakistan, 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 smelter products (refined lead, antimonial lead, mixed bars, and other, unspecified items).

[3] Recoverable metal.

[4] Recoverable metal; content of lead in concentrates for export plus lead content of domestic smelter products (refined lead, antimonial lead, and bismuth-lead bars).

[5] Year ending June 30 of that stated.

[6] Year beginning March 21 of that stated.

[7] Content of concentrates.

[8] Contained in lead-copper concentrate.

Table 31.—Lead: World smelter production, by country [1]

(Short tons)

Country	1969	1970	1971 [p]
North America:			
Canada (refined)	[r] 187,143	204,587	172,600
Guatemala [2]	248	83	99
Mexico (refined)	186,308	165,645	150,070
United States (refined) [3]	638,655	666,730	650,015
South America:			
Argentina	24,250	42,000	48,000
Bolivia (refined, including solder)	24	9	20
Brazil	20,635	21,259	28,270
Peru (refined)	85,478	79,340	74,004
Europe:			
Austria [4]	8,245	9,637	10,267
Belgium	[r] 107,145	98,547	[e] 88,400
Bulgaria [2]	104,800	108,700	[e] 110,000
Czechoslovakia [2]	22,206	19,417	[e] 20,000
France	118,972	132,207	119,380
Germany, East [e]	27,000	27,000	26,000
Germany, West	138,679	123,900	104,600
Greece (refined)	11,795	15,722	12,912
Hungary [e] [2]	1,100	790	790
Italy	68,701	59,842	53,343
Netherlands	16,308	19,415	26,125
Poland (refined) [2]	55,900	60,100	66,400
Portugal (refined)	1,245	631	1,300
Romania [e]	[r] 39,000	40,000	40,000
Spain	[r] 86,411	75,709	79,527
Sweden (refined)	46,400	44,800	35,500
U.S.S.R. (primary) [e]	485,000	485,000	496,000
United Kingdom [5]	43,052	48,246	42,580
Yugoslavia (refined) [2]	117,899	107,364	109,282
Africa:			
Morocco	29,582	27,449	20,631
South-West Africa (refined) [6]	67,085	77,304	64,838
Tunisia	[r] [7] 17,784	[7] 24,847	21,000
Zambia (refined)	25,361	30,093	30,500
Asia:			
Burma	[r] 10,714	10,485	10,451
China, People's Republic of [e]	110,000	110,000	110,000
India	[r] 2,158	2,053	1,707
Iran [e] [8]	200	200	200
Japan (refined)	[r] 205,706	230,383	237,056
Korea, North [e]	60,000	60,000	70,000
Korea, Republic of	3,834	3,968	3,456
Turkey [e]	[r] 220	220	220
Oceania: Australia (refined and bullion)	378,215	388,624	356,731
Total	[r] 3,553,458	3,622,306	3,492,274

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Primary except as noted, or 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] Year ended June 30 of year stated.
[7] Lead in lead bars plus gross weight of antimonial lead; excludes lead in solder.
[8] Year beginning March 21 of year stated.

Lime

By Avery H. Reed [1]

The total value of lime sold or used by producers set a new record of $309.8 million, 8 percent above the 1970 record. The quantity of lime produced, however, decreased 1 percent and was 3 percent below the 1969 record. Refractory and agricultural uses of lime continued to decline.

Table 1.—Salient lime statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
Number of plants	209	206	201	194	187
Sold or used by producers:					
Quicklime	13,449	14,440	15,479	15,248	15,138
Hydrated lime	2,656	2,364	2,864	3,126	3,446
Dead-burned dolomite	1,880	1,833	1,866	1,373	1,007
Total	17,985	18,637	20,209	19,747	19,591
Value [2]	$240,216	$249,639	$280,736	$286,155	$308,100
Average value per ton	$13.36	$13.39	$13.89	$14.49	$15.73
Lime sold	11,461	12,054	13,113	12,718	12,337
Lime used	6,524	6,583	7,096	7,029	7,254
Exports [3]	52	69	51	54	66
Imports for consumption [3]	81	73	184	202	242

[1] Excludes regenerated lime. Excludes Puerto Rico.
[2] Selling value, f.o.b. plant, excluding cost of containers.
[3] Bureau of the Census.

DOMESTIC PRODUCTION

Lime producers sold or used 19.6 million tons, compared with 19.8 million tons in 1970, a decrease of 1 percent. Sales of lime decreased 3 percent and were 6 percent below the 1969 record. Lime used by producers increased 3 percent and established a new record, 2 percent above the 1969 record. Figures include Puerto Rico.

Production of quicklime was 3 percent below 1970 and 7 percent below the 1969 record. Production of hydrated lime was 10 percent more than the 1970 record. Production of refractory dolomite declined 27 percent and was 58 percent below the 1956 record. The number of plants decreased from 195 to 188 and the average output per plant increased from 101,500 tons per year to 104,400 tons.

Six States, Ohio, Pennsylvania, Missouri, Texas, Michigan, and New York, each producing more than 1 million tons, accounted for 59 percent of the total output.

Leading producing companies were Marblehead Lime Co., with four plants in Illinois and one each in Indiana, Michigan, and Missouri; Mississippi Lime Co. in Missouri; Allied Chemical Corp., with plants in Louisiana and New York; Standard Lime & Refractories Co., with plants in Illinois, Ohio, Pennsylvania, and West Virginia; PPG Industries, Inc., with plants in Ohio and Texas; Bethlehem Steel Corp., with one plant in New York and two in Pennsylvania; United States Gypsum Co., with one plant in Alabama, one in Louisiana, one in Ohio, and two in Texas; Pfizer Inc., with plants in California, Connecticut, Massachusetts, and Ohio; The Dow Chemical Co., with plants in Michigan and Texas; and Diamond Shamrock Chemical Co. in Ohio. These 10 companies, operating 31 plants, accounted for 45 percent of the total lime production.

[1] Physical scientist, Division of Nonmetallic Minerals.

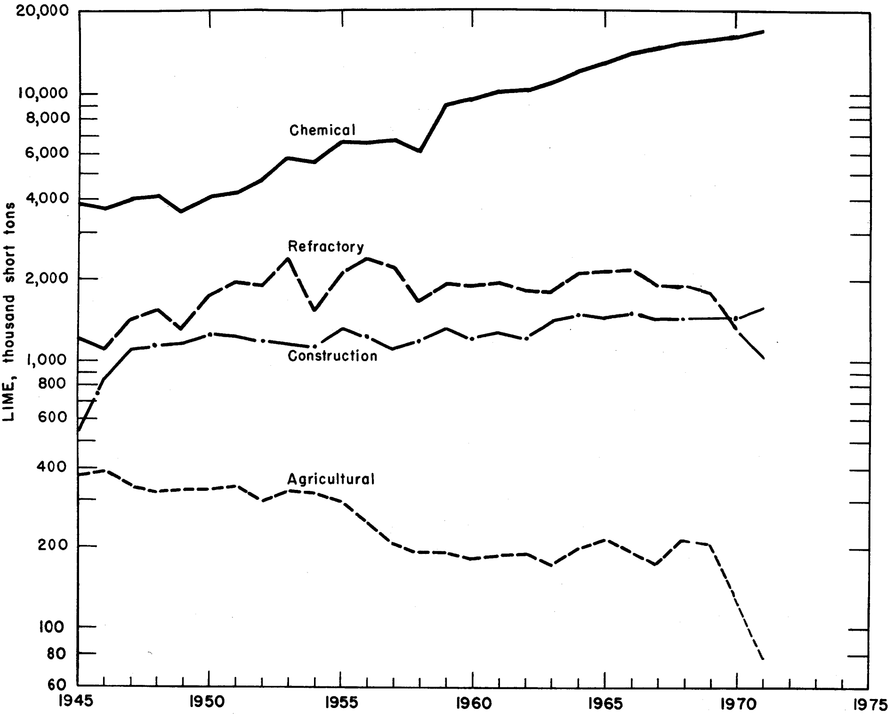

Figure 1.—Trends in major uses of lime.

Table 2.—Lime sold or used by producers in the United States, by State and kind [1]

(Thousand short tons and thousand dollars)

State	1970				1971			
	Hydrated	Quicklime	Total	Value	Hydrated	Quicklime	Total	Value
Alabama	126	623	749	$10,286	137	624	761	$11,454
Arizona	W	W	309	4,523	19	276	296	4,474
Arkansas	W	W	186	2,680	W	W	157	2,313
California	81	490	572	9,911	137	493	630	10,846
Colorado	--	119	119	1,613	46	146	193	3,039
Florida	W	W	167	2,810	W	W	159	2,958
Hawaii	8	1	9	338	7	1	8	228
Kansas	--	6	6	W	8	--	8	W
Louisiana	W	W	1,025	12,811	W	W	960	17,625
Michigan	W	W	1,538	21,355	62	1,383	1,444	20,549
Montana	5	203	208	W	1	197	199	2,416
Nebraska	--	27	27	W	9	19	29	W
New Mexico	37	--	37	W	35	--	35	W
Ohio	234	3,717	3,951	61,197	267	3,740	4,007	65,258
Oregon	W	W	96	1,777	W	W	106	1,989
Pennsylvania	322	1,564	1,887	29,279	331	1,429	1,760	30,008
Puerto Rico	40	1	41	W	43	1	44	W
Texas	782	892	1,673	24,427	771	841	1,612	24,583
Utah	W	W	186	3,756	W	W	172	3,569
Virginia	70	977	1,046	14,090	63	696	759	11,049
West Virginia	W	W	262	3,757	W	W	197	3,073
Wisconsin	W	W	247	4,503	W	W	246	4,570
Wyoming	--	22	22	W	27	--	27	W
Other States [2]	1,461	7,980	5,425	78,440	1,526	6,300	5,826	89,814
Total [3]	3,166	16,622	19,788	287,553	3,489	16,146	19,635	309,813

W Withheld to avoid disclosing individual company confidential data; included in "Other States."

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Includes Connecticut, Idaho, Illinois, Indiana, Iowa, Kentucky (1971), Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New York, North Dakota, Oklahoma, South Dakota, Tennessee, Washington, and States indicated by symbol W.

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

Table 3.–Lime sold or used by producers in the United States, by State and market [1]

(Thousand short tons)

State	1970				1971			
	Plants	Sold	Used	Total [2]	Plants	Sold	Used	Total [2]
Alabama	5	W	W	749	5	W	W	761
Arizona	7	185	124	309	7	180	117	296
Arkansas	4	W	W	186	3	W	W	157
California	15	230	342	572	15	239	391	630
Colorado	11	--	119	119	11	7	186	193
Connecticut	1	W	W	W	1	W	W	W
Florida	3	W	W	167	3	W	W	159
Hawaii	r2	8	1	9	2	2	7	8
Idaho	4	W	W	W	4	W	W	W
Illinois	5	W	W	W	5	W	W	W
Indiana	1	W	W	W	1	W	W	W
Iowa	2	W	W	W	2	W	W	W
Kansas	1	--	6	6	1	--	8	8
Kentucky	--	--	--	--	1	W	W	W
Louisiana	4	W	W	1,025	4	W	W	960
Maryland	3	W	W	W	2	W	W	W
Massachusetts	3	W	W	W	2	W	W	W
Michigan	10	W	W	1,538	10	W	W	1,444
Minnesota	5	W	W	W	4	W	W	W
Mississippi	1	--	W	W	1	W	W	W
Missouri	4	W	W	W	4	W	W	W
Montana	4	--	208	208	4	--	199	199
Nebraska	4	--	27	27	4	--	29	29
Nevada	4	W	W	W	3	W	W	W
New Jersey	1	W	W	W	1	W	W	W
New Mexico	1	--	37	37	1	--	35	35
New York	3	W	W	W	3	W	W	W
North Dakota	1	--	W	W	1	W	W	W
Ohio	20	2,315	1,636	3,951	19	2,217	1,789	4,007
Oklahoma	2	W	W	W	2	W	W	W
Oregon	4	W	W	96	3	W	W	106
Pennsylvania	12	W	W	1,887	11	W	W	1,760
Puerto Rico	1	41	--	41	1	43	1	44
South Dakota	2	W	W	W	2	W	W	W
Tennessee	2	W	W	W	2	W	W	W
Texas	13	934	739	1,673	14	853	759	1,612
Utah	7	W	W	186	6	W	W	172
Virginia	8	W	W	1,046	8	W	W	759
Washington	3	W	W	W	3	W	W	W
West Virginia	3	W	W	262	3	W	W	197
Wisconsin	6	W	W	247	6	W	W	246
Wyoming	3	--	22	22	3	--	27	27
Undistributed	--	9,046	3,768	5,425	--	8,839	3,706	5,826
Total [2]	195	12,759	7,029	19,788	188	12,380	7,254	19,635

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

[1] Excludes regenerated lime. Includes Puerto Rico.

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

Table 4.—Lime sold or used by producers in the United States, by size of plant [1]

(Thousand short tons)

Size of plant	1970			1971		
	Plants	Quantity	Percent of total	Plants	Quantity	Percent of total
Less than 10,000 tons	46	209	1	30	138	1
10,000 to 25,000 tons	35	564	3	37	590	3
25,000 to 50,000 tons	28	1,060	5	37	1,404	7
50,000 to 100,000 tons	28	2,025	10	26	1,775	9
100,000 to 200,000 tons	24	3,770	19	25	3,805	19
200,000 to 400,000 tons	27	7,812	40	26	7,215	37
More than 400,000 tons	7	4,348	22	7	4,708	24
Total	195	19,788	100	188	19,635	100

[1] Excludes regenerated lime. Includes Puerto Rico.

Cheney Lime and Cement Co. added a rotary kiln to their Landmark Plant, greatly increasing its capacity. Black River Mining Co. started a new plant at Carntown, Ky., making quicklime for the Cincinnati area. Chemical Lime Co. started a new plant at Clifton, Tex., and produced quicklime and hydrated lime. Marblehead Lime Co. announced plans for two new kilns at their Buffington, Ind., plant which will raise capacity to 800,000 tons per year. St. Clair Lime Co. added a rotary kiln to their Marble City, Okla. plant, raising capacity to 650-tons-per-day. Plans were announced for the construction of a hydrating plant. Warner Co. completed a new 300-ton-per-day kiln at their Cedar Hollow Plant near Paoli, Pa. It replaces a 52-year-old kiln. During the year, two plants started and nine were closed, resulting in a net loss of seven plants.

National Lime & Stone Co. installed a new 200 ton-per-day calcimatic rotating hearth kiln at its Carey, Ohio, plant. Pfizer Inc. announced plans to add a new 130,000-ton-per-year rotary kiln to their Gibsonburg, Ohio, plant.

Winners were announced for the 1970 National Lime Association Safety Competition: First, Longview Lime Co., Saginaw, Ala.; second, M. J. Grove Co., Stephens City, Va.; third, J. E. Baker Co., York, Pa.; and fourth, National Gypsum Co., Gibsonburg, Ohio. Other Group winners were: The Flintkote Co., Grantsville, Utah, The Dow Chemical Co., Ludington, Mich., and Southern Cement Co., Roberta, Ala.

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

(Thousand short tons and thousand dollars)

Use	1970				1971			
	Sold	Used	Total	Value	Sold	Used	Total [2]	Value
Agriculture	142	--	142	$2,339	80	--	80	$1,449
Construction:								
Soil stabilization	888	--	888	16,136	832	--	832	15,982
Mason's lime	424	W	W	8,428	414	W	W	9,055
Finishing lime	196	--	196	3,582	222	--	222	4,257
Other uses	2	--	2	43	31	--	31	604
Total	1,510	W	W	28,189	1,499	W	W	29,898
Chemical and industrial:								
Steel, BOF	4,317	856	5,173	67,955	4,183	985	5,167	76,352
Alkalies	W	W	3,121	39,348	W	W	3,462	52,391
Water purification	1,217	10	1,227	17,195	W	W	1,273	19,638
Paper and pulp	918	85	1,003	14,734	W	W	869	13,792
Sugar refining	43	654	697	13,422	39	749	787	14,625
Steel, electric	W	W	508	7,087	W	W	560	8,221
Calcium carbide	W	W	561	6,871	304	233	537	7,298
Steel, open-hearth	378	220	598	8,158	W	W	535	7,788
Copper ore concentration	228	350	578	7,612	216	269	485	6,639
Aluminum and bauxite	W	W	381	5,099	W	W	364	5,012
Sewage	293	22	315	4,886	273	76	349	5,305
Glass	327	--	327	4,428	347	--	347	5,126
Magnesia from sea water	W	W	W	W	W	W	298	4,385
Other metallurgy	W	W	124	1,738	W	W	92	1,354
Petroleum refining	58	--	58	853	49	--	49	784
Other ore concentration	W	--	W	W	36	--	36	404
Insecticides	34	--	34	549	32	--	32	569
Tanning	36	--	36	658	30	--	30	588
Food	28	--	28	460	30	--	30	576
Oil well drilling	6	--	6	87	12	--	12	204
Silica brick	4	--	4	68	7	--	7	104
Sand-lime brick	10	--	10	152	6	--	6	96
Paint	3	--	3	46	4	--	4	62
Rubber	W	--	W	W	2	--	2	35
Other uses [3]	1,972	W	W	29,879	4,266	W	W	27,015
Total	9,872	W	W	231,285	9,836	W	W	258,363
Refractory dolomite	1,235	138	1,373	25,740	965	42	1,007	20,103
Grand total [2,4]	12,759	7,029	19,788	287,553	12,380	7,254	19,635	309,813

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes magnesite, chrome, petrochemicals, whiting, acid mine water neutralization, manganese, magnesium metal, coke, wire drawing, sulfur removal from stack gases, and fertilizer.
[4] Includes uses indicated by symbol W.

Table 6.—Destination of shipments of lime sold or used by producers in the United States in 1971, by State [1]

(Short tons)

State	Quicklime	Hydrated lime	Total
Alabama	331,286	82,687	413,973
Arizona	255,506	28,206	283,712
Arkansas	W	W	149,069
California	634,252	181,781	816,033
Colorado	160,902	56,339	217,241
Connecticut	W	W	67,075
Delaware	10,647	5,660	16,307
District of Colombia	--	1,044	1,044
Florida	266,278	43,978	310,256
Georgia	96,902	22,839	119,741
Hawaii	W	W	9,472
Illinois	829,363	141,256	970,619
Indiana	W	W	1,307,237
Iowa	62,573	32,532	95,105
Kansas	41,953	40,832	82,785
Kentucky	489,863	16,415	506,278
Louisiana	W	W	952,639
Maryland	364,416	17,303	381,719
Massachusetts	W	W	61,412
Michigan	1,563,552	92,607	1,656,159
Minnesota	120,178	52,328	172,506
Mississippi	104,406	13,781	118,187
Missouri	W	W	196,153
Montana	223,914	3,765	227,679
Nebraska	31,378	23,049	54,427
Nevada	W	W	52,237
New Hampshire	W	W	4,736
New Jersey	54,741	88,000	142,741
New Mexico	W	W	74,539
North Carolina	85,698	27,072	112,770
North Dakota	W	W	59,236
Ohio	3,085,912	158,198	3,244,110
Oregon	115,268	16,474	131,742
Pennsylvania	1,721,408	246,783	1,968,191
Rhode Island	W	W	9,915
South Carolina	34,219	12,335	46,554
Tennessee	104,718	42,138	146,856
Texas	883,989	785,486	1,669,475
Utah	W	W	120,898
Virginia	152,131	29,956	182,087
Washington	71,121	15,261	86,382
West Virginia	353,090	20,702	373,792
Wisconsin	110,310	53,216	163,526
Exports:			
Canada	34,199	10,511	44,710
Other countries	31,758	18,723	50,481
Other states [2]	3,719,576	1,107,995	1,762,953
Total	16,145,507	3,489,252	19,634,759

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Includes Alaska, Idaho, Maine, New York, Oklahoma, Puerto Rico, South Dakota, Vermont, Wyoming, and States indicated by footnote W.

CONSUMPTION AND USES

Lime was consumed in every State. Leading consuming States were Ohio, Pennsylvania, Texas, Michigan, and Indiana, each of which consumed more than 1 million tons. These five States accounted for 50 percent of the total lime consumed.

Leading quicklime-consuming States were Ohio, Pennsylvania, Michigan, Indiana, and Texas, each of which consumed more than 800,000 tons. These five States accounted for 57 percent of the quicklime consumed.

Leading hydrate consuming States were Texas, Pennsylvania, California, Ohio, and Illinois, each of which consumed more than 140,000 tons. These five States accounted for 43 percent of the hydrate consumed.

The four principal uses for lime sold by producers were chemical, 79 percent; construction, 12 percent; refractory, 8 percent; and agricultural, 1 percent.

Lime consumed by producers was 37 percent of the total compared with 36 percent in 1970 and 35 percent in 1969.

The leading individual uses were basic oxygen steel furnaces, alkalies, water purification, other chemical uses, and refractory dolomite. Each of these uses required more than 1 million tons of lime.

New lime uses canvassed for 1971 included magnesite, chrome, acid mine water neutralization, sulfur removal from stack gases, and fertilizers.

Lime used in agriculture continued to decline and was 44 percent less than in 1970 and 56 percent less than in 1969. Lime used as refractory dolomite continued to decline and was 27 percent less than in 1970 and 46 percent less than in 1969. Chemical and industrial uses, and also contruction uses, were about the same as in 1970.

PRICES

The average value of lime sold or used in 1971 was $15.78 per ton, an increase of 9 percent over the 1970 value of $14.53 per ton.

Values for quicklime ranged from $14.94 for chemical lime to $15.40 for construction lime, $15.53 for agricultural lime, and $19.97 for refractory dolomite, and averaged $15.29 per ton. Each of these values was higher than in 1970 except for construction lime.

Values for hydrated lime ranged from $16.29 for chemical lime to $19.00 for agricultural lime and to $19.52 for construction lime and averaged $17.29 per ton. Each of these values was higher than in 1970.

FOREIGN TRADE

Exports of lime increased 22 percent but were 4 percent below the 1968 record. Of the total quantity exported, Canada received 71 percent, Surinam 21 percent, and Mexico 3 percent. The remaining 5 percent went to 29 countries, listed in order of quantities received: British Bahamas, the Philippines, West Germany, Panama, Bermuda, Chile, Nicaragua, Pacific Trust Islands, Sweden, Singapore, Australia, Jamaica, Argentina, Brazil, Venezuela, Leeward Islands, Italy, New Zealand, Angola, Liberia, Honduras, the Netherland Antilles, Colombia, the United Kingdom, Austria, the Dominican Republic, Belgium, Republic of Korea, and Ecuador.

Imports of lime, mainly from Canada, increased 20 percent above the 1970 record. Small quantities were also imported from the Dominican Republic, Mexico and France.

Table 7.—U.S. exports of lime

Year	Short tons	Value (thousands)
1969	51,006	$1,153
1970	53,876	1,391
1971	65,862	1,971

Table 8.—U.S. imports for consumption of lime

Year	Hydrated lime		Other lime		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	39,270	$542	144,471	$1,911	183,741	$2,453
1970	34,158	479	167,432	1,946	201,590	2,425
1971	39,807	618	202,477	2,690	242,284	3,308

WORLD REVIEW

Canada.—A new lime plant was constructed in British Columbia by Texada Lime Ltd.; capacity of the new calcimatic kiln is 200 tons per day.

A new 220-ton-per-day lime plant was constructed by Reiss Lime Co. of Canada Ltd. at Serpent Harbor, near Spragge, Ontario, on the north shore of Lake Huron.

During 1970, 23 lime plants were active in Canada, 11 in Ontario, four in Quebec, four in Alberta, three in Manitoba, and one in Newfoundland. Of the 77 kilns in operation, 55 were vertical, 19 were rotary, two were rotary-grate, and one was vibratory grate. Production in 1970 was 1,643,000 tons.

Companies active in Ontario included Algoma Steel Corp. Ltd., Allied Chemical Canada Ltd., Bonnechere Lime Ltd., Canadian Gypsum Co. Ltd., Cyanide of Canada Ltd., Dominion Magnesium Ltd., Domtar Chemicals Ltd., Reiss Lime Co. of Canada Ltd., and The Steel Co. of Canada, Ltd.

Active companies in Quebec were Dominion Lime Ltd., Domtar Chemicals Ltd., Gulf Oil Canada Ltd., and Quebec Sugar Refinery.

Germany, West.—West Germany ranked third in world production after the U.S.S.R. and the United States and accounted for 11 percent of the world total.

Italy.—Italy ranked fifth in world production of lime, accounting for 6 percent of the total.

Japan.—Japan ranked fourth in world lime production, accounting for 10 percent.

Turkey.—Tekno-Holding Co. completed a 70,000-ton-per-year lime plant near Omerli, Istanbul.

U.S.S.R.—The U.S.S.R. was the leading lime producing country in the world, accounting for 22 percent of the total production.

Table 9.—Quicklime and hydrated lime, including dead-burned dolomite: World production by country

(Thousand short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada	1,635	1,643	[e] 1,519
Costa Rica	9	11	12
Guatemala	19	24	[e] 24
Puerto Rico	41	41	44
United States (sold or used by producers)	20,209	19,747	19,591
South America:			
Brazil	1,800	1,800	[e] 2,200
Colombia [e]	1,100	1,100	1,100
Paraguay	21	23	26
Uruguay [e]	56	67	[e] 70
Europe:			
Austria [2]	806	820	741
Belgium	3,326	3,187	3,311
Bulgaria	1,002	1,036	1,047
Czechoslovakia [3]	2,349	2,368	2,485
Denmark	214	197	197
Finland	235	254	254
France	4,615	4,819	[e] 4,900
Germany, East	2,770	2,946	[e] 3,000
Germany, West	[r] 12,057	11,812	11,641
Hungary	762	719	671
Ireland	58	65	60
Italy	6,388	[e] 6,400	[e] 6,400
Norway	234	[e] 220	[e] 220
Poland	2,456	3,875	4,142
Romania	2,114	2,217	[e] 2,300
Spain	557	[e] 550	[e] 550
Sweden	[r] 892	897	907
Switzerland	165	160	157
U.S.S.R.	23,524	[e] 23,700	[e] 23,700
Yugoslavia	1,539	1,662	1,755
Africa:			
Ethiopia (including Eritrea)	[r] 25	20	15
South Africa, Republic of (sales)	1,034	1,123	1,214
Tanzania	12	7	6
Tunisia	157	183	183
Uganda	[e] 20	23	[e] 20
Zambia	83	115	[e] 115
Asia:			
Cyprus	[r] 132	117	[e] 110
India	336	508	570
Iran [e]	1,100	1,100	1,100
Japan	4,657	10,110	10,934
Kuwait	1	1	[e] 1
Lebanon	132	143	138
Mongolia [e]	44	44	44
Philippines	238	179	267
Saudi Arabia	17	24	[e] 24
Taiwan	121	141	188
Oceania:			
Australia [e] [4]	230	230	230
Fiji Islands	4	3	--
Total	99,296	106,431	108,183

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Lime is produced in many other countries besides those listed. Zaire (formerly Congo-Kinshasa), Mexico, Nicaragua, Venezuela, and the United Kingdom are among the more important countries for which official data are unavailable.

[2] Includes lime for agriculture for 1969 and 1970; excludes lime for agriculture for 1971.

[3] Excludes output by small producers.

[4] Year ended June 30 of year stated.

TECHNOLOGY

Many lime plants were installing dust control equipment, in order to meet air pollution regulations. Some plants closed rather than trying to meet the standards.

Rising fuel costs are directly reflected in increased costs of manufacturing lime. Fuel shortages were reported at several plants.

The new Carntown, Ky., plant of Black River Mining Co. featured radiation-convection cooling pipes reaching a height of 150 feet in the air. The two rotary kilns are each rated at 500-tons-per-day. The cooler pipes lower the gas temperature to less than 550°F.

Magnesium

By E. Chin [1]

Production and shipments of magnesium metal increased in 1971, and deliveries of metal from the Government stockpile continued throughout the year. In compliance with an order of the Texas Air Control Board, American Magnesium Co. halted production in mid-year to effect improvements in the effluent control systems of its plant. In the Great Salt Lake area of Utah, construction and other development activities aimed at the use of the lake's brines as a source of magnesium continued.

Legislation and Government Programs. —In 1970, the Office of Emergency Preparedness removed magnesium from the list of strategic and critical materials, and the stockpile objective for magnesium was abolished. Under prior legislation (Public Laws 90–604 and 91–321) and Public Law 92–113 enacted on August 11, 1971, the General Services Administration (GSA) was authorized to dispose of all the magnesium remaining in the National Stockpile. A total of 710 short tons of magnesium was sold during 1971, leaving 98,089 short tons in the stockpile at yearend.

Table 1.—Salient magnesium statistics
(Short tons)

	1967	1968	1969	1970	1971
United States:					
Production:					
Primary magnesium	97,406	98,375	99,887	112,007	123,485
Secondary magnesium	13,444	15,525	13,470	12,042	13,418
Shipments: Primary	100,743	103,671	117,695	118,693	120,217
Exports	13,173	19,457	27,372	35,732	24,311
Imports for consumption	9,721	4,808	4,316	3,295	3,671
Consumption	90,825	86,427	95,132	93,495	99,101
Price per pound ... cents	35.25	35.25	35.25	35.25	36.25
World: Primary production	208,575	212,305	221,469	245,324	256,807

DOMESTIC PRODUCTION

U.S. production of primary magnesium rose 10 percent in 1971, to 123,485 short tons. Secondary magnesium recovery was 13,418 short tons for the year. The entire quantity of primary magnesium metal produced came from The Dow Chemical Co.'s electrolytic plants in Freeport, Tex., and from American Magnesium Co.'s electrolytic plant in Snyder, Tex.

NL Industries, Inc. (NL), expected operational startup of its magnesium plant late in the year. NL's $70-million project will use a 250-million-gallon-brine-storage tank that is a mile in circumference and completely lined with 2.4 million square feet of synthetic rubber to protect against leakage. The tank will store more than a year's supply of raw material cell feed. The reduction plant, located on the southwestern shore of the Great Salt Lake, near Rowley and Grantsville, Tooele County, Utah, will have an annual capacity of 45,000 tons per year of magnesium metal and 80,000 tons of chlorine.

Great Salt Lake Minerals and Chemicals Corp. (GSL) continued to concentrate lake brine at its 14,000-acre evaporation pond on the east shore of the Great Salt Lake near Ogden, Utah. The solar evaporation installation, largest of its kind in the

[1] Chemist, Division of Nonferrous Metals.

world, will have initial annual capacities of 200,000 tons of magnesium chloride, 240,000 tons of potassium sulfate, and 150,000 tons of sodium sulfate.

Difficulties arising from weather conditions in 1971 posed problems in brine management at the plant. Wet weather early in the year caused dilution of the brines, thereby increasing volume and creating transportation problems. Additionally, ponds were either run too deep, or too shallow. Efforts to conserve magnesium-rich bitterns resulted in low grade and reduced potash yield. Owing to the difficulties incurred, GSL estimated that normal operations would be set back at least 2 years.

The Dow Chemical Co. announced a slowdown in the construction of its electrolytic plant in Dallesport, Wash. The plant, which has a planned initial capacity of 25,000 tons of magnesium per year, was estimated to be 25 percent complete, and is now scheduled for completion in January 1975.

During December 1971, The Dow Chemical Co. cancelled its contract with GSL under which deliveries of magnesium chloride hexahydrate crystals to Dow's Dallesport facilities were to have begun in 1972. Under the agreement, Dow paid GSL $2,975,000 in cancellation charges.

The Aluminum Co. of America (Alcoa) planned to construct a plant at Addy, Wash., to produce magnesium from dolomite by the silicothermic process. Alcoa was reported to have acquired property for the 20,000-ton-per-year magnesium facility. The plant is estimated to cost $25 to $50 million and will employ between 300 and 400 people when on stream.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1967	1968	1969	1970	1971
Kind of scrap:					
New scrap:					
Magnesium-base	5,062	7,006	4,767	4,564	5,871
Aluminum-base	4,266	5,050	5,712	4,698	4,824
Total	9,328	12,056	10,479	9,262	10,695
Old scrap:					
Magnesium-base	2,973	2,113	1,700	1,518	1,298
Aluminum-base	1,143	1,356	1,291	1,262	1,425
Total	4,116	3,469	2,991	2,780	2,723
Grand total	13,444	15,525	13,470	12,042	13,418
Form of recovery:					
Magnesium alloy ingot [1]	3,760	2,502	3,231	2,006	2,634
Magnesium alloy castings (gross weight)	39	15	11	13	14
Magnesium alloy shapes	103	82	149	189	500
Aluminum alloys	6,157	9,900	8,378	7,088	7,410
Zinc and other alloys	18	18	13	24	17
Chemical and other dissipative uses	25	64	65	80	477
Cathodic protection	3,342	2,944	1,623	2,642	2,366
Total	13,444	15,525	13,470	12,042	13,418

[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

CONSUMPTION AND USES

In 1971 consumption of magnesium increased 6 percent, to 99,101 tons. As in the previous year, the largest single use of magnesium was for aluminum alloys, which accounted for 40 percent of the total consumption. The consumption of magnesium in anodes for cathodic protection increased almost twofold.

Table 3.—Consumption of primary magnesium in the United States, by uses

(Short tons)

	1967	1968	1969	1970	1971
For structural products:					
Castings:					
Sand	3,848	3,740	2,562	1,735	1,505
Die [1]	8,366	7,337	7,484	9,002	9,659
Permanent mold	555	607	404	260	781
Wrought products:					
Sheet and plate	(2)	(2)	(2)	(2)	(2)
Extrusions (structural shapes, tubing) [3]	10,517	11,280	13,110	12,250	13,290
Total	23,286	22,964	23,560	23,247	25,235
For distributive or sacrificial purposes:					
Powder	(4)	(4)	(4)	5,646	3,410
Aluminum alloys	31,244	34,484	37,375	36,543	39,988
Zinc alloys	53	52	54	35	39
Other alloys	2,370	(4)	(4)	(4)	(4)
Scavenger and deoxidizer	(4)	(4)	(4)	(4)	(4)
Chemical	5,214	(4)	(4)	8,385	9,008
Cathodic protection (anodes)	4,855	5,714	6,087	5,778	9,416
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	6,704	6,209	7,363	6,300	5,588
Nodular iron	(4)	2,480	2,374	4,720	4,135
Other [5]	17,099	14,524	18,319	2,841	2,282
Total	67,539	63,463	71,572	70,248	73,866
Grand total	90,825	86,427	95,132	93,495	99,101

[1] Includes primary metal to produce small quantities of investment castings.
[2] Included with "Extrusions."
[3] Includes "Forgings."
[4] Included with "Other."
[5] Includes primary metal for experimental purposes.

PRICES

For more than a decade, the quoted base price for primary magnesium pig and ingot in 10,000-pound lots, 99.8-percent magnesium, f.o.b. plant, remained at 35.25 and 36.00 cents per pound, respectively. However, effective on January 1, 1971, the price of pig and ingot was increased to 36.25 and 37.00 cents per pound, respectively. Because of rising production costs, on April 1, 1971, The Dow Chemical Co. announced a 5-percent price increase on specification-grade magnesium. The increase applied only to custom-made sheet, plate, and extrusions for such markets as aircraft and construction equipment, lawn mowers, and bakery racks.

Depending upon the condition of the metal available from the national stockpile, GSA accepted bids for primary magnesium ranging from 28.25 to 34.25 cents per pound, f.o.b. storage locations. The average price of metal sold by GSA during the year was 32.11 cents per pound.

STOCKS

Producer and consumer stocks of primary magnesium totaled 13,021 tons as of December 31, 1971. Yearend stocks of primary magnesium alloy ingot were 1,727 short tons. Stocks a year earlier were 9,195 short tons of primary metal and 3,501 short tons of alloy ingot.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1971

(Short tons)

Scrap item	Stocks Jan. 1 [r]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Cast scrap	294	2,213	789	1,451	2,240	267
Solid wrought scrap [1]	800	5,719	5,749	--	5,749	770
Total	1,094	7,932	6,538	1,451	7,989	1,037

[r] Revised.
[1] Includes borings, turnings, drosses, etc.

FOREIGN TRADE

U.S. exports of primary magnesium declined from 35,732 short tons in 1970 to 24,311 tons in 1971. Exports to West Germany were down 9,163 tons from the 1970 level. However, West Germany was the largest customer for U.S. magnesium, accounting for 41 percent of the total exported in 1971. Imports by Brazil, Canada, and Mexico accounted for 28, 9, and 4 percent, respectively, of the total U.S. primary metal exported. Shipments to Italy, Argentina, Spain, and Australia collectively totaled 2,190 tons or 9 percent of total exports; the remaining 2,260 tons was exported to approximately 20 countries.

Total imports for consumption of magnesium increased 11 percent over that of 1970. Canada, by far the largest of U.S. sources, contributed 53 percent of the total metal imported. Receipts from West Germany and the United Kingdom constituted 20 and 4 percent, respectively, of the total imports. The remainder of U.S. imports, 834 tons, was contributed by 10 other nations.

Under the provisions of the "Kennedy round" trade agreements, another series of tariff reductions became effective on January 1, 1971. The import duty on nonalloyed unwrought magnesium was dropped to 24 percent from the 28 percent ad valorem rate of the previous year; the duty on unwrought alloys was lowered from 11 cents per pound on magnesium content plus 5.5 percent ad valorem to 9.5 cents per pound plus 4.5 percent ad valorem; and the duty on wrought magnesium was reduced from 9.4 per pound on magnesium content plus 4.5 percent ad valorem to 8 cents per pound plus 4 percent ad valorem.

Table 5.—U.S. exports of magnesium, by classes and countries

Destination	1970				1971			
	Primary metals, alloys, and scrap		Semifabricated forms, n.e.c., including powder		Primary metals, alloys, and scrap		Semifabricated forms, n.e.c., including powder	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Angola	--	--	--	--	--	--	60	$77
Argentina	211	$127	16	$26	502	$374	1	6
Australia	982	563	56	112	455	294	46	106
Austria	198	111	--	--	48	29	--	--
Belgium-Luxembourg	771	441	9	17	225	135	3	9
Brazil	5,495	3,113	(1)	(1)	6,692	3,787	2	6
Canada	1,389	852	216	388	2,024	1,319	207	291
Colombia	(1)	1	13	18	12	9	5	12
France	383	405	14	28	36	25	17	38
Germany, West	19,144	10,774	13	33	9,857	5,742	137	317
Ghana	--	--	130	66	1	1	2	2
India	124	89	80	60	9	8	--	--
Indonesia	(1)	(1)	27	43	--	--	--	--
Israel	32	19	50	69	6	4	35	54
Italy	378	216	70	47	674	412	51	43
Japan	1,127	872	299	359	230	130	243	435
Mexico	1,164	907	189	207	910	705	32	41
Netherlands	316	178	169	725	282	155	34	104
New Zealand	60	34	1	2	15	9	--	--
Norway	757	456	1	4	106	60	1	1
South Africa, Republic of	163	94	--	--	112	63	2	1
Spain	481	270	58	37	457	256	4	6
Surinam	25	15	--	--	--	--	--	--
Sweden	--	--	25	44	--	--	33	93
Switzerland	225	127	12	21	65	48	1	1
Taiwan	--	--	--	--	66	43	--	--
United Kingdom	309	176	19	43	350	195	17	46
Venezuela	249	162	40	36	148	113	32	33
Yugoslavia	122	68	--	--	--	--	--	--
Other	80	50	40	37	57	39	7	15
Total	34,185	20,120	1,547	2,422	23,339	13,955	972	1,737

[1] Less than ½ unit.

Table 6.—U.S. exports and imports for consumption of magnesium

Year	Exports: Metal and alloys in crude form and scrap — Short tons	Value (thousands)	Semifabricated forms, n.e.c. — Short tons	Value (thousands)
1969	26,032	$15,137	1,340	$2,824
1970	34,185	20,120	1,547	2,422
1971	23,339	13,955	972	1,737

Year	Imports: Metal and scrap — Short tons	Value (thousands)	Alloys (magnesium content) — Short tons	Value (thousands)	Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content) — Short tons	Value (thousands)
1969	3,515	$1,913	467	$1,175	334	$1,168
1970	2,948	1,566	122	300	225	637
1971	3,442	1,633	99	286	130	397

WORLD REVIEW

World production of magnesium rose about 5 percent in 1971 and totaled 256,807 short tons. The United States produced 48 percent of the estimated world total, followed by the U.S.S.R., 22 percent, and Norway, 16 percent.

World producers of magnesium with capacities, processes, and plant locations are as follows:

Country	Company	Capacity (short tons)	Process	Plant location
Canada	Dominion Magnesium Ltd	12,000	Silicothermic	Haley, Ontario.
France	Compagnie de Produits Chimiques et Electrométallurgiques (Péchiney)—(35 percent). Société d'Electrochimie, d'Electrométallurgie et des Aciéries Electriques d'Ugine (35 percent), Société des Produits Azotés (SPA)—(30 percent).	9,000	do	Marignac.
Italy	Società Italiana per il Magnesio e Leghe di Magnesio.	7,000	do	Bolzano.
Japan	Furukawa Magnesium Co. Ltd	6,600	do	Koyama.
	UBE Industries, Ltd	6,000	do	Yamaguchi.
Norway	Heroya Electrokemiske Fabrikker A/S subsidiary of Norsk Hydro-Elektrisk A/S	47,000	I. G. Farben-industrie.	Heroya.
U.S.S.R.	NA	50,000	Electrolytic	NA.
United States	American Magnesium Co	30,000	do	Snyder, Tex.
	The Dow Chemical Co	120,000	Dow cells	Freeport, Tex.
	Titanium Metals Corp. of America	[1] 12,000	Electrolytic	Henderson, Nev.
	Oregon Metallurgical Corp	[1] 10,000	do	Albany, Oreg.

NA Not available.
[1] Captive use.

Table 7.—Magnesium: World production by countries

(Short tons)

Country	1969	1970	1971 [p]
Canada	10,637	10,354	7,252
China, People's Republic of [e]	1,100	1,100	1,100
France	4,866	5,115	[e] 5,200
Italy	[r] 7,093	8,356	[e] 8,800
Japan	[r] 10,342	11,395	10,685
Norway	34,333	38,959	40,185
U.S.S.R. [e]	50,000	55,000	57,000
United Kingdom	3,211	3,038	[e] 3,100
United States	99,887	112,007	123,485
Total	[r] 221,469	245,324	256,807

[e] Estimate. [p] Preliminary. [r] Revised.

Canada.—International Nickel Co. of Canada was constructing a $3.6 million plant at Port Colborne, Ontario, for the production of nickel-magnesium alloys used for producing ductile iron. Initial annual production of 14 million pounds was scheduled for mid-1972. The plant will eventually have an annual capacity of 25 million pounds.

France.—Société Générale du Magnesium owned jointly by Péchiney and Ugine Kuhlmann completed the installation of a sixth furnace at its plant at Marignac. This facility, with an annual capacity of 9,000 tons per year, produces magnesium by the magnetherm process. Plans for a further increase in capacity to 16,000 tons per year were being considered.

Netherlands.—Shell Dellstoffen Nederland N.V. applied to provincial authorities for a concession to exploit large deposits of magnesium salts in the province of Friesland. The deposits, estimated to total about 300 million tons, consist mainly of carnallite—a double salt of magnesium and potassium chloride. According to a press release issued by Shell, plans are under consideration for setting up a magnesium plant.

Norway.—Norsk Hydro—Elektrisk A/S completed the expansion of its magnesium production facility at Heroya raising its production capacity to 47,000 tons per year. Magnesium chloride brine will be supplied by Kali and Salz GmbH, a subsidiary of Salzdetfurth A.G. New facilities being built at Heroya by Norsk Hydro to process the brine material are expected to be completed in the autumn of 1972.

TECHNOLOGY

A new technique for making pore-free die castings, using a reactive gas in place of air in the die chamber, has gone into commercial production under a cross-licensing agreement between the International Lead Zinc Research Organization and Nippon Light Metal.[2] The technique is applicable to magnesium as well as aluminum and zinc die casting. The pore-free die castings have a 10-percent greater as-cast strength and up to two times the elongation of conventionally die-cast parts.

The capacity of seawater activated batteries containing magnesium anodes is often limited by clogging. During discharge the space between the electrodes of the cells nearest to the negative terminal gradually fill with magnesium hydroxide and battery capacity is reduced. By using a filter, the formation of flocculent magnesium hydroxide during discharge can be controlled in low rate AgCl/Mg seawater batteries. When disodium ethylenediaminetetraacetate is used as the filter medium, the capacity of these batteries was reportedly increased.[3]

Battelle Memorial Institute will establish an international magnesium research center at its Columbus, Ohio, laboratories.[4] The Dow Chemical Company will transfer its files on magnesium research and development to Battelle for a nominal sum and will place an initial $1 million, 5-year research contract with the new center. The Dow files contain about 14,000 separate reports accumulated over more than 50 years of magnesium research by the company. The files also include indexes listing nearly all pre-1944 scientific publications on magnesium.

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[2] Metals Week. New Process Makes Pore-free Die Castings. V. 42, No. 33, Aug. 16, 1971, p. 7.

[3] Mueller, Carl E., and Frederic M. Bowers. The Control of Insoluble Magnesium Compounds Formed During Seawater Battery Discharge. J. Electrochem., Soc., v. 118, No. 2, February 1971, pp. 394–397.

[4] Chemical & Engineering News. Magnesium: Dow Moves Lab to Battelle. V. 49, No. 24, June 24, 1971, p. 12.

Magnesium Compounds

By E. Chin [1]

World production of magnesite in 1971 increased 6 percent over that of 1970. Principal producing countries were the U.S.S.R., Czechoslovakia, North Korea, and Austria. The increase in world capacity to produce magnesia from well brines and sea water, however, continued to exert competitive pressure on producers of magnesite.

The National Research Council of Iceland planned to build a chemical complex on the Reykjanes peninsula, utilizing geothermal steam and sea water for the production of magnesium chloride and salt. Estimated capital investment for the complex was $26 million.

Table 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Caustic-calcined and specified magnesias: [1]					
Shipments:					
Quantity	114	r 119	r 125	r 122	102
Value	r $18,698	r $17,958	r $19,876	r $19,301	$18,244
Exports: [2]					
Value	$2,095	$2,301	$2,687	$3,200	$2,840
Imports for consumption: [2]					
Value	$585	$758	$983	$702	$736
Refractory magnesia:					
Sold and used by producers:					
Quantity	688	661	737	802	627
Value	$43,148	$44,535	$51,843	$60,333	$50,299
Exports:					
Value	$5,889	$4,706	$4,973	$9,133	$5,897
Imports:					
Value	$5,171	$6,179	$5,913	$7,357	$9,219
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	1,880	1,833	1,866	1,373	1,020
Value	$34,083	$31,627	$33,580	$25,740	$19,128
World: Crude magnesite production:					
Quantity	11,248	11,781	10,627	12,218	12,933

r Revised.
1 Excludes caustic-calcined magnesia used in production of refractory magnesia.
2 Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Basic, Inc., produced crude magnesite and brucite from its Gabbs, Nev., property. Northwest International produced olivine from its operations in Washington and North Carolina; Olivine Corp. also produced olivine in Washington.

Kaiser Aluminum & Chemical Corp., Basic Magnesia, Inc., Standard Lime and Refractories Co., Corchem, Inc., and Northwest Magnesite Co. produced refractory magnesia from well brines and sea water. Harbison-Walker Refractories Co., A. P. Green Refractories, Co., International Minerals & Chemicals Corp., and Basic, Inc. were also producers of refractory magnesia. The State of Michigan supplied more refractory magnesia than any of the other producing States, which included California, Florida, Mississippi, Nevada, New Jersey, and Texas.

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[1] Chemist, Division of Nonferrous Metals.

Caustic-calcined magnesia was produced by Kaiser Aluminum & Chemical Corp., Basic Magnesia, Inc., Michigan Chemical Corp., Standard Lime and Refractories, Co., and The Dow Chemical Co. FMC Corp., Philadelphia Quartz Co., Merck and Co., Mallinckrodt Chemical Works, J. T. Baker Chemical Co., Great Salt Lake Minerals and Chemical Corp., and Waverly Chemical Co., Inc., were producers of other magnesium compounds.

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	Value
1967	1,880	$34,083
1968	1,833	31,627
1969	1,866	33,580
1970	1,373	25,740
1971	1,020	19,128

CONSUMPTION AND USES

Dolomite was consumed as a processing agent in the production of magnesium hydroxide from well brines and sea water. Principal uses for magnesium hydroxide were in the production of magnesium chloride for metal cell feed, and in the production of refractory magnesia.

Brucite and domestic and imported magnesite were used in the production of refractory magnesia. Consumption of specified magnesias and caustic-calcined magnesia for uses other than the production of refractory magnesia included chemical processing, pulp and paper, and rayon.

Olivine was consumed as a molding sand in various foundries.

Table 3.—Magnesium compounds shipped and used in the United States

Year and product	Plants	Shipped and used	
		Short tons	Value (thousands)
1970			
Caustic-calcined [1] and specified (U.S.P. and technical) magnesias	11	r 122,416	r $19,301
Refractory magnesia [2]	10	801,762	60,333
Magnesium hydroxide (100 percent $Mg(OH)_2$) [1]	6	87,051	3,655
Magnesium chlorides [3]	8	513,029	36,002
Precipitated magnesium carbonate [1]	6	6,779	NA
1971			
Caustic-calcined [1] and specified (U.S.P. and technical) magnesias	12	102,864	$18,244
Refractory magnesia [2]	9	626,929	50,299
Magnesium hydroxide (100 percent $Mg(OH)_2$) [1]	9	71,366	2,937
Magnesium chlorides [3]	8	575,674	39,650
Precipitated magnesium carbonate [1]	6	5,510	NA

r Revised. NA Not available.
[1] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.
[2] Includes both single-burned and double-burned.
[3] Production for 1970, 841,370; 1971, 827,486; Includes magnesium chloride used in the production of magnesium metal.

Table 4.—Domestic consumption of caustic-calcined magnesia and specified magnesias, by use

(Percent)

Use	1970	1971
Ceramic	(1)	--
Chemical processing	22	20
Electrical	1	1
Fertilizer	11	5
Flux	2	(1)
Glass	(1)	--
Medicinal	1	5
Oxycholoride and oxysulfate cements	(1)	2
Pulp and paper	12	12
Rayon	7	9
Rubber	4	3
Water treatement	(1)	1
Other: animal feed, sugar, uranium processing, and uses indicated by footnote 1	13	12
Unspecified uses	27	30

[1] Included in "Other" category.

PRICES

Prices for magnesia, calcined, technical, heavy, 90 percent and 93 percent (bags, carlot, f.o.b. Luning, Nev.) showed no change from the 1970 rates of $53.00 and $56.00 per short ton, respectively, according to the Oil, Paint and Drug Reporter. Magnesia, technical, synthetic rubber-grade, neoprene-grade, light, was quoted with no change from the 1970 price at $0.24 per pound (bags, carlot, freight-equalized).

Prices for magnesium carbonate, technical (bags, carlot, freight-equalized), remained the same as in 1970 at $0.16 per pound and for truckload quantities at $0.18 to $0.185 per pound with no change from the 1970 rate. For magnesium hydroxide, NF, powder (drums, carlot, and truckload, works) the price range was unchanged from that of 1970 and remained at $0.21 to $0.295 per pound. Magnesium chloride, hydrous, 99 percent, flake, bags, carlot, works, was quoted at $72.80 per ton compared to $60.00 in 1970. Magnesium lauryl sulfate, tanks, freight-allowed, dropped to $0.175 per pound from $0.18 in 1970.

FOREIGN TRADE

Exports of dead-burned magnesite and magnesia in 1971 totaled 53,448 short tons, a decrease of 40 percent from the 1970 total. The loss was due largely to decreased exports to Argentina, Chile, Italy, Mexico, Peru, and Spain. Exports of magnesite, including crude, caustic-calcined, lump or ground, decreased 30 percent to 7,050 tons in 1971. Deliveries to Canada, El Salvador, West Germany, Italy, and the United Kingdom accounted for over 50 percent of the exports in this class.

Imports for consumption of lump or ground caustic-calcined magnesia increased less than 1 percent in 1971 to 11,518 tons. Imports of dead-burned and grain magnesia and periclase containing a maximum of 4 percent lime increased 22 percent to 115,879 short tons. Imports for the same class of material containing over 4 percent lime decreased from 33,518 tons in 1970 to 13,146 tons in 1971. Total imports increased 1 percent over those of 1970 to 129,025 tons.

Under the "Kennedy round" tariff agreement, tariffs, as of January 1, 1971, were further reduced on a number of magnesium compounds. The tariff on precipitated magnesium carbonate was increased, as the following tabulation shows:

Item	1970	1971	1972
Magnesite:			
Crude	$3.67 per ton	$3.15 per ton	$2.62 per ton
Caustic-calcined	$7.35 per ton	$6.30 per ton	$5.25 per ton
Magnesium carbonate:			
Precipitated	0.24¢ per pound	0.25¢ per pound	0.25¢ per pound
Not precipitated	5.5 percent ad valorem	5 percent ad valorem	4 percent ad valorem
Magnesium chloride:			
Anhydrous	0.7¢ per pound	0.6¢ per pound	0.5¢ per pound
Other	0.29¢ per pound	0.25¢ per pound	0.21¢ per pound
Magnesium oxide:			
Calcined magnesia	1.4¢ per pound	1.2¢ per pound	1¢ per pound
Magnesium sulfate:			
Epsom salts	0.26¢ per pound	0.225¢ per pound	0.187¢ per pound

Table 5.—U.S. exports of magnesite and magnesia, by country

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude, caustic-calcined, and lump or ground			
	1970		1971		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	553	$77	330	$49	78	$38	80	$34
Australia	25	7	120	68	521	295	450	254
Belgium-Luxembourg	--	--	--	--	78	31	107	44
Brazil	7	4	28	7	58	26	52	24
Canada	38,217	4,103	40,586	4,040	1,524	303	893	360
Chile	1,602	146	975	97	92	21	121	32
Colombia	16	9	--	--	33	20	12	6
Costa Rica	--	--	--	--	772	72	262	27
Denmark	1	1	--	--	54	31	34	19
El Salvador	8	2	5	1	440	37	550	55
Finland	--	--	--	--	86	42	89	35
France	--	--	62	9	234	105	274	103
Germany, West	140	59	157	81	797	446	890	445
Honduras	--	--	56	8	70	10	--	--
Israel	--	--	--	--	17	8	27	14
Italy	5,175	538	--	--	2,027	355	592	258
Japan	77	38	44	27	103	81	47	13
Mexico	30,777	2,921	5,679	569	705	69	102	19
Netherlands	30	4	50	7	167	85	264	87
New Zealand	25	16	36	23	94	60	116	67
Peru	2,471	227	1,667	154	1	(1)	5	2
Philippines	45	7	3	1	30	15	105	33
South Africa, Republic of	121	76	81	52	195	80	314	174
Spain	5,879	495	2,432	224	152	68	281	82
Sweden	47	31	76	42	223	165	310	212
Switzerland	42	4	--	--	60	19	62	22
United Kingdom	74	38	718	397	1,062	612	755	318
Venezuela	3,468	322	305	32	236	28	66	14
Other	48	8	38	9	180	78	190	87
Total	88,848	9,133	53,448	5,897	10,089	3,200	7,050	2,840

[1] Less than ½ unit.

Table 6.—U.S. imports for consumption of crude [1] and processed magnesite, by country

Country	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Lump or ground caustic-calcined magnesia:				
Australia	1,399	$136	498	$52
Austria	551	20	561	24
Belgium-Luxembourg	437	33	6	1
Greece	2,673	189	426	34
India	5,509	280	7,848	458
Japan	319	12	--	--
Netherlands	210	14	177	15
New Zealand	--	--	162	17
Turkey	166	9	1,840	135
Yugoslavia	212	9	--	--
Total	11,476	702	11,518	736
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4 percent lime:				
Australia	--	--	60	5
Austria	2,638	174	6,761	448
Belgium-Luxembourg	23	2	--	--
Bulgaria	717	97	--	--
Canada	5	11	149	9
Germany, West	25	2	--	--
Greece	78,942	6,319	76,267	6,392
Ireland	--	--	26,616	1,967
Japan	6,638	380	6,009	362
Turkey	5,667	365	--	--
United Kingdom	20	7	17	36
Total	94,675	7,357	115,879	9,219
Containing over 4 percent lime:				
Austria	6,411	284	2,408	138
Canada	3,309	183	2,417	165
Greece	1,086	39	--	--
Spain	--	--	2,927	151
United Kingdom	(2)	2	--	--
Yugoslavia	22,712	1,167	5,394	341
Total	33,518	1,675	13,146	795
Grand total	128,193	9,032	129,025	10,014

[1] Crude magnesite 1970, 21 S.T. ($863); 1971, 7 S.T. ($303).
[2] Less than ½ unit.

Table 7.—U.S. imports for consumption of magnesium compounds

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]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	103	$47	836	$157	368	$70	641	$19	43,685	$605	3,727	$372
1970	521	200	808	192	--	--	824	26	34,939	617	3,608	327
1971	628	222	138	60	26	2	453	15	45,597	654	2,889	304

[1] Not specifically provided for; includes magnesium silicofluoride or fluosilicate and calcined magnesium

WORLD REVIEW

Greece.—Magnesite Mining Industrial and Trading Co., S.A., was formed to mine, process, and market magnesite on the island of Euboea. This company is owned 45 percent each by the Chemical Products and Fertilizers Co. (Bodossakis-Athanassiades group) and D. P. Papastratis and Co., and 10 percent by the National Investment Bank for Industrial Development. Magnesite Mining Industrial, capitalized at $1.8 million, planned to extend operations to cover other minerals at a later time.

Financial Mining-Industrial and Shipping Corp. (Scalistiri group) proposed a 70,000-ton-per-year increase of its heat-treating facilities at Mantoudi, Euboea, where a refractory brick plant is under construction. Macedonian Magnesite S.A. (Scalistiri group) was installing a 120,000-ton-per-year ore-dressing plant at Vavdos, Khalkidiki.

Hungary.—Magnesite Industrial Works of Budapest developed a process whereby Hungarian dolomite and carbonic acid are used as chief feed stock to produce synthetic magnesite of 98.5 to 99.2 percent purity. A pilot plant, built in the northeast part of the country, will be used for semi-industrial testing of the process.

Iceland.—The National Research Council of Iceland planned to build a chemical complex using geothermal steam and sea water to produce 250,000 tons per year of salt and 107,000 metric tons per year of magnesium chloride. Capital investment for the salt plant, which would also produce per year 58,000 tons of calcium chloride, 25,000 tons of potassium chloride, and 700 tons of bromine, was estimated at $13 million. The magnesium chloride plant would cost an additional $13 million. Reykjanes peninsula in southwest Iceland was a possible site for the plant. The National Energy Authority of Iceland drilled eight steel-lined, 9-inch-diameter steam wells on the peninsula in an area of less than 1 square mile. The wells were from 531 to 5,740 feet deep. The deepest well produced steam at 150°C at a rate of 100 tons per hour.

Japan.—Shin Nihon Chemical Industries Co., a subsidiary of Asahi Chemical Industries Co., Ltd., completed expansion of its sea water magnesia facilities at Minamata on Kyushu Island. Two heavy oil-fired multiple-hearth furnaces built in Japan to the specifications of Steetley Co. Ltd. of the United Kingdom were in operation at full capacity. Shin Nihon's total capacity to produce sea-water magnesia was over 200,000 tons per year.

The new $10 million facility of Ube Chemical Industries Co., Ltd. began operations to produce 120,000 tons of synthetic magnesio-dolomite refractory materials. The new facility used the expanded lime plant from the main plant across the river. The new site had its own sea-water handling pumps, lime slakers, thickeners, rotary drier, and rotary kiln. Ube's total capacity to produce magnesia was over 400,000 tons per year.

South Africa, Republic of.—Magna Mining (Pty.) Ltd., through its associate company, Romada (Pty.) Ltd., established the existence of a 22-million-ton deposit of magnesite in Eastern Transvaal. This was the largest deposit discovered in South Africa to date. The average chemical composition of the ore was magnesium carbonate, 80 percent plus; calcium carbonate, 8 percent; silicon dioxide, 3.5 percent; and ferrous oxide, 0.4 percent.

Table 8.—Magnesite: World production by country [1]

(Short tons)

Country	1969	1970	1971 p
North America: United States	W	W	W
South America:			
Brazil	e 200,000	e 260,000	220,000
Mexico	--	8,999	8,800
Europe:			
Austria	1,772,979	1,773,992	1,715,700
Czecholslovakia e	2,400,000	3,300,000	3,900,000
Greece	r 629,116	832,438	995,064
Italy	4,410	--	--
Poland e	50,000	55,000	55,000
Spain [2]	r 116,244	114,564	e 115,000
U.S.S.R. e	r 1,545,000	1,569,000	1,598,000
Yugoslavia	526,262	564,222	548,950
Africa:			
Kenya	554	4	244
South Africa, Republic of	53,044	92,874	86,711
Sudan	550	110	e 100
Tanzania	1,651	854	e 880
Asia:			
China, People's Republic of	r 1,000,000	1,100,000	1,100,000
India	325,741	384,664	329,800
Iran [3]	23,100	22,000	e 22,000
Korea, North e	1,700,000	1,800,000	1,900,000
Pakistan	10,560	512	239
Turkey	241,442	313,946	e 314,000
Oceania:			
Australia	r 25,931	24,759	e 22,000
New Zealand	882	534	e 550
Total	r 10,627,466	12,218,472	12,933,038

e Estimate. p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Quantities in this table represent crude salable magnesite. Magnesite is also produced in Bulgaria, Canada, Colombia, and Southern Rhodesia, but data on production are not available.
[2] Estimated from data reported as MgO.
[3] Year beginning March 21 of that stated.

TECHNOLOGY

A water treatment process that will cut costs and eliminate pollution from the disposal of alum sludge was developed.[2] Magnesium and calcium minerals, which are removed from municipal water supplies by flocculation with aluminum hydroxide, can be recovered for reuse or sale. Carbon dioxide gas dissolves magnesium hydroxide in the sludge, leaving calcium carbonate for return to the lime kiln. The resulting magnesium bicarbonate solution is heated to 35°–45°C, followed by aeration, and the magnesium is precipitated as the carbonate trihydrate. The carbonate can be vacuum-filtered, dried, and bagged for shipment. Clay and other colored or turbid material can be disposed of as landfill and are the only wastes from the entire operation. This process was tested in batch operations at the Ottawa water treatment plant in Dayton, Ohio. A pilot plant for continuous water treatment at 50 gallons per minute is scheduled for operation at Montgomery, Ala.

A magnesium-base acid sulfite evaporator comprised a major portion of a system scheduled to reclaim spent chemicals, curb discharges, and reduce the biochemical oxygen demand (BOD) of water effluent from Crown Zellerbach's paper mill bisulfite pumping operation in Camas, Wash.[3] Digesters are loaded with wood chips and heated at 330° F for five hours in an acid solution of magnesium bisulfite. During the digestion, lignin is dissolved and becomes part of the spent cooking solution that is considered waste.The spent liquor is concentrated from 8.4 percent solids to 60 percent solids; it then can be burned as fuel oil in a recovery furnace. This procedure evaporates the balance of water remaining in the liquor, burns the lignin, producing heat and generating steam for

[2] Chemical and Engineering News. Water Treatment: No Alum Sludge. V. 49, No. 39, May 1971, p. 8.
[3] American Metal Market. Chemical Recovery System Attacks Magnefite Pollution. V. 78, No. 172, May 1971, p. 23.

mill use or electrical generation, and produces a fly ash which is the spent cooking chemical. The wood solids are converted to carbon dioxide and water, and the magnesium and sulfur compounds to magnesium oxide dust and sulfur dioxide gas. The magnesium oxide dust is collected, washed, and slaked to magnesium hydroxide, which is reacted with the sulfur dioxide gas to produce magnesium bisulfite for reuse.

Manganese

By Gilbert L. DeHuff [1]

Although a small tonnage of manganese nodules was shipped in 1971, there was no actual production in the United States of manganese ore, concentrate, or nodules, containing 35 percent or more manganese. Slackened demand for manganese ferroalloys resulted from lowered levels of steel production worldwide and general sluggishness of the economy. U.S. imports of manganese ferroalloys and metal were substantial, although ferromanganese imports were down somewhat from those of 1970, having fallen off in the last quarter from the high rate that prevailed earlier. One new domestic ferromanganese plant, that of Airco, Inc., at Theodore, Ala., was brought on stream, and substantial increases in productive capacity were underway in several countries abroad.

Legislation and Government Programs.—Public Law 92-100, approved August 11, gave the Administrator of General Services Administration (GSA) authority to dispose of 4,424,840 short dry tons (manganese ore equivalent) of metallurgical-grade manganese held in the national and supplemental stockpiles. Public Law 92-101, also approved August 11, authorized disposal of 4,805 short dry tons of synthetic manganese dioxide held in the national stockpile. Both laws provide that time and method of disposition be such that producers, processors, and consumers are protected against avoidable disruption of usual markets. GSA continued to follow its policy of limiting deliveries of metallurgical ore to 300,000 tons per fiscal year.

Sales of metallurgical ore on a negotiated basis in calendar year 1971 were 921,576 short tons; sales of synthetic manganese dioxide were 3,991 short tons. Several GSA offerings to sell surplus chemical-grade and natural battery grade ore during the calendar year on a sealed-bid basis resulted only in one sale of 486 short dry tons of natural battery ore, at a price of $45 per ton.

Manganese stockpile inventory changes in the calendar year consisted of the following: Metallurgical ore, stockpile grade, decreased 256,432 short tons to 8,163,241 tons; metallurgical ore, nonstockpile grade, decreased 14,447 tons to 1,393,571 tons; synthetic dioxide decreased 2,278 tons to 19,638 tons; and stockpile grade natural battery ore decreased 441 tons to 253,496 tons.

[1] Supervisory physical scientist, Division of Ferrous Metals.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1967	1968	1969	1970	1971
Manganese ore (35 percent or more Mn):					
Production (shipments):					
Metallurgical	W	10,536	5,630	4,737	142
Battery	W	842	--	--	--
Total	12,585	11,378	5,630	4,737	142
Imports general	2,058,691	1,827,626	1,959,661	1,735,055	1,914,264
Consumption	2,382,984	2,228,412	2,181,333	2,363,937	2,155,454
Manganiferous ore (5 to 35 percent Mn):					
Production (shipments)	289,160	244,590	430,637	368,302	198,334
Ferromanganese:					
Production	940,927	879,962	852,019	835,463	759,896
Exports	1,861	3,710	1,759	21,747	4,526
Imports for consumption	216,279	203,212	307,891	290,946	242,778
Consumption	982,130	1,016,559	1,071,042	1,000,611	899,011

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Except for a small quantity of metallurgical oxide nodules shipped from stocks by The Anaconda Company, and made several years ago from Montana carbonate ore, there was neither production nor shipments of manganese ore, concentrates, or nodules in the United States in 1971.

Ferruginous manganese ores or concentrates containing 10 to 35 percent manganese were produced and shipped from the Cuyuna Range of Minnesota, and from New Mexico and Utah; but there was no production nor shipments of manganiferous iron ore containing 5 to 10 percent manganese in the United States in either 1971 or 1970. Manganiferous zinc residuum continued to be produced from New Jersey zinc ores.

Table 2.—Manganese and manganiferous ore shipped [1] in the United States, by State

(Short tons)

Type and State	1970		1971	
	Gross weight	Manganese content	Gross weight	Manganese content
Manganese ore (35 percent or more Mn, natural):				
Montana	512	272	142	75
New Mexico	4,225	2,040	--	--
Total	4,737	2,312	142	75
Manganiferous ore:				
Ferruginous manganese ore (10 to 35 percent Mn, natural):				
Minnesota	321,436	44,927	169,732	23,005
New Mexico	46,166	4,856	28,490	3,504
Utah	700	196	112	37
Total	368,302	49,979	198,334	26,546
Manganiferous iron ore (5 to 10 percent Mn, natural)	--	--	--	--
Total manganiferous ore	368,302	49,979	198,334	26,546
Value manganese and manganiferous ore	$2,839,863	--	$1,468,249	--

[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 13.0 pounds per short ton of raw steel produced. Of this total, 11.2 pounds was ferromanganese; 1.3 pounds, silicomanganese; 0.05 pound, spiegeleisen; 0.25 pound, manganese metal; and 0.2 pound, ore. The comparable 1970 total, on the same basis, was 13.1 pounds with ferromanganese at 11.5, silicomanganese at 1.3, spiegeleisen at 0.05, and metal at 0.2.

Demand for manganese ferroalloys was strong in the first half of the year in anticipation of a steel strike that was averted, but was weak in the second half as a result of a material drop in steel production, a general softening of the economy, and continued high imports of steel and manganese ferroalloys. Serious railroad strikes in the summer, and a 3-week strike at the Philo, Ohio, plant of Ohio Ferro-Alloys Corp. in October, added to the industry's problems. Producers of manganese ferroalloys continued to make large expenditures for pollution-control equipment, and reported considerable progress toward meeting clean-air goals.

Electrolytic Manganese and Manganese Metal.—All of the manganese metal produced in the United States was electrolytic metal, 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 consum-

Table 3.—Consumption and stocks of manganese ore [1] in the United States

(Short tons)

	Consumption 1970	Consumption 1971	Stocks Dec. 31 1971 [2] (including bonded warehouses)
By use:			
Manganese alloys and metal	2,099,426	1,837,683	1,643,853
Pig iron and steel	107,733	187,251	104,150
Dry cells, chemicals and miscellaneous	156,778	130,520	262,129
Total	2,363,937	2,155,454	[3] 2,010,132
By origin:			
Domestic	25,472	28,316	21,588
Foreign	2,338,465	2,127,138	1,988,544
Total	2,363,937	2,155,454	[3] 2,010,132

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Excludes small tonnage of dealers' stocks.

Table 4.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States, in 1971

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Silico-manganese	Spiegel-eisen	Manganese metal [1]
Steel:					
Carbon	615,446	87,043	74,206	9,467	5,360
Stainless and heat resisting	2,099	5,213	6,213	--	7,205
Alloy (excludes stainless and tool)	103,850	30,839	30,530	1,769	2,038
Tool	797	118	8	--	403
Cast irons	17,686	2,143	3,512	8,350	8
Superalloys	334	W	W	1	342
Alloys (excludes alloy steels and superalloys)	5,175	1,322	2,297	54	11,071
Miscellaneous and unspecified	25,347	1,599	6,147	36	1,096
Total	770,734	128,277	122,913	19,677	27,523
Stocks December 31 [2]	269,508	34,656	61,719	12,495	8,107

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1] Virtually all electrolytic.
[2] Industry stocks held by producers, consumers, and bonded warehouses.

ers as manganese metal. Production of electrolytic manganese metal in the United States was by Foote Mineral Co., New Johnsonville, Tenn.; Kerr-McGee Chemical Corp., Hamilton (Aberdeen), Miss.; and Union Carbide Corp., Marietta, Ohio. During the year, Foote Mineral Co. transferred all of its Knoxville, Tenn., manganese activities to New Johnsonville, permanently closing the out-dated Knoxville electrolytic manganese plant. Actual production of metal was terminated at Knoxville in the latter part of 1970. Both Foote and Union Carbide reported favorable market acceptance by the aluminum industry of their manganese-aluminum additives marketed under the trade names of Solumang and Ucar manganese-aluminum, respectively. Both are briquets made from electrolytic manganese metal, and have a 75-percent-manganese–25-percent-aluminum content. Kerr-McGee reported that its capacity to make electrolytic manganese metal at Hamilton, Miss., was increased.

Ferromanganese.—Airco Alloys and Carbide Division, Airco, Inc., began production of ferromanganese at its Theodore, Ala., plant, situated a few miles southwest of Mobile. The plant is located on a barge canal which gives it access to the ocean for import of raw materials and export of products. Airco purchased the plant in late 1970 from McWane Cast Iron Pipe Co., and converted its one electric furnace to the production of ferroalloys.

Bethlehem Steel Co. and U.S. Steel Corp. continued to be the only domestic ferromanganese producers using blast furnaces: Bethlehem at Johnstown, Pa.; U.S. Steel at Clairton and McKeesport, Pa., both in the

Pittsburgh district. Ferromanganese was produced in electric furnaces by Airco Alloys and Carbide Division, Airco, Inc., Calvert City, Ky., and Theodore (Mobile), Ala.; Chromium Mining & Smelting Corp., Woodstock (Memphis), Tenn.; Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Electric Furnace Division 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 Division, Diamond Shamrock Chemical Co., Kingwood, W. Va., to make low-carbon ferromanganese which is sold under the trade name of Massive Manganese. U.S. shipments of ferromanganese totaled 800,000 short tons, compared with 807,000 tons in 1970.

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	
1967	940,927	78.2	735,177	2,182,997	4,367	2.3
1968	879,962	78.0	686,370	2,013,360	15,207	2.3
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

[1] Containing 35 percent or more manganese (natural).
[2] Includes ore used in producing silicomanganese and metal.
[3] Includes ore used in producing silicomanganese.

Silicomanganese.—Production of silicomanganese in the United States was 165,000 short tons, compared with 193,000 tons in 1970. Shipments from furnaces totaled 144,000 tons, compared with 173,000 tons in 1970. In 1971, seven companies utilized 10 plants to make silicomanganese: Airco Alloys and Carbide Division, Airco, Inc., Calvert City, Ky.; Chromium Mining & Smelting Corp., Woodstock (Memphis), Tenn.; Interlake Steel Corp., Beverly, Ohio; Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Electric Furnace Division of Woodward Corp., a Division of Mead Corp., Rockwood, Tenn.; Tenn-Tex Alloy Corporation of Houston, Houston, Tex.; and Union Carbide Corp., Alloy, W. Va., Ashtabula and Marietta, Ohio, and Portland, Oreg. The ratio of consumption of silicomanganese to consumption of ferromanganese was 13.7 percent in 1971, 13.8 percent in 1970, and 14.2 percent in 1969.

Spiegeleisen.—The New Jersey Zinc Co. continued to produce spiegeleisen solely by electric furnaces at Palmerton, Pa.

Pig Iron.—A total of 796,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural) was consumed for the production of pig iron (or its equivalent hot metal). Domestic sources supplied 606,000 tons, of which 252,000 tons was manganiferous iron ore containing 5 to 10 percent manganese, 353,000 tons was ferruginous manganese ore containing 10 to 35 percent manganese, and 500 tons contained more than 35 percent manganese. Foreign sources supplied 190,000 tons, of which 34,000 tons was manganiferous iron ore, and 156,000 tons contained more than 35 percent manganese.

Table 6.—Manganese ore used in producing ferromanganese, silicomanganese, and manganese metal in the United States in 1971, by source of ore

Source	Gross weight (short tons)	Mn content, natural (percent)
Domestic [1]	7,033	42
Foreign:		
Africa	935,559	47
Australia	81,153	47
Brazil	532,361	48
Chile	32,725	45
India	101,382	44
Mexico	51,758	39
U.S.S.R.[1]	29,797	50
Other or unidentified	55,673	--
Total	1,827,441	47

[1] Obtained entirely from U.S. Government surplus stockpile disposals.

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.

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.

In the middle of the year, Marathon Battery Co. transferred its manufacture of manganese dry cells from Wausau, Wis., and St. Paul, Minn., to Waco, Tex.

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. Ore containing 46 to 48 percent manganese was quoted by the American Metal Market from the beginning of the year into May at 56 to 59 cents, nominal, per long ton unit, c.i.f. eastern seaboard and Gulf ports. An increase at that time to 59 to 63 cents, nominal, same basis, carried to the end of the year. Quotations by the same source for ore containing 48 to 50 percent manganese were 60 to 63 cents, nominal, and 63 to 68 cents, nominal, for the same respective periods.

Manganese Alloys.—Domestically produced standard high-carbon ferromanganese containing 74 to 76 percent manganese was quoted by the American Metal Market at $184.50, nominal, per long ton, f.o.b. producer plant with freight equalized to nearest competitive point, until October when domestic material of this grade apparently was no longer being produced or marketed. The price for standard high-carbon ferromanganese having 78 percent minimum manganese content continued to be quoted $190, nominal, per long ton, same basis, throughout the year. An effort by one producer in March to increase this price by $10 per ton apparently did not hold. Other producers did not follow. In the latter part of September, Union Carbide Corp. announced that, effective immediately, it was abandoning its firm quarterly pricing policy that it had followed since April 1969, and would sell at the price in effect at time of shipment. Metals Week quoted imported standard ferromanganese containing 74 to 76 percent manganese at $180 per long ton, delivered in Pittsburgh or Chicago, until the middle of March when it increased the quota to $182 to $184 and carried this to the middle of December at which time it was dropped to $176–$178, nominal. In doing so, it was stated that "little of this material is either available or used. The more popular 78 percent grade is currently going for about $178–$180."

Manganese Metal.—The price of standard electrolytic manganese metal remained throughout the year at 33.25 cents per pound, f.o.b. producer plant, for shipments of 30,000 pounds or more. This was 2 cents per pound more than the 1970 price, the change being effective as of Jan. 2, 1971.

FOREIGN TRADE

Ferromanganese exports totaled 4,526 short tons valued at $1,204,819, compared with 21,747 tons valued at $4,355,525 in 1970. Of the 1971 total quantity, Mexico took 1,664 tons; Canada, 1,542 tons; Turkey, 756 tons; Colombia, 170 tons; Dominican Republic, 149 tons; France, 146 tons; and the remainder was divided among seven other countries. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" were 1,203 tons valued at $911,785 in 1971, and 2,971 tons valued at $2,042,469 in 1970. Exports of ore and concentrate containing more than 10 percent manganese totaled 55,413 tons at a value of $2,683,070, compared with 20,294 tons at $2,461,176 in 1970. Of the 1971 total, 22,968 tons valued at $410,162 went to Sweden, apparently metallurgical ore of foreign origin exported from industry stocks, and 15,097 tons valued at $458,988 went to Poland. Most of the remainder was probably imported manganese dioxide ore exported with or without having been subjected to grinding, blending, or otherwise classifying.

The average grade of imported manganese ore was 49.0 percent manganese in 1971, compared with 48.8 percent in 1970 and 50.6 percent in 1969. More than half of the total continued to come from Brazil and Gabon. Reported imports of manganiferous ore containing more than 10 but less than 35 percent manganese in 1971, 2,389 short tons from Australia, appear to be in error.

Table 7.—U.S. imports [1] of manganese ore (35 percent or more Mn), by country

Country	1970 Gross weight (short tons)	1970 Mn content (short tons)	1970 Value (thousands)	1971 Gross weight (short tons)	1971 Mn content (short tons)	1971 Value (thousands)
Angola [2]	70,276	33,535	$1,364	56,721	27,603	$982
Australia	67,613	32,774	1,301	107,593	52,630	2,629
Brazil	610,949	292,420	11,879	701,772	334,851	14,852
Canada	16,415	7,829	450	18,495	8,547	595
Gabon [3]	480,342	241,615	8,841	597,102	305,589	13,409
Ghana	74,738	36,171	1,831	78,271	37,815	2,040
India	80,793	37,023	1,391	2,900	1,283	43
Ivory Coast	9,343	3,644	81	--	--	--
Japan	49	18	6	--	--	--
Malaysia	49	24	1	--	--	--
Mexico	35,505	16,988	968	27,291	12,986	492
Morocco	35,794	19,940	2,306	24,460	12,730	1,205
Singapore	--	--	--	193	106	11
South Africa, Republic of	139,067	66,452	1,809	185,636	87,358	3,705
South Africa, n.e.c.[4]	10	7	(5)	--	--	--
Turkey	3,360	1,546	75	8,064	3,790	220
Western Africa, n.e.c.[6]	36,922	19,693	703	--	--	--
Western Portuguese Africa, n.e.c	6,518	3,259	117	--	--	--
Zaire (Congo, Kinshasa) [2]	67,312	33,768	1,140	105,766	52,834	2,001
Total	1,735,055	846,706	34,263	1,914,264	938,122	42,184

[1] Quantities for general imports and imports for consumption are identical.
[2] Part or all of the ore reported to have come from Angola in 1970 and in 1971 is believed to have originated in Gabon or Zaire (Congo, Kinshasa).
[3] In addition in 1970 Gabon imports reported as Western Africa, n.e.c., were approximately 37,000 tons (gross weight), and it is probable that some or all reported as Angola originated in Gabon. In 1971, some imports reported as Angola may have originated in Gabon.
[4] Probably Botswana.
[5] Less than ½ unit.
[6] Actually from Gabon.

Table 8.—U.S. imports for consumption of ferromanganese, by country

Country	1970 Gross weight (short tons)	1970 Mn content (short tons)	1970 Value (thousands)	1971 Gross weight (short tons)	1971 Mn content (short tons)	1971 Value (thousands)
Belgium-Luxembourg	551	423	$60	1,456	1,136	$198
Canada	357	288	90	570	460	118
Chile	613	536	96	--	--	--
France	100,036	77,745	10,285	92,321	71,481	10,944
Germany, West	8,342	6,499	1,022	1,552	1,329	599
India	35,597	27,128	3,255	32,717	24,463	3,769
Italy	1,111	896	199	652	546	166
Japan	5,556	4,373	913	2,757	2,133	488
Mozambique	12,340	9,648	1,485	--	--	--
Netherlands	2,065	1,611	194	--	--	--
Norway	3,291	2,577	351	14,523	11,633	2,333
South Africa, Republic of	119,292	93,759	13,161	90,078	70,892	12,089
Sweden	1,795	1,496	452	5,469	4,640	1,530
Yugoslavia	--	--	--	683	547	158
Total	290,946	226,979	31,563	242,778	189,260	32,392

Silicomanganese imports for consumption were 29,928 short tons containing 19,970 tons of manganese. Sources and tonnage (gross weight) were as follows: Norway, 23,559; Mexico, 2,539; Yugoslavia, 2,346; Sweden, 659; Japan, 342; Canada, 253; and France, 230. Imports for consumption classified as unwrought manganese metal, except alloys, and waste and scrap of such metal, totaled 2,870 short tons, compared with 1,276 tons in 1970. Of the 1971 quantity, 1,980 tons came from the Republic of South Africa, 800 tons from Japan, 50 tons from the Netherlands, and 15 tons from

Cyprus, all valued at about 20 to 23 cents per pound; 25 tons valued at 2.5 cents per pound came from Canada; and 100 pounds valued at $4.80 per pound came from the United Kingdom.

Imports for consumption classified as "manganese compounds, other" totaled 2,942 tons in 1971, compared with 3,209 tons in 1970. The sources, gross weights, and values per pound in 1971 were as follows: Japan, 2,662 tons (15.3 cents); the United Kingdom, 168 tons (6.6 cents); Belgium-Luxembourg, 99 tons (13.4 cents); the Republic of South Africa, 7 tons (6.4 cents); West Germany, 4 tons ($1.14); and Canada, 2 tons ($1.04). The imports from Japan and Belgium-Luxembourg appear to have consisted largely, if not entirely, of synthetic manganese dioxide.

WORLD REVIEW

Markets for metallurgical manganese ore were poor because the year was a depressed one for the steel industry around the globe. Union Carbide Corp. reported completion of new dry-cell battery production facilities in Brazil, India, Pakistan, Philippines, and Singapore.

Angola.—No manganiferous iron ore was produced in 1971. Ore production, reported as manganese ore, had a value of approximately $11 per short ton.

Argentina.—Exports of rhodochrosite in 1970 totaled 20 short tons, valued at $74,624. None went to the United States. Imports of manganese ores and concentrates amounted to 38,000 tons.

Australia.—The manganese deposit at Groote Eylandt, Northern Territory, is within 12 miles of a deep water port. It consists essentially of a bed of oxides varying in thickness from 2 to more than 50 feet, composed of pyrolusite, cryptomelane, quartz sand, and kaolinitic clay in varying proportions, with intercalated seams of clay. The two principal types of ore mined have been a "high-grade, bouldery, cemented pisolite ore above loose pisolites, and a more siliceous ore consisting of cemented cryptomelane fragments, pisolites, oolites, and quartz sand grains." The ore is believed to have originated as a shallow-water marine sediment with some subsequent concentration of manganese by weathering. A thin cover of overburden is removed by wheeled scrapers. The output is exported except for that quantity shipped to Tasmania to satisfy the greater part of Australia's metallurgical ore requirements. Since 1968, all of the country's production of ferromanganese and silicomanganese has been at the affiliated Bell Bay plant of Tasmanian Electro Metallurgical Co. Pty. Ltd., where high-carbon ferromanganese is produced for 8 months of the year and silicomanganese for the remaining 4 months. In 1969, this plant consumed 129,000 short tons of Groote Eylandt metallurgical ore and 12,000 tons of manganiferous iron ore from South Australia. Australian consumption of battery-grade ore is approximately 1,200 short tons per year, now entirely supplied by imports that are largely, if not entirely, from Ghana. No battery-grade ore has been produced since 1965. Approximately 700 tons of imported electrolytic manganese dioxide was consumed in 1969 for the manufacture of batteries, and small quantities of Groote Eylandt ore were used in the treatment of uranium ores. Manganese dioxide sludges recovered from zinc refining operations at Risdon, Tasmania, were used in chemical processes and as a trace element in fertilizer.[2]

The ferruginous manganese ore deposits of Longreach Manganese Pty. Ltd., subsidiary of Longreach Metals N. L., at Ripon Hills, Western Australia, were reported to have an estimated reserve of 60 million tons of ore averaging 22 percent manganese and approximately 24 percent iron. Diamond and percussion drilling was under way to confirm the reserve, and a large pilot plant containing an electronic ore sorter was installed at the site. Development of the deposits is expected to cost $30 million; production will start about 1974. An eventual production rate of one million tons per year of a 30-percent-manganese shipping product was envisioned. Japanese firms, including Nippon Steel Corp., are interested in the development.[3]

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[2] Pratt, R. Manganese—The Supply-Demand Position. Australian Mineral Industry, Quarterly Review, Quart. Statistics, v. 23, No. 3, March 1971, pp. 78–95.

[3] Australian Mineral Industry, Quarterly Review. Quart. Statistics, v. 24, No. 1, September 1971, p. 9. American Metal Market. V. 78, No. 186, Sept. 27, 1971, p. 14.

Table 9.—Manganese ore: World production by country [1]

(Short tons)

Country	Percent Mn e	1969	1970	1971 p
North America:				
Mexico [2]	35+	158,252	301,938	294,198
United States	35+	5,630	4,737	142
South America:				
Argentina	30-40	24,095	34,847	e 35,000
Bolivia [3]	28+	--	93	842
Brazil	38-50	r 2,216,543	2,071,020	2,868,000
Chile	41-47	26,124	29,457	26,277
Colombia	NA	606	511	496
Peru	30+	13,228	2,119	8,601
Europe:				
Bulgaria	30+	43,000	36,000	e 33,000
Greece	50	7,125	7,264	6,754
Hungary	30−	172,000	186,028	e 187,000
Italy	30−	58,385	55,216	33,735
Portugal	38-44	7,637	6,091	5,237
Spain	30+	r 25,774	11,770	19,848
U.S.S.R.[4]	NA	7,221,000	7,541,000	e 7,700,000
Yugoslavia	30+	13,593	16,298	17,762
Africa:				
Angola	30+	32,044	25,000	25,000
Arab Republic of Egypt, (formerly United Arab Republic)	NA	4,400	4,400	e 4,400
Botswana	30+	24,769	45,019	39,246
Gabon	50-53	r 1,535,519	1,601,656	2,059,753
Ghana [5]	48+	366,800	446,837	659,801
Ivory Coast	32-47	r 140,048	25,419	--
Morocco	35-53	143,935	123,873	111,836
South Africa, Republic of	30+	2,429,600	2,953,609	3,567,666
Sudan	36-44	940	1,279	e 1,300
Zaire (formerly Congo-Kinshasa)	42+	343,291	382,446	427,000
Zambia	30+	28,284	--	--
Asia:				
China, People's Republic of e	30+	1,100,000	1,100,000	1,100,000
India [6]	NA	r 1,637,798	1,819,936	1,961,000
Indonesia	35-49	r 7,056	11,946	13,181
Iran [7]	42+	r 23,100	22,000	e 22,000
Japan	30-43	331,587	298,099	314,164
Korea, Republic of	35+	3,199	3,749	2,495
Malaysia	30-40	11,392	--	--
Pakistan	NA	90	13	101
Philippines	30+	22,048	5,645	5,658
Thailand	46-50	32,872	26,310	15,412
Turkey	35+	15,090	10,465	14,222
Oceania:				
Australia	46	r 980,272	827,959	1,186,026
Fiji	30-50	22,917	27,054	8,440
New Hebrides	43-44	--	16,926	16,537
Total	--	r 19,230,043	20,084,029	22,792,130

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

[1] In addition to the countries listed, Cuba and South-West Africa also produce manganese ore but information is inadequate to make reliable estimates of output levels. Low grade ore not included in the table has been reported as follows (short tons): Czechoslovakia (about 17 percent Mn), 1969—93,000; 1970—95,000; 1971—e 99,000; Romania (about 22 percent Mn), about 140,000 tons in each year; Sweden (about 12 percent Mn), 1969—9,700; 1970 and 1971—0.

[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] Dry weight.

[6] Indian output not reported by grade, but of total exports of 1,331,349 tons in 1969 and 1,744,294 tons in 1970, 57 percent and 67 percent respectively graded less than 35 percent manganese.

[7] Iranian calendar year beginning March 21; all figures are mine run ore.

Metallurgical ore produced in Australia in 1971 had an average manganese content of 45.9 percent, compared with 47.6 percent in 1970. Chemical grade manganese ore produced in 1970 amounted to 200 tons averaging 72 percent manganese dioxide. Production data released by the Hon. Minister for Mines, Western Australia, for the quarter ending September 31, 1971, showed that 31,000 short tons of metallurgical ore shipped from the Pilbara district in the period averaged 45 percent manganese; while 4,500 tons from Peak Hill averaged 35 percent. For the quarter ending December 31, 45,000 tons from Pilbara averaged 46.6 percent manganese.

Bolivia.—Legislation was passed in 1970 to the effect that the iron and manganese mineral reserve of the Mutún deposit may be mined and concentrated only by the State. An agreement was signed November 3, 1971, between the Government of Bolivia and the United Nations to provide diamond drilling and a geological investigation of the deposit. Mining, crushing, and washing of the iron ores was begun in April 1971 by COMIBOL, the Government mining agency, with plans to ship to the iron furnaces at San Nicolas, Argentina. Bolivian export data for 1970 showed that the "medium miners" category of the private sector exported 93 short tons of manganese ore, all to Argentina and valued at $4,134.

Botswana.—The Kgwakgwe manganese mine located east of Kanye, in southern Botswana, was purchased in December 1970 by Anglo-American Corp. of South Africa Ltd. Botswana Exploration & Mining Co. (Pty) Ltd., which has mined the deposits since 1967, was the seller with an area of 316 square miles being involved. Mining has been by room and pillar at a depth of 120 feet with entry by several adits into the hillsides. The high-grade ore was screened, crushed, jigged and hand-sorted; the low-grade ore was dry-screened. Output was trucked to the railhead at Lobatse for shipment. High-grade ore went to battery and ferroalloy manufacturers; the low-grade ore and rejects from the high-grade ore were sold to uranium plants.[4] On November 18, 1971, Anglo-American Corp. announced that it would end operations by the close of the year. Disappointing prospecting results and unfavorable marketing conditions were given as the reasons for termination. The mine employed 530 when purchased by Anglo-American.

Brazil.—Mine run manganese ore produced in 1971 at the Amapa deposits of Indústria e Comércio de Minerios S.A. (ICOMI) totaled 3,089,000 short tons. Washed ore production by the company was 2,294,000 tons averaging approximately 48 percent manganese. Urucum production near the Bolivian border amounted to 83,000 tons averaging 46.27 percent manganese; the Meridional mine in Minas Gerais produced 80,000 tons averaging 36.52 percent manganese.

Manganese ore exports from Brazil in 1970 totaled 1,750,000 short tons, compared with 949,000 tons in 1969. Distribution was as follows (1969 in parentheses): United States, 774,000 (396,000); Netherlands, 263,000 (142,000); Norway, 178,000 (128,000); Canada, 149,000 (96,000); United Kingdom, 111,000 (32,000); France, 106,000 (60,000); West Germany, 62,000 (11,000); Argentina, 33,000 (32,000); Japan, 25,000 (38,000); Czechoslovakia, 20,000 (zero); Italy, 19,000 (14,000); and Spain, 10,000 (zero).

Canada.—Because of difficulties in meeting Ontario pollution requirements, Union Carbide Canada Ltd. planned to phase out production of ferromanganese and silicomanganese at Welland and transfer this operation to a new 80,000 tons-per-year furnace (55,000 kilovolt-amperes) to be completed by mid-1973 at its Beauharnois, Quebec, plant.[5]

Chile.—Manganese ore produced in 1970 averaged 41.7 percent manganese. Manganesos Atacama S.A. continued to be the largest producer.

Fiji.—Of the manganese ore produced in 1970, only a few hundred tons was reported to contain more than 35 percent manganese.

Gabon.—Shipments of manganese ore in 1971 were a record high of 2.1 million short tons. Production of battery- and chemical-grade ore was 41,000 short tons in 1971, compared with 26,000 tons in 1970.

Greece.—A contract was signed on June 21, 1971, between the Government and Petros M. Nomikos, a Greek shipowner, whereby the latter would map and conduct a mineral survey of the territorial waters and sea bottom off the island of Thira (Santorini). Manganese-iron nodules were previously reported as occuring in this locale.

India.—Production of ferromanganese continued to be by the same seven companies that have been producers. Production was 190,000 short tons in 1971, and installed annual capacity was 213,000 tons. Except for Mysore Iron and Steel, Ltd., owned by the state of Mysore and the smallest of the seven producers in terms of both production and capacity, all the companies are privately owned. Preliminary reports from consumers indicated that do-

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[4] South African Mining & Engineering Journal (Johannesburg). V. 83, No. 4052, January 1971, p. 43.
Skillings' Mining Review. V. 60, No. 5, Jan. 30, 1971, p. 8.

[5] Metals Week. Carbide's Canadian Improvements. V. 42, No. 49, Dec. 6, 1971, p. 31.

mestic consumption of ferromanganese in 1971 was roughly 85,000 tons. Exports dropped sharply to 52,000 tons, or only half those of 1970. The United States took 26,000 tons; Sweden, 11,000 tons; Romania, 9,000 tons; Egypt, 2,400 tons; Japan, 2,200 tons; New Zealand, 770 tons; and other countries, the remainder. Producer stocks at the end of the year created an unprecedented surplus of 50,000 tons.

Japan took 84 percent of the reported manganese ore exports of the first 10 months of the year. With an average unit value of only $12.34 per metric ton, it appears that much of these exports were ferruginous manganese ore or manganiferous iron ore. Domestic consumption of manganese ore was 864,000 short tons in 1971, compared with 825,000 tons in 1970. The quantity used by battery producers was 9,000 tons in 1971 and 11,000 tons in 1970.

Acknowledging that a lack of adequate exploration drilling makes firm assessment difficult, the Geological Survey of India and the Indian Bureau of Mines have reappraised the country's reserves of manganese ore, arriving at totals of 8.4 million shorts tons of measured ore and 108.4 million tons of inferred ore, for a grand total of 116.8 million tons. With a recovery of approximately 50 percent in the Madhya Pradesh-Maharashtra mining belt and assuming no better recoveries for other districts, recoverable reserves are estimated to be no better than 65 million tons. Of the 8.4 million tons total measured ore, 7.7 million tons are high-grade ore containing 46 percent or more manganese and located in Madhya Pradesh-Maharashtra. Of the 108.4 million tons of inferred ore, 33.0 million tons are of this grade in the same district. No other district contributes to the measured reserves of this grade, and only 3.3 million tons of inferred reserves of this grade are found elsewhere. Reserves of ore containing 38 to 46 percent manganese consist of 0.13 million ton of measured ore and 4.8 million tons of inferred ore in Madhya Pradesh-Maharashtra, and 0.26 million ton of measured ore and 6.5 million tons of inferred ore in other districts. A total of 49.6 million tons, consisting almost entirely of inferred ore and lying mostly in Orissa and Mysore, are categorized as "unclassified—grades are overlapping." The remainder of the grand total consists of 10.3 million tons of low-grade ore, mostly inferred, containing less than 38 percent manganese, and credited principally to Orissa, Andhra Pradesh, and Mysore; plus 1.2 million tons of ore in Goa designated as "indicated recoverable with manganese content varying from 25 percent to 48 percent." [6]

Italy.—Manganese ore produced in 1971 had an average content of 25 percent manganese.

Ivory Coast.—Exports of manganese ore were from stocks and totaled 16,850 short tons.

Japan.—The ferroalloy plant of Nippon Denko Co. Ltd. at Tokushima, established in 1969 on the eastern seacoast of Shikoku Island, is equipped with two electric furnaces rated at 36,400 kilovolt-amperes and 40,500 kilovolt-amperes capable of producing 100,000 tons of ferromanganese and 65,000 tons of silicomanganese per year. From 50 to 70 percent of the ore charged to the furnaces is sintered in a Dwight-Lloyd machine. With costs of electric power high in Japan, the tendency is to alleviate them by pretreating the feed materials.[7]

Morocco.—As in the previous year, all manganese ore produced in 1971 was chemical-grade concentrate, averaging 84 percent manganese dioxide. Virtually all came from the Imini mine. The drop in production resulted from a drop in demand. Total exports were 100,000 short tons, of which the United States took 25,000 tons, and France received 20,000 tons.

Norway.—Porsgrunn Elektrometallurgiske placed a new 40,000 ton-per-year ferromanganese furnace in operation at its Salten works.[8] Tinfoss Jernverk, presently producing ferromanganese and ferrosilicon at Notodden in southern Norway, will build a new ferromanganese plant at Kvinesdal, also in southern Norway. When completed in 1974 or 1975, the new plant will take over the ferromanganese production of Notodden, which will then be used for ferrosilicon production. At Kvinesdal, special closed furnaces will guard against air pol-

[6] Balasundaram, M. S. A Review of the Reserves and Demand Pattern of Iron, Manganese and Chromite Ores in India. Eastern Met. Rev. (Calcutta), v. 25, April 1972, pp. 39–49.

[7] Naruse, Wataru. Production by the Sintering Process. Met. Bull. (London), Ferrous Alloys Special Issue, 1971, pp. 87–91.

[8] Metals Week. Norwegian alloy expansion. V. 42, No. 50, Dec. 13, 1971, p. 5.

lution, and other equipment will clean the waste water before its release.[9]

South Africa, Republic of.—South African Manganese Ltd. reported that it was establishing a new mine at its Wessels property in the Kuruman district, Cape Province. The ore lies at a depth of at least 1,000 feet below surface, and is of a grade similar to that of the company's nearby Hotazel mine. It will be developed by two shafts, one of which will be an incline. Production was expected to start in 1972 and to reach 400,000 to 500,000 tons per year in 1973. The company's currently producing mines in the district—Hotazel and Mamatwan—are open pit operations.[10] Metalloys Ltd. and Ferrometals Ltd., subsidiaries of Amcor Limited, announced a $42 million expansion program that will add three new furnaces—two for ferromanganese and one for ferrochromium—with attendant pollution-control equipment. This will reportedly make Amcor one of the world's largest ferroalloy producers. The two subsidiaries were reported to have contracts for delivery of appreciable quantities of alloy to the United States, Canada, Europe, and Japan, over a 15-year period.[11] At the end of the year, Electrolytic Metal Corp. (Pty) Ltd. (EMCOR) had completed its previously reported expansion program, bringing its Krugersdorp electrolytic manganese metal plant to an annual capacity of 13,450 short tons. Long-term contracts for the product were finalized, and it was anticipated that the entire increase in production would be sold in 1972. The company reported a reasonably satisfactory profit for 1971, although lower than that of the previous year because of low prices resulting from keen competition in the world markets.

Spain.—A plant, due on stream in 1972 and capable of producing about 30,000 tons of refined ferromanganese per year, was under construction at Monzón, Huesca.[12] The manganese ore produced in 1971 had an average manganese content of 30.1 percent.

Sweden.—Airco Alloys AB, Swedish subsidiary of Airco, Inc., was building a new 40,000-kilowatt furnace in southwestern Sweden at its Vargon plant where both ferromanganese and ferrosilicon are produced. The new furnace, brought on stream in June 1972, will replace part of the existing facilities. The cost will be $8 million, of which $2 million will be for air pollution-control equipment. Controls have been installed on two older furnaces at a cost of $800,000. The Swedish Government subsidized 25 percent of the pollution-control costs for these three furnaces, and will subsidize 75 percent of an additional $1.4 million to be spent on equipment for three smaller furnaces. The plant will then be in full compliance with the country's clean-air program by the end of 1972.

Thailand.—Battery-grade ore (75 percent manganese dioxide) production in 1971 totaled 5,600 short tons. No ore of chemical grade was produced.

Turkey.—Ore produced in 1971 had an average manganese content of 41 percent, compared with 38.5 percent in 1970.

Zaire (formerly Congo—Kinshasa).—Société Minière de Kisenge (SMK), a wholly owned subsidiary of Société Générale de Belgique, continued to produce the greater part, if not all, of the country's production of manganese ore at Kisenge in the southwest corner of Shaba (formerly Katanga) Province near the Angolan border. Mining was from two open pits with the ore crushed and blended before shipment over the Benguela railway to the Angolan port of Lobito for export to the United States and Europe. During 1971, the company was removing overburden for the preparation of a third pit for mining, and was considering construction of a plant to produce a high-grade (90 percent plus) concentrate that could be sold for chemical uses. Both of these plans were later abandoned because of weak prices for manganese ores. Exports in 1971 included 3,600 short tons of concentrate containing 80 percent manganese dioxide. SMK employs 26 Europeans and approximately 500 Zairians. Terms of the company's charter with the Zairian Government give the Government 60 percent of the profits and 50 percent of the voting rights. The dry-cell plant of the company's subsidiary, Afripile Battery Co., has not reopened since its closure in 1967.

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[9] Mining Journal (London). V. 277, No. 7105, Oct. 22, 1971, p. 367.
[10] World Minerals (London). No. 1, May–June 1971, p. 24.
[11] American Metal Market. V. 78, No. 59, Mar. 26, 1971, p. 24.
[12] Chemical Age (London). V. 102, No. 2700, Apr. 16, 1971, p. 18.

TECHNOLOGY

In small-scale laboratory work, the Bureau of Mines obtained good recoveries of manganese from unroasted Cuyuna Range (Minn.) manganiferous ores by leaching at either atmospheric or elevated pressures. Using a reagent combination of pyrite, sulfuric acid, and lignite char, manganese extractions of 99 percent were achieved at 100°C and atmospheric steam pressure from a very fine grained ore analyzing 14.0 percent manganese, 35.6 percent iron, and 20.6 percent silica. The manganese occurred as psilomelane, manganite, and pyrolusite. Hematite, goethite, and quartz were other principal mineral constituents, and the iron silicates—stilpnomelane and minnesotaite—were noted.[13]

Using a 1 ton-per-day pilot plant, Deepsea Ventures Inc. obtained 95-percent recoveries of manganese, nickel, copper, and cobalt from Pacific sea-floor nodules containing 26 to 27 percent manganese, 1.3 percent nickel, 1.0 percent copper, and 0.2 percent cobalt. In the process, the nodules are crushed and dried to promote reactivity by providing large surface area. Reduction with hydrogen chloride gas in a multihearth furnace at temperatures exceeding 120°C yields the chlorides of the metals. These are leached with water and the solution filtered. The solid residue, containing inert silicates, sulfates, and oxides (mainly of iron) is discarded. In commercial practice, this would constitute a suitable clean land fill. From the filtered liquor, using a series of liquid ion exchange processes employing proprietary reagents, pure aqueous solutions of copper, nickel, and cobalt, are successively separated out, from each of which the respective pure metals are produced by electrolysis. The remaining solution, which contains manganese and other metal chlorides, is concentrated, and the manganese chloride is precipitated and dried. Upon heating with an unidentified metal, the chloride of that metal is formed with resulting production of manganese metal. Possibilities for the recovery of other metals, particularly silver and molybdenum, were being investigated.[14]

Maps of the distribution of manganese nodules and crusts on the various ocean floors were prepared from photographs taken by the deep-sea cameras of the Lamont-Doherty Geophysical Observatory of Columbia University in the course of 28 oceanographic cruises over a period of 17 years. Approximately 3,000 camera stations with more than 50,000 individual photographs were involved.[15] In an associated study, similar maps were prepared from an examination of data from 6,000 piston cores obtained from the ocean floors over the last 25 years.[16] These two studies disclosed varying concentrations of manganese with respect to various major submarine physiographic features. An association of high manganese concentrations with red clays was observed. A cursory examination of the published generalized maps shows that the stations without manganese are more numerous than those with manganese.

The National Oceanic and Atmospheric Administration reported finding extremely heavy encrustations of manganese oxides, containing nickel, copper, and cobalt, on rock exposures where the Atlantic Ocean floor has been fractured by earth movements. The project, Trans-Atlantic Geotraverse, covered an area 200 miles wide across the ocean from Cape Hatteras, N.C., to Cap Blanc, Africa.[17]

Encrustations of manganese oxides over an area of at least 50 square miles was reported to have been found at depths of 5,000 to 8,000 feet, from 5 to 8 miles off Kauai Island, Hawaii, by researchers from the University of Hawaii. Although some nodules are found on the ocean floor, the deposits occur essentially as crusts—one of which is on the ocean floor and the other 1 to 5 feet below.[18]

The South African Council for Scientific and Industrial Research (CSIR) has developed a pulse galvanostatic analyzer for de-

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[13] Leak, Vance G. Autoclave and Ambient Pressure Leaching of Lake Superior Manganiferous Ores. BuMines RI 7501, 1971, 18 pp.

[14] Chemical and Engineering News. Process Makes Pure Metals From Ocean Nodules. V. 49, No. 19, May 10, 1971, pp. 56–57.
Caldwell, A. Blake. Deepsea Ventures Readying Its Attack on Pacific Nodules. Min. Eng., v. 23, No. 10, October 1971, pp. 54–55.

[15] Ewing, M., D. Horn, L. Sullivan, T. Aitken, and E. Thorndike. Photographing Manganese Nodules On the Ocean Floor. Oceanology Internat., v. 6, No. 12, December 1971, pp. 26–32.

[16] Horn, D. R., M. Ewing, B. M. Horn, and M. N. Delach. World-Wide Distribution of Manganese Nodules. Ocean Ind., v. 7, No. 1, January 1972, pp. 26–29.

[17] Oceanology International. V. 6, No. 10, October 1971, pp. 22–23.

[18] Oceanology International. V. 6, No. 3, March 1971, p. 22.

termining within a few hours the depolarizing capacity of manganese dioxide for its use in dry cells.[19] Heretofore, determination of this characteristic has been by means of a "shelf test" of an actual cell over a period measured in weeks or months. From investigations employing the newly developed analyzer, it was found that suitable manganese dioxide for dry cells was not confined to the gamma form (nsutite) as had been widely believed.[20]

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[19] Council for Scientific and Industrial Research, Pretoria, Republic of South Africa. The Pulse Galvanostatic Analyzer. Tech. Inf. for Ind., v. 9, No. 4, April 1971, 4 pp.

[20] Schweigart, Hilde, and Indru Olivier. Pulse Galvanostatic Analyser. Coal, Gold and Base Minerals of Southern Africa (Johannesburg, Republic of South Africa), v. 19, No. 6, August 1971, pp. 43–47.

Mercury

By V. Anthony Cammarota, Jr.[1]

In 1971, production of prime virgin mercury decreased to its lowest level since 1964. A total of 17,627 flasks[2] were produced, a reduction of 35 percent from that of 1970. On the other hand, secondary production was up sharply, aided by the closing of several chlor-alkali plants and releases of mercury by the General Services Administration (GSA). Although overall consumption was down 15 percent from the previous year, electrical apparatus and antifouling paint registered significant gains. Both imports and exports increased substantially. There were no commercial sales of mercury by GSA.

A decreased demand for mercury led to continuously lower prices during the year. By yearend, the price range had fallen to $216 to $218 from $350 to $360 in January.

World production increased by 8 percent from that of 1970. Algeria, Czechoslovakia, Ireland, Mexico, Spain, and Turkey showed substantial increases.

On March 31, the Environmental Protectio Agency (EPA) published a list, pursuant to the Clean Air Act of 1970, in which mercury was designated a hazardous air pollutant. On December 7,[3] a mercury emission standard of 5 pounds of mercury to the atmosphere per 24-hour period was proposed by EPA for each primary mercury plant and chlor-alkali plant.

An almost 100 percent reduction in mercury discharges into open waters was achieved by 50 major mercury users, according tot EPA. In spite of these accomplishments, several mercury-cell chlor-alkali plants closed or announced plans to do so, citing high costs for pollution control and the technical difficulty of attaining total elimination of mercury from discharge waters as decisive factors.

Legislation and Government Programs.—Government financial assistance on a participatory basis was available through the Office of Minerals Exploration, U.S. Geological Survey, for mercury exploration projects to the extent of 75 percent of the acceptable costs. Repayment was to be made at the annual rate of 5 percent royalty on production from the property. One contract was executed during 1971.

Throughout 1971, GSA abstained from offering its surplus mercury for sale to commercial buyers. Releases of 5,767 flasks were made to other Government agencies, including 5,700 flasks to the Agency for International Development for export to

[1] Physical scientist, Division of Nonferrous Metals.
[2] Flask as used throughout this chapter refers to the 76-pound flask.
[3] Federal Register. National Emission Standards for Hazardous Air Pollutants. V. 36, No. 234, Dec. 7, 1971, pp. 23239-23256.

Table 1.—Salient mercury statistics

	1967	1968	1969	1970	1971
United States:					
Producing mines	122	87	109	79	55
Production ... flasks	23,784	28,874	29,640	27,296	17,627
Value ... thousands	$11,639	$15,464	$14,969	$11,130	$5,154
Exports ... flasks	2,627	7,496	507	4,653	7,232
Reexports ... do	475	103	108	50	--
Imports:					
For consumption ... do	24,348	23,246	31,924	21,972	28,449
General ... do	23,899	23,956	30,848	21,672	29,750
Stocks Dec. 31 ... do	18,277	22,907	22,692	16,554	17,000
Consumption ... do	69,517	75,422	77,372	61,503	52,475
Price: New York, average per flask	$489.36	$535.56	$505.04	$407.77	$292.41
World:					
Production ... flasks	232,073	259,694	289,267	283,816	305,723
Price: London, average per flask	$499.36	$546.80	$536.41	$411.45	$282.46

India. The GSA stock available for disposal at the end of 1971 was 7,723 flasks.

As of December 31, 1971, total strategic stockpile accumulations from all programs stood at 200,105 flasks.

The depletion allowance for mercury remained at 22 percent for domestic deposits and 14 percent for foreign deposits.

DOMESTIC PRODUCTION

Mine closings were the dominant feature of the industry during 1971. A total of 55 mines reported production, down from 79 in 1970, although by yearend only 22 remained operative. Significant producing mines that closed during the year included the Red Devil in Alaska, the Abbott, Altoona, Buena Vista, Klau, and Alpha-Guadalupe in California, the Ruja in Nevada, and the Study Butte and Whit-Roy in Texas. The low price for mercury made mining uneconomical for most producers. Some exploration and development work was conducted at several small properties. The number of mines reporting outputs of 1,000 flasks or more decreased from 12 in 1970 to 6 in 1971. Properties producing 500 to 999 flasks increased by one, and properties producing 100 to 499 flasks decreased by one. Of the total producton, 65 percent came from producers of 1,000 flasks or more, 20 percent from producers of 500 to 999 flasks, and 11 percent from producers of 100 to 499 flasks. Principal mines in 1971 were as follows:

State	County	Mine
PROPERTIES PRODUCING 1,000 FLASKS OR MORE		
California	Sonoma	Culver-Baer.
Do	Santa Barbara	Gibraltar.
Do	Santa Clara	Guadalupe.
Do	Sonoma	Mt. Jackson.
Do	San Benito	New Idria.
Idaho	Washington	Idaho-Almaden.
PROPERTIES PRODUCING 500 TO 999 FLASKS		
California	Lake	Abbott.
Do	Napa	Manhattan-One Shot.
Do	Santa Clara	New Almaden.
Nevada	Humboldt	Quinn River (Cordero).
Do	Do	Ruja.
Texas	Brewster	Study Butte.
PROPERTIES PRODUCING 100 TO 499 FLASKS		
Alaska	Kuskokwim River Region	Alice & Bessie.
Do	Do	Schaefer (Cinnabar Creek).
California	Trinity	Altoona.
Do	Marin	Chileno Valley.
Do	Napa	Corona.
Do	San Luis Obispo	Klau.
Do	Napa	Oat Hill.
Nevada	Pershing	Red Bird.
Texas	Presidio	Whit-Roy.

California, with 13 fewer mines than in 1970, increased its share of total mercury producton from 68 percent in 1970 to 75 percent in 1971. Two mines, Guadalupe and Oat Hill, showed significantly higher production. At the Guadalupe mine, construction was underway on an 80-ton-per-day rotary furnace.

Two of California's largest producers, New Idria Mining and Chemical Co. (New Idria) and Sonoma Mines, Inc. (Mt. Jackson), decreased their dependence on mercury mining by diversifying into nonmining business activities.

Nevada produced 9 percent of the total mercury with 5 fewer mines than in 1970. The Ruja mine, the State's largest producer, closed in June. At the same time, Sierra Mineral Management of Tucson, Ariz., leased the Cordero mine and began milling and furnacing the ore at the adjacent Ruja site. By yearend this operation had shut down. The Carlin Gold Mining Co., which recovered mercury as a byproduct from its gold mine in Eureka County, remained as the only continuing producer of mercury in Nevada.

The Idaho-Almaden mine in Idaho continued production at the 1970 level. Alaskan production of mercury metal was confined to the Alice & Bessie and Schaefer mines. Concentrate from the Schaefer mine was transported to California for retorting. Some concentrate was reportedly shipped to Japan and Hong Kong from several other Alaskan mines. Minor production was reported from Arkansas and Oregon.

The St. Joe Minerals Corp. continued to recover byproduct mercury from its zinc smelter at Monaca, Pa. The zinc concentrate originated from the company's zinc mine in New York.

The average grade of all ore processed in 1971, increased to 5 pounds of mercury per ton. More of the major producers treated higher grade ore than that of 1970. Data from selected mines indicated that ore grade at open pit operations ran about 3 pounds per ton, whereas underground ore was about 7 pounds.

Secondary production of mercury was about double that of 1970; this was due primarily to GSA releases and the closing of several chlor-alkali plants. Dental amalgams, scrap batteries, various types of sludges, and discarded mercury-containing instruments were other sources of secondary mercury.

Table 2.—Mercury produced in the United States, by State

Year and state	Producing mines	Flasks	Value [1] (thousands)
1970			
California	51	18,593	$7,582
Idaho	1	1,038	423
Nevada	13	r 4,909	r 2,001
Oregon	5	274	112
Alaska, Arkansas, New York, Texas, Washington	9	2,482	1,012
Total	79	r 27,296	r 11,130
1971			
California	38	13,233	3,869
Idaho	1	1,057	309
Nevada	8	1,589	465
Alaska, Arkansas, New York, Oregon, Texas	8	1,748	511
Total	55	17,627	5,154

r Revised.
[1] 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	Mercury produced: Pounds per ton of ore
1967	439,753	23,767	4.1
1968	434,193	28,857	5.1
1969	432,591	28,552	5.0
1970	r 424,510	r 26,795	4.8
1971	261,684	17,188	5.0

r Revised.
[1] Excludes mercury produced from old surface ores, dumps, placers, and as a byproduct.

Table 4.—Production of secondary mercury in the United States

Year	Flasks [1]
1967	22,150
1968	34,380
1969	13,650
1970	8,051
1971	16,666

[1] Includes GSA releases.

CONSUMPTION AND USES

Consumption suffered another setback in 1971, decreasing to 52,475 flasks. Although increased consumption was noted for electrical apparatus and antifouling paint, consumption in dental preparations, general laboratory, industrial and control instruments, and pharmaceuticals remained at 1970 levels. With the discontinuance of the mercury amalgamation process for gold recovery by the Homestake Mining Co., Lead, S. Dak., almost no mercury was consumed for this use. Use of mercury in paper and pulp manufacture was negligible. Mercury needed to increase the capacity of existing mercury-cell chlor-alkali plants was much less than that used in 1970. The largest uses of mercury were electrical apparatus, 32 percent; electrolytic preparation of chlorine and caustic soda 23 percent; and mildew proofing for paint, 16 percent.

Total chlorine production decreased about 5 percent from that of 1970 to an estimted 9.3 million tons. Of this total, 27.2 percent was produced in mercury cells, the same as in 1970. Mercury used as makeup in the cells declined to 12,262 flasks, down 18 percent from that of 1970. Consumption of mercury per ton of chlorine produced continued its downward trend to 0.37 pound. In contrast to previous years, much of this mercury is being recovered through the installation of pollution control devices.

No new mercury-cell plants are planned for the United States.

The Olin Corp. announced plans to close its Saltville, Va., mercury-cell facility by March 1972. The Dow Chemical Co., which already had closed its Plaquemine, La., plant in late 1970, intends to replace its mercury-cell facility at Sarnia, Ontario, with a diaphragm cell by early 1973.

Table 5.—Mercury consumed in the United States, by use

(Flasks)

Use	1967 [1]	1968 [1]	1969	1970	1971
Agriculture	3,732	3,430	2,689	1,811	1,477
Amalgamation	219	267	195	219	W
Catalysts	2,489	1,914	2,958	2,238	1,141
Dental preparations	2,386	3,079	2,880	2,286	2,387
Electrical apparatus	16,223	19,630	18,490	15,952	16,938
Electrolytic preparation of chlorine and caustic soda	14,306	17,453	20,720	15,011	12,262
General laboratory use	1,940	1,989	1,936	1,806	1,809
Industrial and control instruments	7,459	7,978	6,655	4,832	4,871
Paint:					
Antifouling	152	392	244	198	414
Mildew proofing	7,026	10,174	9,486	10,149	8,191
Paper and pulp manufacture	446	417	558	226	W
Pharmaceuticals	283	424	712	690	682
Other [2]	12,856	8,275	9,134	5,858	2,300
Total known uses	69,517	75,422	76,657	61,276	52,472
Total uses unknown	--	--	715	227	3
Grand total	69,517	75,422	77,372	61,503	52,475

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included under "Other."

[1] Uses include proportion of mercury previously reported under "Redistilled."

[2] Includes mercury used for installation and expansion of chlorine and caustic soda plants.

Table 6.—Mercury consumed in the United States in 1971

(Flasks)

	Primary	Redistilled	Secondary	Total
Agriculture [1]	1,464	W	W	1,477
Amalgamation	W	--	--	W
Catalysts	862	W	W	1,141
Dental preparations	W	1,776	W	2,387
Electrical apparatus	12,979	W	W	16,938
Electrolytic preparation of chlorine and caustic soda	10,543	W	W	12,262
General laboratory use	W	782	W	1,809
Industrial and control instruments	1,637	2,747	487	4,871
Paint:				
Antifouling	W	W	W	414
Mildew proofing	8,075	W	W	8,191
Paper and pulp manufacture	W	W	--	W
Pharmaceuticals	345	W	W	682
Other	2,971	4,021	3,783	2,300
Total known uses	38,876	9,326	4,270	52,472
Total uses unknown	--	3	--	3
Grand total	38,876	9,329	4,270	52,475

W Withheld to avoid disclosing individual company confidential data; included under "Other."

[1] Includes fungicides and bactericides for industrial purposes.

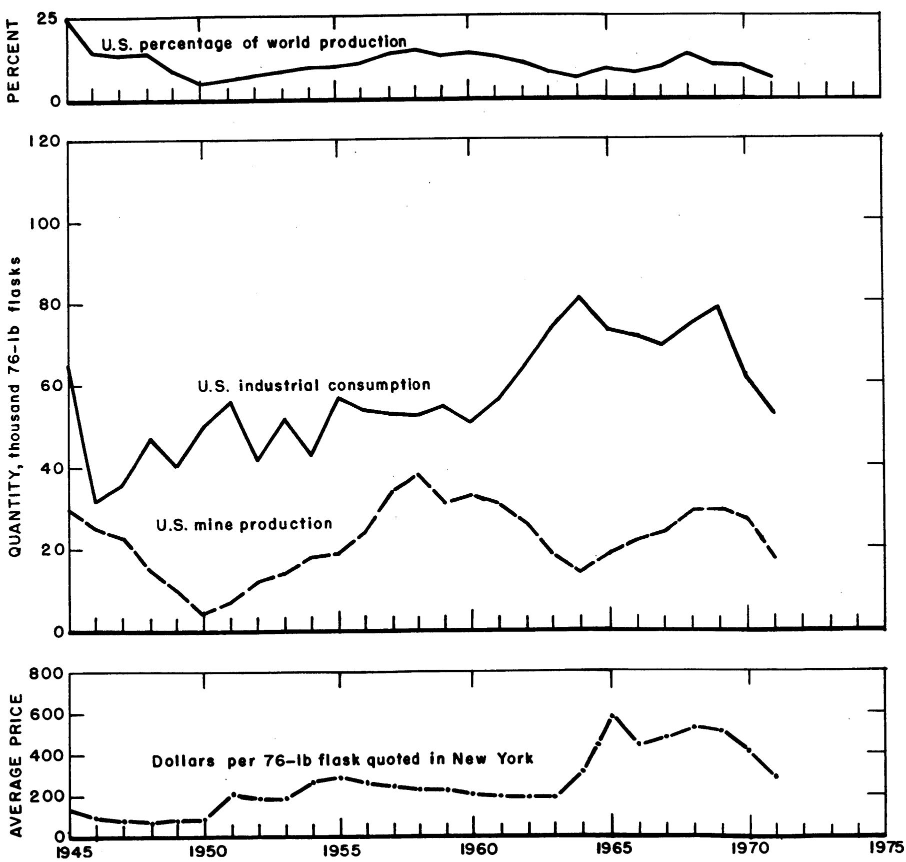

Figure 1.—Trends in production, consumption, and price of mercury.

Table 7.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1967	757	17,520	18,277
1968	1,059	21,848	22,907
1969	2,920	19,772	22,692
1970	3,861	r 12,693	r 16,554
1971	4,867	12,133	17,000

r Revised.

PRICES

The price of mercury continued the downward trend of the past several years. From a price of $350 to $360 per flask in January, it gradually slipped to $216 to $218 per flask by yearend. A minor rally developed in June to carry the price upward to $300 to $318 per flask from $262 to $267. The virtual lack of demand was the main cause of price weakness. Announcements by the EPA in March listing mercury as a hazardous air pollutant and in December proposing an emission standard on mercury-producing and chlor-alkali plants depressed prices. The average price of mercury at New York was $292.41 per flask for 1971.

Prices also declined on the London market to show an annual average of $282.46 per flask. Beginning about midyear, New York prices exceeded London prices by about 10 percent. As the European market declined, the U.S. market held, and the spread between the two markets widened by roughly the amount of the U.S. duty, $19 per flask, in effect between August and December.

Table 8.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1970		1971	
	New York [1]	London [2]	New York [1]	London [2]
January	$482.50	$494.25	$349.50	$359.76
February	462.47	460.13	346.26	359.61
March	459.76	463.97	328.26	335.80
April	467.23	464.03	309.95	316.57
May	442.00	439.27	281.50	285.89
June	411.14	414.33	266.23	251.09
July	409.09	413.09	297.95	278.68
August	358.48	370.34	283.86	255.36
September	351.05	355.65	283.10	255.97
October	341.59	346.17	271.35	244.22
November	353.42	359.38	258.75	233.90
December	354.50	358.46	230.24	210.18
Average	407.77	411.45	292.41	282.46

[1] Metals Week, New York.

[2] Metal Bulletin prices in terms of pounds sterling were converted to U.S. dollars by using average rates of exchange recorded by Federal Reserve Board.

FOREIGN TRADE

Mercury exports increased significantly to 7,232 flasks, compared with 4,653 flasks in 1970. The major recipient was India with 5,574 flasks, followed by Japan, 377 flasks; United Kingdom, 328 flasks; and Canada, 326 flasks.

Imports for consumption, which include mercury imported for immediate consumption plus material withdrawn from bonded warehouses, increased by 29 percent to 28,449 flasks. General imports, which include mercury imported for immediate consumption plus material entering the country under bond, totaled 29,750 flasks. The major suppliers were Canada, 64 percent; Mexico, 17 percent; Spain 8 percent; and Turkey, 5 percent. Smaller amounts came from Colombia, Italy, Peru, and Yugoslavia. No mercury ore was imported and trade in mercury compounds was insignificant. About 15 flasks, included in the import figures, entered the country as scrap from Canada.

The U.S. rate of duty on mercury imports dropped from $11.40 per flask during the year to $9.50 per flask as of January 1, 1972, in accordance with provisions of the General Agreement on Tariffs and Trade. From August 16, 1971, to December 20, 1971, a 10-percent ad valorem surcharge was imposed on all dutiable imports, up to the statutory limit. For mercury, this limit was $19 per flask.

Table 9.—U.S. exports and reexports of mercury

Year	Exports: Flasks	Exports: Value (thousands)	Reexports: Flasks	Reexports: Value (thousands)
1969	507	$294	108	$57
1970	4,653	2,133	50	19
1971	7,232	2,789	--	--

Table 10.—U.S. imports for consumption [1] of mercury, by country

Country	1969 Flasks	1969 Value (thousands)	1970 Flasks	1970 Value (thousands)	1971 Flasks	1971 Value (thousands)
Belgium-Luxembourg	--	--	--	--	2	$2
Bolivia	11	$6	--	--	--	--
Canada	15,546	7,455	17,872	$7,140	18,198	5,477
Colombia	--	--	--	--	400	101
Germany, West	--	--	(2)	(2)	203	49
Ghana	107	4	--	--	--	--
Italy	5,041	2,520	1,101	560	250	75
Japan	--	--	--	--	3	(2)
Mexico	7,398	3,409	920	r386	4,786	1,160
Peru	--	--	14	6	600	155
Spain	2,602	1,216	2,002	945	2,152	659
Sweden	--	--	12	4	--	--
Switzerland	--	--	1	1	5	8
Turkey	--	--	--	--	1,430	366
United Kingdom	388	186	50	26	--	--
Yugoslavia	831	411	--	--	420	113
Total	31,924	15,207	21,972	r9,068	28,449	8,165

r Revised.

1 In 1969, general imports were 30,848 flasks ($14,699,376); Spain supplied 2,902 flasks ($1,355,396) and Italy 3,665 flasks ($1,872,834). In 1970, general imports were 21,672 flasks ($8,962,335); Spain supplied 1,702 flasks ($805,504). In 1971, general imports were 29,750 flasks ($8,500,607); Spain supplied 3,353 flasks ($970,028) and Mexico, 4,886 flasks ($1,184,826).

2 Less than ½ unit.

WORLD REVIEW

Algeria.—The mercury plant at Ismail, with a rated annual capacity of 9,200 flasks, went into production during the year. Most of the production has been stockpiled. Original plans called for increasing the capacity to 25,000 flasks by 1973.

Canada.—Cominco, Ltd., Canada's only mercury producer, announced it had reduced producton at its Pinchi Lake mine by about 25 percent from that of 1970. Cominco mined 248,000 tons of ore, compared with 390,000 tons in 1970. Present ore reserves at Pinchi Lake are sufficient for at least 10 years of production at the 1970 level, according to Cominco. In addition, recent exploration work has indicated a good potential for extension of these reserves.

Czechoslavakia.—The Rudnany mine byproduct mercury recovery plant near Spisska Nova operated near capacity during the year. The plant handled 40 tons per day of concentrate analyzing 1.92 percent mercury. During testing, mercury recovery was 97.1 percent.

India.—The first occurrence of high-grade mercury ore in India was reported to have been discovered in the Vadkara region in north Malabar, Kerala. Apparently it has been found in red lateritic rock, normally used for building. The Kerala

Government has requested that the Geological Survey of India conduct an investigation of the area.

Indonesia.—Nickelfields of Australia N.L. has acquired a 75-percent interest in five mercury leases in West Kalimantan from Firina Dipanegara Corp. of Djakarta. The deposits are reported to contain over 3 million cubic yards of mercury-bearing ore, 21 samples of which assayed 0.24 percent mercury on an average.

Ireland.—During the first 6 months of 1971, Gortdrum Mines, Ltd., treated 3,321 tons of concentrate in the mercury extraction plant to recover 804 flasks as a byproduct at its copper and silver mine. Most of the mercury was exported to the United Kingdom through Cominco-Gardner, Ltd.

Italy.—Production fell about 4 percent from 1970 to 42,671 flasks. The average ore grade was down slightly to 9.5 pounds of mercury per ton. It appears that inventories continued to build, and possibly reached close to 60,000 flasks by yearend. Exports remained level at 15,203 flasks. West Germany was the largest buyer, followed by East Germany, Romania, and France. Exports to the United Kingdom decreased substantially from those of 1970.

Japan.—Shipments of cinnabar concentrate from the Red Devil mine in Alaska to the Nomura Mining Co. were discontinued during the year. Consumption of mercury in the past few years has been about 30,000 flasks, most of which was used by the chlor-alkali industry.

Mexico.—With substantial reductions in production and export taxes, essentially all mercury production is being legally declared, and smuggling has become insignificant. Mercurio Mexicana, S.A. de C.V., is in the process of expanding its present floatation mill at Mazapil, Zacatecas, to a 750-ton-per-day capacity. Once in operation, the plant will produce 10,000 flasks annually, about double the present rate. In order to supply the additional feed for this mill, the existing Tiro General mine shaft slash will be increased from 13 feet to 18 feet.

Peru.—Near the town of Huancavelica, the Santa Bárbara mine, Peru's only producer, stockpiled most of its output. The ore is said to average 10 pounds of mercury per ton. Mining technicians in Peru have estimated that at the normal rate of exploitation the Santa Bárbara cinnabar deposits would last another 10 to 12 years.

Spain.—Mine production increased 48 percent from 1970 to 67,528 flasks. Metal production was 48,843 flasks indicating some ore stockpiling. The ore grade apparently dipped in 1971 to about 30 pounds of mercury per ton. Plans made public by the Plan Nacional de la Mineria indicate that by 1980 total production for Spain will be 80,250 flasks. Of this total, Minas de Almadén, the State-owned company, will account for 70,000 flasks. Some

Table 11.—Mercury: World production, by country
(Flasks)

Country	1969	1970	1971 p
Algeria	--	--	7,136
Bolivia (exports)	68	12	--
Canada	21,200	24,400	e 18,000
Chile	286	388	e 310
China, People's Republic of e	20,000	20,000	20,000
Colombia	r 312	215	(1)
Czechoslovakia	435	4,815	e 7,000
Finland	e 10	e 100	135
Ireland	420	1,304	e 2,000
Italy	48,733	44,382	42,671
Japan	r 5,613	5,170	e 5,700
Mexico	2 r 22,500	30,265	35,390
Peru	r 3,592	3,125	e 1,800
Philippines	3,478	4,648	5,022
Spain 3	64,862	45,543	67,528
Tunisia	244	100	340
Turkey	r 6,544	8,592	e 9,500
U.S.S.R. e	47,000	48,000	50,000
United States	29,640	27,296	17,627
Yugoslavia	14,330	15,461	15,564
Total	r 289,267	283,816	305,723

e Estimate. p Preliminary. r Revised.
1 Less than ½ flask.
2 Although total for 1971 is reported in sources, the distribution of that total by countries is not. Detailed figures given are the exports to listed countries for the first 6 months only; the undistributed total for the last 6 months (including additional shipments to listed destinations)is included with other countries and undis tribted.
3 Officially reported mercury content of ore mined. Official metal production figures are as follows, in flasks: 1969—64,531; 1970—44,736; 1971—48,843.

Table 12.—Mercury: Exports from Italy, Spain, and Yugoslavia, by country

(Flasks)

Destinations	Italy			Spain			Yugoslavia		
	1969	1970	1971 [1]	1969	1970	1971	1969	1970 r	1971 [2]
Australia	203	30	NA	203	87	116	--	--	NA
Belgium-Luxembourg	116	--	NA	1,276	2,321	290	--	--	NA
Bulgaria	145	698	255	174	--	--	--	--	NA
Canada	--	--	NA	261	667	29	--	--	NA
Colombia	--	([3])	NA	([3])	203	1,189	--	--	NA
Czechoslovakia	--	--	NA	3,481	580	--	--	900	[4] 260
France	1,421	600	1,140	1,915	3,423	1,711	360	362	[4] 182
Germany, East	r 6,382	4,353	2,100	377	1,799	9,138	--	--	NA
Germany, West	4,902	1,111	5,300	13,866	13,924	6,672	1,980	2,075	[4] 1,050
Greece	232	--	NA	--	--	3	3	--	[4] 145
Hungary	841	--	NA	986	377	--	--	--	NA
India	2,843	--	NA	--	2,611	841	--	--	NA
Japan	4,409	2,277	NA	783	6,788	841	--	--	NA
Netherlands	145	1,731	NA	1,160	174	986	--	--	NA
Poland	1,799	--	920	1,740	1,276	1,508	--	--	NA
Portugal	--	--	NA	638	667	261	--	--	NA
Romania	r 348	150	1,958	2,437	493	--	--	--	NA
South Africa, Republic of	--	--	NA	261	377	812	([5])	--	NA
Sweden	r 29	--	NA	1,189	1,392	2,176	330	535	[4] 150
Switzerland	29	--	NA	58	1,189	348	600	553	[4] 300
Taiwan	--	--	NA	58	2,292	493	--	--	--
United Kingdom	5,889	3,267	801	7,716	290	1,653	3,301	1,512	[4] 600
United States	r 4,090	1,101	NA	2,901	1,682	3,336	5,546	4,729	[4] 2,580
U.S.S.R.	--	--	NA	145	--	--	2,611	2,610	NA
Other countries and undistributed	r 233	172	2,729	r 321	668	492	r 44	654	9,005
Total	34,056	15,490	15,203	41,946	43,280	32,895	14,775	13,930	14,272

r Revised. NA Not available.

[1] Source gives only a partial distribution of total, many recipient countries are not listed separately; the total for all such countries is listed under "Other countries and undistributed."

[2] Although total for 1971 is reported in sources, the distribution of that total by countries is not. Detailed figures given are the exports to listed countries for the first 6 months only; the undistributed total for the last 6 months (including additional shipments to listed destinations) is included with other countries and undistributed.

[3] Less than ½ unit.

[4] Partial figure (first 6 months only).

[5] Revised to zero.

mercury observers view the expansion policy as unduly optimistic in view of the current depressed state of the mercury market and the unlikelihood of any marked increase in world demand over the next few years. Exports decreased significantly to 32,895 flasks. The mercury in stocks may possibly be about 50,000 flasks. In August, the Spanish Government increased the tax refund on exports from 1.5 percent to 9 percent to make Spanish mercury more competitive on the world market.

Turkey.—A recent report of Turkey's mercury potential indicated that there exist total ore reserves of 60 million tons, with a grade of between 4 and 6 pounds of mercury per ton. Six modern mercury plants, two of which are operated by Etibank, have an annual capacity of about 12,000 flasks. Planned expansions will increase capacity to about 15,000 flasks by the end of 1972.

U.S.S.R.—Three mercury deposits have been reported in the Caucasus Mountains. Development of these deposits will probably start within a year and will increase existing production, which has largely originated from the Shorbulakh mine.

TECHNOLOGY

Fulmer Research Institute of Stoke Poges, Buckinghamshire, England, has installed a new vacuum chamber in which to test two recently-built mercury ion engines.[4] The ion engine, which derives its thrust from the ejection of a beam of mercury ions, offers a promising technique for long-duration space missions.

The growing concern over environmental contamination by mercury has encouraged increased research activity into the detection of low-level mercury in air, water, and biota. Several instruments were introduced during the year that have the capability of detecting mercury concentrations

[4] Metal Bulletin. No. 5660, Dec. 21, 1971, p. 19.

as low as 1 part in 10 billion.[5] In a method developed at Lawrence Radiation Laboratory, University of California, Berkeley, mercury contamination in fish can be measured at sea, in 1 minute, with 40 parts per billion sensitivity.[6] This new type of atomic absorption spectrometer detects trace mercury based on hyperfine structure lines in a magnetic field. The advantage cited was that no chemical separation from the host material is necessary.

A simple rapid neutron activation method for mercury in fish tissue has been described in the literature.[7] The technique employs separation of the activated mercury as a mercuric tetrachloride complex ion on an anion-exchange resin and direct counting of the absorbed mercury. The analyses have a 10-percent deviation for samples containing mercury in the 0.05 to 10 parts per million range.

The chlor-alkali industry has mounted a huge effort to develop and implement the technology for reducing mercury emissions into the environment.[8] One company has obtained exclusive world rights to build mercury recovery systems based on the sodium borohydride process.[9] The company estimates that chemical costs of the process run about $1 per pound of recovered mercury. Two Canadian companies were installing a process for precipitating the mercury as insoluble mercuric sulfide from chlor-alkali plant effluents.[10] A zinc-dust bed that can reduce mercury in industrial waste streams to as low as 2 parts per billion was reported.[11]

At the Bureau of Mines Reno Metallurgy Research Center, Reno, Nev., pilot plant studies were completed on the electrooxidation of cinnabar ores. Over 40 different ores were tested for amenability resulting in 90 to 99 percent mercury recovery. Several mining companies have expressed interest in designing plants based on the procedure. Studies at the University of Nevada under a Bureau Research Grant have been directed toward a better understanding of the mechanism of the electrooxidation process.

A publication by researchers at the College Park Metallurgy Research Center, College Park, Md., described the collection of methyl mercury and inorganic mercury by a selective chelating resin.[12] The collected mercury is readily eluted over the pH range 1 to 9, and the resin can be reused for many cycles. For analytical applications, the two forms of mercury can be separated by collection at a pH of less than 1. It was also found that a methyl group attached to the mercuric ion produced an enhancement of 50 percent in the atomic absorption signal compared with the signal from the inorganic mercuric ion.[13]

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[5] American Metal Market. V. 78, No. 124, June 29, 1971, p. 16.
Mining Journal (London). V. 277, No. 7103, Oct. 8, 1971, p. 325.

[6] Hadeishi, T., and R. D. McLaughlin. Hyperfine Zeeman Effect Atomic Absorption Spectrometer for Mercury. Science. V. 174, No. 4007, Oct. 22, 1971, pp. 404–08.

[7] Rottschafer, J. M., J. D. Jones, and H. B. Mark, Jr. A Simple, Rapid Method for Determining Trace Mercury in Fish via Neutron Activation Analysis. Environmental Science and Technology. V. 5, No. 4, April 1971, pp. 336–38.

[8] Rosenzweig, M. D. Paring Mercury Pollution. Chemical Engineering. V. 78, No. 5, Feb. 22, 1971, pp. 70–72.

[9] Chemical and Engineering News. V. 49, No. 51, Dec. 13, 1971, p. 35.

[10] Chemical and Engineering News. V. 49, No. 43, Oct. 18, 1971, p. 41.

[11] Chemical Engineering. V. 78, No. 5, Feb. 22, 1971, p. 63.

[12] Law, S. L. Methyl Mercury and Inorganic Mercury Collection by a Selective Chelating Resin. Science. V. 174, No. 4006, Oct. 15, 1971, pp. 285–88.

[13] Law, S. L. Absorption Enhancement by an Organo-Metallic in Aqueous Solution—Methyl Mercury in Dilute Acid. Atomic Absorption Newsletter. V. 10, June 1971, pp. 75–76.

Mica

By Benjamin Petkof [1]

Scrap and flake mica production, the mainstay of the domestic mica industry, increased in both quantity and value from the previous year. A small quantity of sheet mica was produced during the year after a lapse in production in 1970. Ground mica production remained strong and increased in both quantity and value. Total exports of all classes of mica declined in quantity and value. Imports for consumption of uncut sheet and punch mica and scrap mica increased in quantity and value. The domestic consumption of all forms of sheet mica declined.

Table 1.—Salient mica statistics

	1967	1968	1969	1970	1971
United States:					
Sold or used by producers:					
Sheet mica____thousand pounds__	20	15	W	--	17
Value____thousands__	W	W	$3	--	$7
Scrap and flake mica thousand short tons__	119	125	133	119	127
Value____thousands__	$2,876	$3,014	$2,893	$2,527	$2,917
Ground mica____thousand short tons__	97	111	125	115	120
Value____thousands__	$5,756	$7,072	$8,058	$7,350	$8,280
Consumption, block and film thousand pounds__	1,972	1,628	1,498	1,299	1,301
Value____thousands__	$2,757	$2,591	$2,595	$2,058	$2,259
Consumption, splittings____thousand pounds__	6,188	4,785	5,077	5,214	4,177
Value____thousands__	$2,759	$2,010	$2,196	$2,254	$1,818
Exports____thousand short tons__	7	14	6	9	8
Imports for consumption____do____	4	5	5	6	7
World: Production____thousand pounds__	317,381	346,513	367,635	356,045	367,041

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Sheet Mica.—After no reported production of sheet mica in 1970, 17,005 pounds of punch and circle mica, valued at $6,652, was produced in Colorado and North Carolina. The average value of this material was low, indicating low quality. The probability of any continued long-term domestic sheet production remained unlikely.

Scrap and Flake Mica.—The output of scrap and flake mica increased 7 percent in quantity and 15 percent in value. North Carolina was the major producer of scrap and flake mica, accounting for slightly over half of the total domestic output. Nine States accounted for the remaining output. Beneficiation of material from pegmatite and kaolin deposits was the major source of flake mica. The major portion of this material was processed to ground mica for various industrial end uses.

Ground Mica.—Sales of ground mica increased 4 percent in quantity and 13 percent in value over those of 1970. Dry-ground mica accounted for 86 percent of total sales. Sixteen companies, operating a total of 20 plants, processed scrap and flake to a small particle size. Of these plants, 15 produced dry-ground mica; three, wet-ground; and two, both wet-and-dry-ground.

Development was begun on a muscovite mica deposit located on Pequea Creek near Lancaster Pa. The Aguda Mining Corp., Pittsburgh, Pa., has drilled and trenched the property and has estimated reserves at 35 million tons. The mica from the deposit will be wet-ground for marketing.[2]

[1] Physical scientist, Division of Nonmetallic Minerals.

[2] Skillings' Mining Review. Developing Mica Deposit in Pennsylvania. V. 60, No. 23, June 25, 1971, p. 22.

Table 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica: Uncut punch and circle mica, Pounds	Sheet mica: Uncut punch and circle mica, Value	Sheet mica: Uncut mica larger than punch and circle, Pounds	Sheet mica: Uncut mica larger than punch and circle, Value	Sheet mica: Total sheet mica, Pounds	Sheet mica: Total sheet mica, Value	Scrap and flake mica[1], Short tons	Scrap and flake mica[1], Value
1967	--	--	20,500	W	20,500	W	118,503	$2,876,149
1968	--	--	15,000	W	15,000	W	125,323	3,013,855
1969	W	$3,244	--	--	W	$3,244	133,058	2,893,183
1970	--	--	--	--	--	--	118,843	2,527,450
1971:								
Colorado	8,300	4,150	--	--	--	--	W	W
Connecticut	--	--	--	--	--	--	2,694	W
North Carolina	8,705	2,502	--	--	--	--	66,785	1,769,542
Other[2]	--	--	--	--	--	--	57,605	1,147,337
Total	17,005	6,652	--	--	--	--	127,084	2,916,879

W Withheld to avoid disclosing individual company confidential data, included with "Other."
[1] Includes finely divided mica recovered from mica and sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.
[2] Alabama, Arizona, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota.

Table 3.—Ground mica sold by producers in the United States by methods of grinding[1]

Year	Dry-ground: Short tons	Dry-ground: Value (thousands)	Wet-ground: Short tons	Wet-ground: Value (thousands)	Total: Short tons	Total: Value (thousands)
1967	82,849	$3,842	14,204	$1,915	97,053	[2] $5,756
1968	96,410	4,862	14,979	2,210	111,389	7,072
1969	109,152	5,486	15,704	2,572	124,856	8,058
1970	r 101,188	r 5,070	r 13,905	r 2,280	115,093	7,350
1971	103,428	5,463	16,176	2,817	119,604	8,280

r Revised.
[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 sheet mica, consisting of block, film, and splittings, declined from 6.5 million pounds in 1970 to 5.5 million pounds in 1971.

About 1.2 million pounds of block mica was consumed for the production of vacuum tubes, capacitors, and various other electrical and nonelectrical products. Of the total consumption, vacuum tubes required 72 percent and capacitors accounted for 2 percent. Lower than Stained quality was in greatest demand, accounting for 58 percent of total consumption; Stained, 40 percent; and Good Stained or better, the remainder.

Muscovite block and film was consumed by 15 companies in seven States. New Jersey with four consuming plants, and North Carolina and New York, with three each, consumed 62 percent of the domestically fabricated block and film mica. The consumption of phlogopite block increased 10 percent, to 67,149 pounds.

Total consumption of mica splittings decreased almost 20 percent from that of 1970. India and the Malagasy Republic supplied the bulk of the splittings consumed. Splittings were fabricated into various built-up mica products by 11 companies with 12 plants in nine States. Five companies with six plants, two in New York, two in Pennsylvania, and one each in Massachusetts and New Hampshire, consumed 3.5 million pounds of splittings, or almost 85 percent of the total consumption.

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 1971

(Pounds)

Variety, form, and quality	Electronic uses				Nonelectronic uses			Grand total
	Capacitors	Tubes	Other	Total	Gage glass and diaphragms	Other	Total	
Muscovite:								
Block:								
Good Stained or better	858	8,843	2,175	11,876	3,940	20	3,960	15,836
Stained	2,582	447,993	39,502	490,077	2,632	90	2,722	492,799
Lower than Stained [1]	6,793	435,730	128,062	570,585	17,328	122,658	139,986	710,571
Total	10,233	892,566	169,739	1,072,538	23,900	122,768	146,668	1,219,206
Film:								
First quality	3,482	--	--	3,482	--	--	--	3,482
Second quality	7,603	--	375	7,978	--	--	--	7,978
Other quality	3,100	--	--	3,100	--	--	--	3,100
Total	14,185	--	375	14,560	--	--	--	14,560
Block and film:								
Good Stained or better [2]	11,943	8,843	2,550	23,336	3,940	20	3,960	27,296
Stained [3]	5,682	447,993	39,502	493,177	2,632	90	2,722	495,899
Lower than Stained	6,793	435,730	128,062	570,585	17,328	122,658	139,986	710,571
Total	24,418	892,566	170,114	1,087,098	23,900	122,768	146,668	1,233,766
Phlogopite: Block (all qualities)	--	--	3,564	3,564	--	63,585	63,585	67,149

[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 1971, 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	2,805	2,990	1,860	4,277	--	11,932
Stained	23,961	49,889	56,963	326,183	17,426	474,422
Lower than Stained	12,421	76,020	71,913	317,111	170,170	647,635
Total	39,187	128,899	130,736	647,571	187,596	1,133,989
Nonruby:						
Good Stained or better	1,881	325	1,448	250	--	3,904
Stained	4,752	6,641	2,114	4,870	--	18,377
Lower than Stained	17,500	12,536	800	2,100	30,000	62,936
Total	24,133	19,502	4,362	7,220	30,000	85,217
Film:						
Ruby:						
First quality	607	525	350	550	--	2,032
Second quality	1,150	3,288	1,890	550	--	6,878
Other quality	--	--	--	--	3,100	3,100
Total	1,757	3,813	2,240	1,100	3,100	12,010
Nonruby:						
First quality	--	--	800	650	--	1,450
Second quality	--	--	1,100	--	--	1,100
Other quality	--	--	--	--	--	--
Total	--	--	1,900	650	--	2,550

[1] Figures for block mica include all smaller than No. 6 grade mica and punch mica.

Table 6.—Consumption and stocks of mica splittings in the United States, by source

(Thousand pounds and thousand dollars)

	India		Malagasy		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1967	5,857	$2,566	331	$193	6,188	$2,759
1968	4,579	1,874	206	136	4,785	2,010
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
Stocks Dec. 31:						
1967	2,737	NA	159	NA	2,896	NA
1968	2,469	NA	149	NA	2,618	NA
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

NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

Built-Up Mica.—This category of mica-based alternate material was produced in various forms, primarily for use as an electrical insulating material. The production of built-up mica increased during 1969 and 1970. Production in 1971 decreased 15 percent in both quantity and value from the previous year. The form in greatest demand was tape (29 percent), segment plate (25 percent), and molding plate (18 percent).

Reconstituted Mica.—This form of mica-based alternate material was fabricated from good quality, delaminated scrap mica by 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. Mica paper was fabricated from the delaminated mica using papermaking techniques. According to the National Electrical Manufacturers Association, net domestic sales of mica-paper products declined from $4.7 million in 1970 to $3.7 million in 1971.

Table 7.—Built-up mica [1] sold or used in the United States, by product

(Thousand pounds and thousand dollars)

Product	1970		1971	
	Quantity	Value	Quantity	Value
Molding plate	1,005	$3,024	698	$2,102
Segment plate	1,389	2,863	993	2,072
Heater plate	43	94	W	W
Flexible (cold)	605	1,187	520	1,031
Tape	1,051	3,796	1,165	4,253
Other	589	1,898	596	1,499
Total	4,682	12,862	[2] 3,971	10,957

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 total shown because of independent rounding.

Table 8.—Ground mica sold by producers in the United States, by use

Use	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	28,409	$947	17,835	$669
Wallpaper	506	84	W	W
Rubber	6,673	793	5,284	876
Paint	25,382	2,458	26,807	2,710
Plastics	570	109	479	93
Welding rods	W	W	W	W
Joint cement	34,834	2,183	45,230	2,977
Other [1]	18,719	775	23,969	956
Total	115,093	[2] 7,350	119,604	[2] 8,280

W Withheld to avoid disclosing individual company confidential data, included with "Other."
[1] Includes mica used for molded electric insulation, house insulation, Christmas tree snow, annealing, well drilling, textile coating, texture paint, and uses indicated by symbol W.
[2] Data may not add to total shown because of independent rounding.

STOCKS

At yearend there was about 2.1 million pounds of sheet mica in fabricators' stocks. Of this quantity, 67 percent was splittings and the remainder was almost entirely block. Only a minor quantity was film. This information was obtained by direct canvass of fabricators of sheet mica. Similar information is not available for scrap and flake mica, but it is thought that producers maintain stock inventories equal to 5 to 10 percent of domestic production.

PRICES

With the decline of the domestic sheet mica industry, any published prices have very little meaning. The average value of uncut punch and circle mica produced in 1971 was $0.39 per pound. The average value of muscovite sheet mica in 1971, based on consumption data, was as follows: block, $1.68 per pound; film, $5.94 per pound; and splittings, $0.43 per pound. The average value of phlogopite sheet mica, also based on consumption data, was as follows: phlogopite block, $1.88 per pound; phlogopite splittings, $0.73 per pound.

The average value of scrap and flake mica produced during the year was $22.95 per ton. Prices for ground mica, prepared from scrap and flake quoted in the Oil, Paint and Drug Reporter were unchanged for all mesh sizes of dry-ground mica from those of the previous year. However, the prices for all mesh sizes of wet-ground mica increased one-half cent per pound during February and March 1971. Yearend prices are shown in table 9.

Table 9.—Price of dry- or wet-ground mica in the United States in 1971 [1]

	Cents per pound
Dry-ground:	
Joint cement	3¾
Plastic, 100 mesh	3¾
Roofing, 20 to 80 mesh	2–3
Wet-ground: [2]	
Biotite	8
Biotite, less than carlots [3]	9
Paint or lacquer, 325 mesh	9
Paint or lacquer, 325 mesh, less than carlots [3]	10
Rubber	9
Rubber, less than carlots [3]	10
Wall paper	10

[1] In bags at works, carlots, unless otherwise noted.
[2] Freight allowed east of the Mississippi River, ½ cent higher west of the Mississippi River, 1 cent higher west of the Rockies.
[3] Ex-warehouse or freight allowed east of the Mississippi River.
Source: Oil, Paint and Drug Reporter. V. 200, No. 26, Dec. 27, 1971.

FOREIGN TRADE

All classes of mica exports decreased 19 percent in quantity and 20 percent in value from that of the previous year. Almost half of the material exported was shipped to Canada, Venezuela, and Singapore. Reported export data do not provide information on the grade or type of mica exported, but it is assumed that more than half of the material exported is ground mica.

Imports of scrap and waste mica increased 20 percent in quantity and 26 percent in value. Total imports of all forms of processed mica showed only a minor decline in both quantity and value.

Table 10.—U.S. exports of mica and manufactures of mica, by country

Destination	Mica, including block, film and splittings, waste and scrap and ground mica		Manufactured	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Arab, Republic of Egypt, n.e.c.	77,196	$9	--	--
Algeria	132,000	4	--	--
Argentina	89,620	12	9,855	$25
Australia	574,450	16	3,598	17
Belgium-Luxembourg	60,000	4	4,690	36
Brazil	4,457	22	13,288	56
Canada	4,728,136	327	284,654	895
Chile	13,000	2	2,499	9
Colombia	45,913	13	689	5
Dominican Republic	156,000	16	56	(1)
France	919,510	85	9,417	60
Germany, West	518,715	139	10,945	14
Guyana	525,294	5	226	1
Indonesia	446,605	28	--	--
Italy	314,826	47	21,395	73
Jamaica	263,392	19	80,619	594
Japan	616,250	63	6,088	18
Mexico	58,852	11	142,236	368
Netherlands	916,956	52	1,681	14
Peru	83,150	7	158	1
Philippines	91,050	11	248	1
Singapore	945,000	87	--	--
South Africa, Republic of	40,000	1	9,551	10
Spain	10,000	1	4,858	27
Sweden	880	2	88,550	88
Switzerland	30,851	16	--	--
Taiwan	--	--	12,887	74
Trinidad and Tobago	43,500	5	1,132	3
United Kingdom	836,975	129	70,788	121
Venezuela	1,579,578	51	2,087	6
Other	261,232	25	16,761	43
Total	14,383,388	1,209	798,956	2,559

[1] Less than ½ unit.

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
1969	12,449	$3,108	1,601	$1,695	3,078	$74	5,520	$3,060
1970	18,721	4,732	875	966	6,048	r 136	4,530	2,549
1971	15,182	3,768	1,355	1,171	7,284	171	4,464	2,476

r Revised.

Table 12.—U.S. imports for consumption of mica, by kind and country

Year and country	Unmanufactured[1]									
	Waste and scrap				Block mica		Other			
	Phlogopite		Other				Muscovite		Other, n.e.c.	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1969	135,207	$10	2,942,643	$64	1,253,092	$1,204	133,274	$285	215,141	$206
1970	380,619	13	5,667,328	123	681,134	690	48,981	105	144,550	171
1971:										
Brazil	188,107	4	1,332,197	31	523,160	542	126,168	36	98,881	64
Canada	--	--	--	--	--	--	--	--	220	(2)
Ceylon	--	--	31,080	(2)	--	--	--	--	--	--
France	--	--	--	--	--	--	--	--	7,640	8
Hong Kong	--	--	--	--	--	--	--	--	44	4
India	--	--	5,425,976	128	449,303	329	5,332	11	3,563	62
Malagasy Republic	--	--	--	--	14,455	22	--	--	33,621	45
Mexico	--	--	11,828	(2)	--	--	--	--	--	--
Mozambique	--	--	126,708	4	--	--	--	--	--	--
Nepal	--	--	--	--	--	--	--	--	20	2
South Africa, Republic of	--	--	168,662	4	1,323	1	76,364	5	13,305	12
Tanzania	--	--	--	--	1,042	6	--	--	675	7
United Kingdom	--	--	--	--	110	2	81	2	468	11
Total	188,107	4	7,096,451	167	989,393	902	207,945	54	158,437	215

Year and country	Manufactured							
	Splittings		Not cut or stamped not over 0.006 inch in thickness		Cut or stamped			
					Not over 0.006 inch in thickness		Over 0.006 inch in thickness	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1969	5,093,992	$1,139	84,939	$136	90,984	$1,372	109,743	$165
1970	4,244,832	1,310	31,938	63	72,067	888	85,657	143
1971:								
Austria	--	--	--	--	122	1	--	--
Belgium-Luxembourg	--	--	--	--	--	--	10,553	28
Brazil	--	--	45,808	24	925	16	2,618	7
Czechoslovakia	672	1	--	--	--	--	--	--
Haiti	--	--	489	1	302	3	--	--
India	4,009,415	1,096	5,503	17	71,430	888	71,146	108
Italy	--	--	--	--	220	1	--	--
Korea, Republic of (South)	--	--	--	--	5	(2)	--	--
Malagasy Republic	50,078	35	--	--	3,546	18	--	--
Mexico	--	--	--	--	2,204	63	359	(2)
South Africa, Republic of	4,960	2	--	--	--	--	21,513	25
Taiwan	--	--	--	--	55	2	--	--
Tanzania	--	--	471	(2)	--	--	--	--
United Kingdom	--	--	--	--	902	21	6,916	12
Total	4,065,125	1,134	52,271	42	79,711	1,013	113,105	180

See footnotes at end of table.

Table 12.—U.S. imports for consumption of mica, by kind and country—Continued

Year and Country	Manufactured					
	Mica plates and built-up mica		Ground or pulverized		Articles not especially provided for of mica	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1969	71,457	$97	55,115	$5	13,898	$146
1970	79,258	90	4,480	1	12,464	54
1971:						
Belgium-Luxembourg	19,911	14	--	--	702	1
Canada	2,698	7	--	--	227	1
Germany, West	5,389	8	--	--	30	(2)
India	--	--	105,820	2	6,685	36
Netherlands	--	--	--	--	713	3
Switzerland	--	--	--	--	50	(2)
United Kingdom	1,200	3	--	--	10,976	32
Total	29,198	32	105,820	2	19,383	73

[1] In addition to classes shown for 1970, of untrimmed phlogopite from which no piece over 2 by 1 inch may be cut was 33,069 pounds ($705) from Brazil; none in 1971.
[2] Less than ½ unit.

WORLD REVIEW

World mica production varied only slightly from that of the previous year. India and the Malagasy Republic were the major producers of muscovite and phlogopite mica, respectively.

Canada.—Effort was made during the year to develop a large phlogopite mica deposit located at Parent, Quebec Province. The deposit was discovered in 1964 and has indicated reserves greater than 11 million tons with a minimum mica content of 70 to 85 percent. It is thought that the area can be mined by open pit or underground methods. The deposit is currently owned by Provinces X Explorations Ltd. of Quebec, which intends to develop the deposit initially for the use of the construction and agricultural industries and later for other end uses of mica.[3]

India.—Crude mica production (based on exports plus consumption) declined slightly from 36,299 short tons in 1970 to 35,119 tons in 1971. Exports also declined from 29,699 tons valued at US$22.1 million in 1970, to 26,319 tons valued at US$21.7 million in 1971. Thirty-two percent of exports consisted of sheet mica in 1971, compared with 31 percent in 1970. The remainder consisted of other forms of processed mica. Production in 1970 came from 504 privately operated mica mines.

[3] Industrial Minerals (London). Qui vent du mica de Quebec? No. 51, December 1971, p. 31.

Table 13.—Mica: World production by country

(Thousand pounds)

Country [1]	1969	1970	1971 p
Argentina:			
Sheet	262	170	e 170
Waste, scrap, etc	1,263	1,464	e 1,500
Bolivia	--	13	--
Brazil [2]	r 3,920	4,451	e 4,400
Colombia	37	57	71
France e	r 4,560	4,600	4,600
India:			
Exports:			
Block	r 3,990	3,616	2,915
Splittings [3]	r 15,285	14,756	13,832
Scrap	r 27,145	41,026	35,891
Domestic consumption, all classes e	13,200	13,200	17,600
Total e	59,620	72,598	70,238
Malagasy Republic (phlogopite):			
Block	137	86	74
Splittings	2,218	1,935	978
Scrap	251	42	244
Mexico	1,310	1,235	1,561
Mozambique (including scrap)	772	557	e 550
Norway (including scrap) [2]	r 8,512	9,586	7,668
Portugal	r 3,675	4,266	e 4,400
South Africa, Republic of:			
Sheet	220	24	7
Scrap	13,997	16,647	15,785
Tanzania:			
Sheet	r 214	99	81
Scrap	253	28	e 29
United States:			
Sheet	W	--	17
Scrap and flake	266,115	237,686	254,168
Yugoslavia	299	501	e 500
Grand total	r 367,635	356,045	367,041

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] In addition to the countries listed, People's Republic of China, Romania, Southern Rhodesia, South-West Africa, Sweden, and the U.S.S.R. are known to produce mica, but available information is inadequate to make reliable estimates of output levels.
[2] Exports.
[3] Includes condenser film, washer, and discs.

TECHNOLOGY

Laboratory batch and continuous tests were run on the micacious sediments of the Nolichucky Reservoir near Greenville, Tenn., to develop a process for the recovery of commercial-grade muscovite mica concentrates. The tests showed that a simple two-stage concentration method recovered salable-quality flake mica. Preconcentration by use of a Humphreys spiral eliminated the heavy mineral fraction and substantially increased flotation feed grade. Sampling of the sediments of the Nolichucky Reservoir indicated that a minimum of 250,000 tons of flake mica are recoverable using this method.[4]

A method has been developed to break apart natural or synthetic mica into very fine particles that are suitable for use in the manufacture of reconstituted mica. Mica crystals are slurried in a fluid medium and passed at high velocity in oriented streams through openings to cause turbulence which disintegrates the crystals in planes corresponding to the principal axes of the solid crystal lattice. The resulting small particle size mica has a large specific surface area and high ratio of length to thickness.[5]

The composition, properties, and uses of wet ground mica were discussed, and it was concluded that the addition of small particle size mica to some paints improved the corrosion resistance of the paint.[6]

[4] Adair, Ralph B., and Jerome O. Crabtree. Recovery of Mica From Silt Deposits in the Nolichucky Reservoir, Tennessee. BuMines Rept. of Inv. 7488, March 1971, 9 pp.
[5] Ruzika, J. Ultradisintegration and Agglomeration of Minerals Such as Mica, Products Therefrom and Apparatus Therefore. U.S. Pat. 3,608,835, Sept. 28, 1971.
[6] American Paint Journal. Use and Performance of Wet Ground Mica Explained at Buffalo. V. 55, No. 45, Apr. 26, 1971, p. 24.

Molybdenum

By Andrew Kuklis [1]

Free world molybdenum output dropped 5.6 million pounds compared with that of 1970 because of a worldwide industrial recession. In response to a weak demand, some mining facilities curtailed operations and several high-cost mines ceased production during the year to reduce output. At yearend, United States industrial and Government stocks of molybdenum material exceeded the 100 million pounds mark, one of the highest on record. Also, the industrial stocks in Canada, Japan, and other industrialized countries reportedly were at record levels.

Despite the oversupply, large expenditures were obligated for new mines; however, completion dates for some of these facilities were rescheduled. The short-range outlook is for a significant increase in new molybdenum production capacity from both primary and coproduct sources.

Legislation and Government Programs.—The Office of Emergency Preparedness (OEP) revised conventional war stockpile objectives for molybdenum from 36.5 million pounds to zero. In declaring molybdenum surplus, OEP's action made it available for disposal through the General Services Administration (GSA). However, Congress must approve legislation for its sale.

At yearend, molybdenum material in the national stockpile totaled 46.8 million pounds, about 318,000 pounds lower than yearend 1970. Approximately 5.5 million pounds of stored molybdenum in concentrate and in oxide was classed as sold but unshipped. At current price quotations, the value of material in the stockpile exceeds $77 million.

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Table 1.—Salient molybdenum statistics

(Thosuand pounds of contained molybdenum and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Concentrate:					
Production	90,097	93,447	99,807	111,352	109,592
Shipments	81,596	93,245	103,009	110,381	97,882
Value	$133,604	$151,000	$173,819	$190,077	$164,917
Consumption	58,967	75,647	73,275	76,101	66,399
Imports for consumption	1,179	1	(1)	25	854
Stocks, Dec. 31: Mine and plant	9,919	12,208	8,398	9,715	29,077
Primary products:					
Production	54,922	69,675	68,526	r75,383	67,016
Shipments	57,231	63,761	77,726	76,095	66,654
Consumption	49,506	49,271	51,622	45,337	40,950
Stocks, Dec. 31: Producers	7,156	18,170	17,844	25,904	31,048
World: Production	141,673	144,771	159,470	177,982	173,024

r Revised.
[1] Less than ½ unit.

Table 2.—U.S. Government molybdenum stockpile material inventories and objectives on Dec. 31, 1971

(Thousand pounds molybdenum)

Type material	Stockpile objective	National (strategic) stockpile
Molybdenum, disulfide	0	22,756
Molybdenum, ferro	0	7,501
Molybdenum oxide	0	11,050
Total	0	41,307

Table 3.—U.S. Government molybdenum stockpile material, sold but unshipped on Dec. 31, 1971 [1]

(Thousand pounds molybdenum)

Type material	National (strategic) stockpile
Molybdenum, disulfide	5,467
Molybdic oxide	31

[1] Not included in table 2.

DOMESTIC PRODUCTION

Domestic molybdenum production in concentrate for 1971 declined 1.8 million pounds and was nearly 2 percent below that of 1970. Of the total output, 65 percent was produced from primary molybdenum sources and the balance was recovered as coproduct of copper, tungsten, and uranium ores.

Output of molybdenum from primary ores in 1971 dropped to 71.3 million pounds from 76.5 million pounds produced in 1970. Molybdenum production from primary sources declined from 68 to 65 percent of the total domestic output in 1971. Nearly 23 million tons of primary ores were mined in 1971 for the their molybdenum content. As in past years, the Climax mine in Colorado of American Metal Climax, Inc. (AMAX), was the world's largest producer.

Output of molybdenum from coproduct sources rose over 10 percent compared with 1970 figures. The increase in output was due to a strong demand for copper and full-year operations of new mines. Of the 15 copper-porphyry plants reporting production of molybdenum, nine increased in output and the remainder had lower production. Molybdenum recovered from uranium ores approximated that produced in 1970; that from tungsten ores dropped significantly in 1971 compared with 1970. Over 38.2 million pounds of molybdenum was recovered from processing 153 million tons of molybdenum-bearing copper, tungsten, and uranium ores containing from 3 to 8 pounds of molybdenum per ton.

Pennzoil United, Inc., the parent company of Duval Corp. and Duval Sierrita Corp., was the leading domestic producer of molybdenum from coproduct sources, a position held by Kennecott Copper Corp. for many years. Other large producers of coproduct molybdenum were, in order of output, Kennecott Copper Corp., Magma Copper Co., and American Smelting and Refining Co. (Asarco).

A copper industry-wide labor dispute closed some coproduct molybdenum producers at midyear. The strike was of short duration and did not effect the supply of molybdenum. Also at midyear, the Oil, Chemical and Atomic Worker's Union signed a 3-year contract with AMAX, operator of the Climax and Urad molybdenum mines and the Henderson project. The contract provides for annual wage increases of 8.5, 7.5, and 7 percent respectively, for each of the next 3 years. Improved insurance coverage and retirement benefits also were included in the labor agreement. Approximately 1,651 workers were covered by the contract.

Molybdenum remained in oversupply because of lower than anticipated consumption, principally by the steel industry. In response to lower requirements, several mines curtailed production during the year and operations at one coproduct facility were shutdown at yearend. However, many coproduct facilities, including those starting production in the last half of 1970, operated at near designed capacity and contributed to the surplus.

Duval Corp. suspended mining and milling operations at the Esperanza copper-molybdenum property near Tucson, Ariz. The closing became necessary because of a cutback in smelter throughput by Asarco, the processor of their copper concentrate. Asarco advised Duval Corp. that the production level at its Hayden, Ariz., smelter was reduced to meet air-quality standards imposed by the Arizona State Board of Health.

Duval Sierrita Corp.'s open-pit copper-molybdenum mine completed its first full year of operation, the facility started production in mid-1970. At yearend, an expansion of the mine and mill was completed. The copper-molybdenum ore throughput was increased to 82,000 tons per day. To control air pollutants, the company installed additional dust-collecting and gas-scrubbing equipment at the roasting plant at a cost of $1.3 million.

Molybdenum Corporation of America (Molycorp) curtailed molybdenum production at the Questa mine in New Mexico. The company, second largest domestic producer of primary molybdenum, vacationed nearly one-third of its employees at midyear, mostly mine production workers.

Mine development continued at the AMAX Henderson molybdenum deposit near Empire, Colo. Major work projects underway in 1971 were preparation and construction of a mill site, tailings disposal area, and pond. The western section of a 9.3-mile ore tunnel was under construction; Dravo Corp. was the contractor. The No. 2 shaft was sunk through very difficult ground in the Vasquez Fault and should bottom out in mid-1972. About 12,000 feet of development drift were advanced in the mine. The $250 million project, scheduled for completion in the mid-1970's, will have an ultimate capacity of 50 million pounds of molybdenum annually.

A labor dispute, which closed many copper-molybdenum mines, interrupted the first full year production of molybdenum at the Twin Buttes facility of the Anaconda Co. The molybdenum recovery plant, designed to produce 1.5 million pounds annually, commenced operation late in 1970. According to the company's annual report, 1.2 million pounds of molybdenum was recovered in 1971.

At yearend, Pima Mining Co. nearly completed a $17 million expansion of its copper-molybdenum mine south of Tucson. The additional crushing, grinding, and concentrating equipment will increase the facility's capacity from 40,000 tons to about 54,000 tons of ore daily. The expansion will result in a 35-percent increase in molybdenum production, currently at about 1.5 million pounds annually. The parent company (Cypress Mines Corp.) continued exploratory drilling of the Thompson Creek molybdenum prospect in central Idaho. Four underground diamond drill holes totaling about 3,500 feet were reportedly drilled, three of which indicated encouraging molybdenum mineralization. Underground tunneling and diamond drilling was scheduled to continue through 1972.

Table 4.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds molybdenum)

	1970	1971	1970	1971	1970	1971
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
Received from other producers	7,148	3,823	612	12	496	11
Gross production during year	84,099	74,043	3,042	2,619	3,329	2,961
Used to make other products listed here	26,430	24,124	1,301	201	1,584	1,261
Net production	r 57,669	49,918	1,741	2,418	1,745	1,700
Shipments	57,158	48,383	2,244	2,481	1,865	1,498
Producer stocks, Dec. 31	20,217	24,279	545	491	610	760
	Sodium molybdate		Other [2]		Total [3]	
Received from other producers	114	43	356	2,426	8,726	6,315
Gross production during year	777	879	13,516	14,301	104,763	94,803
Used to make other products listed here	34	14	31	2,187	29,380	27,787
Net production	743	865	r 13,485	12,115	r 75,383	67,016
Shipments	886	896	13,942	13,396	76,095	66,654
Producer stocks, Dec. 31	132	143	4,400	5,375	25,904	31,048

r Revised.
1 Includes molybdic oxide, briquets, molybdic acid, and molybdenum trioxide.
2 Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.
3 Data may not add to total shown because of independent rounding.

CONSUMPTION AND USES

Consumption of molybdenum in concentrate dropped significantly (13 percent) compared with that of 1970 and was the lowest since 1967. The decline in demand for molybdenum was due to lower domestic requirements and to a drop in exports. 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 concentrate was used in producing purified molybdenum disulfide for lubricants.

Domestic end use consumption of molybdenum totaled 41.0 million pounds, a decrease of over 10 percent compared with that of 1970 (table 5). Molybdenum consumption was closely associated with the level of activity in the iron and steel industry, particularly in the production of alloys and stainless steel. A decline in production of these steel products in 1971 was reflected in lower requirements for molybdenum material. Steel manufacturers take advantage of the unique properties that molybdenum conveys to various types of steel, such as hardenability, corrosion resistance, strengthening, and toughness. Molybdenum was used either as the alloy material or in combination with other alloy materials, such as chromium, manganese, nickel, and tungsten. Molybdenum consumed in its various end uses was in the form of molybdic oxide (64 percent), ferromolybdenum (22 percent), ammonium and sodium molybdate (3 percent), and other (11 percent).

Steel production accounted for 65 percent of the reported consumption while 9 percent was used in cast iron, 7 percent in superalloys and other alloys, and 5 percent in mill products such as sheet, rod, and wire. The chemical industry consumed 8 percent for use in making pigments, catalysts, and other uses. The remaining 6 percent was used in miscellaneous and unspecified applications.

AMAX and Interprovincial Steel & Pipe Co. developed an arctic grade steel for use in manufacturing pipeline steel for service in geographical areas of subzero temperature. The steel has an acicular ferrite structure and contains 0.05 percent carbon, 0.06 percent columbium, 1.6 percent manganese, 0.25 percent molybdenum, and 0.05 percent silicon. Two Canadian pipeline companies utilized 80 miles of linepipe produced from arctic grade steel for transportation of hydrocarbons, the first use of such steel in pipeline service.

Table 5.—Consumption of molybdenum materials by end uses in 1971

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides	Ferromolybdenum [1]	Ammonium and sodium molybdate	Other molybdenum materials [2]	Total [3]
Steel:					
Carbon	1,736	454	--	--	2,190
Stainless and heat resisting	3,266	1,584	--	94	4,944
Alloy (excludes stainless and heat resisting)	15,256	1,935	--	27	17,218
Tool	1,349	748	--	144	2,241
Cast irons	755	2,633	--	95	3,483
Superalloys	314	310	--	1,104	1,728
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	360	--	16	376
Other alloys [4]	71	495	--	67	633
Mill products made from metal powder	--	--	--	2,122	2,122
Chemical and ceramic uses:					
Pigments	681	--	391	7	1,079
Catalysts	1,407	--	W	--	1,407
Other	65	5	25	702	797
Miscellaneous and unspecified	1,318	416	710	285	2,729
Total [3]	26,220	8,940	1,127	4,663	40,950
Consumer stocks December 31, 1971	2,058	1,175	86	691	4,010

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] Data may not add to totals shown because of independent rounding.
[4] Includes magnetic and nonferrous alloys.

STOCKS

The industrial inventory of molybdenum in concentrate and compounds rose to 64.1 million pounds, the highest on record. Mine and plant stocks accounted for most of the increase, 199 percent higher than in 1970. Stocks at producers plant increased 20 percent, but those at consumer plants declined 30 percent compared with 1970 levels.

PRICES

Molybdenum prices during 1971 reflected excess supply and a general weakness in the free world's economy. While prices for high-quality molybdenum concentrate remained unchanged, byproduct producers were selling concentrate in the $1.52 to $1.71 per pound of molybdenum range, depending on the grade of the material and its copper, lead, and other impurity content. Molybdenum concentrate was virtually a nominal market for dealers.

At midyear, two grades of molybdic oxides were introduced by Kennecott Copper Corp. for use in manufacturing speciality steel products. The molybdenum was marketed at prices below those published for technical grade molybdic oxide. Dealer oxide prices were reported ranging from $1.82 to $1.90 per pound of molybdenum; however, some sales were negotiated below this price range.

The market for ferromolybdenum was the weakest; at yearend, a trade magazine lowered its published price on dealers ferromolybdenum about 10 cents per pound of molybdenum.

The price softness was expected to extend into 1972 and until such time as the economic expansion generates an equitable balance between supply and demand of molybdenum.

FOREIGN TRADE

Exports.—Despite a decline in exports for the past 3 years, the United States continued to be a major supplier of molybdenum for the free world. Foreign markets received about 42 percent of the Nation's production compared with 50 and 57 percent in 1970 and 1969, respectively. U.S. share of the foreign market may continue to decline because of competition from excess production capacity in Canada and Chile.

Exports of molybdenum concentrate including roasted concentrate in 1971 declined by 9.5 million pounds and was 17 percent below that of 1970 (table 7). The drop in exports was due to lower shipments to countries with large steel production capability. The Netherlands, West Germany, United Kingdom, and Japan received 83 percent of the molybdenum exported from the United States. Most of the concentrate exported to the Netherlands was converted to technical grade molybdic oxide for reshipment to other European countries.

Table 6.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds molybdenum)

Product	1970	1971
Molybdenite concentrate	32,998	31,513
Molybdic oxide	15,801	12,292
All other primary products	1,929	1,718

Table 7.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds and thousand dollars)

Destination	1970		1971	
	Molybdenum (content)	Value	Molybdenum (content)	Value
Australia	890	$1,408	252	$412
Austria	203	386	160	300
Belgium-Luxembourg	786	1,465	1,936	3,473
Brazil	199	260	147	263
Canada	517	846	1,353	2,372
Czechoslovakia	642	915	--	--
France	3,022	5,155	855	1,321
Germany:				
East	368	638	105	191
West	5,569	8,810	4,521	6,832
India	326	477	461	765
Italy	805	1,457	504	889
Japan	13,738	23,386	11,032	17,959
Mexico	335	473	531	596
Netherlands	24,411	42,861	20,777	37,750
New Zealand	14	24	3	6
Philippines	58	114	63	122
South Africa, Republic of	105	168	31	51
Spain	11	19	14	25
Sweden	1,980	3,322	1,649	2,515
United Kingdom	1,533	2,728	1,856	3,216
Venezuela	186	259	--	--
Other	39	75	34	53
Total	55,737	95,246	46,284	79,111

Ferromolybdenum totaling about 1.4 million pounds was shipped to 15 countries; Japan and Australia received 56 percent of the total exported. Molybdenum metal and alloy in crude form and scrap shipped to the Netherlands and the United Kingdom totaled 174,000 pounds, or 78 percent of exports. Molybdenum wire totaling 140,000 pounds, valued over $1.2 million was exported; of this total, West Germany and Canada received 29 percent of the value shipped. Molybdenum powder exports of 41,000 pounds valued at $170,000 was shipped to 16 countries; Japan and Sweden received 56 percent of the total. Exports of semifabricated forms, not elsewhere classified, totaled 623,000 pounds valued at $1.2 million (table 8).

Imports.—Although the Nation is self-sufficient in molybdenum material, some concentrate, manufactured molybdenum products, and scrap enters the United States from numerous countries throughout the free world. High tariff rates preclude the importation of such material in large quantities. Import duties negotiated under the 1967 "Kennedy Round" of Tariff Negotiations effective January 1, 1972, are shown in table 9.

Table 8.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1970		1971	
	Quantity	Value	Quantity	Value
Ferromolybdenum: [1]				
Argentina	52	$71	51	$69
Australia	167	228	307	413
Bolivia	33	20	--	--
Brazil	18	24	16	24
Canada	65	144	183	253
Finland	112	172	--	--
Germany, West	33	51	--	--
Hungary	99	154	--	--
India	504	902	201	370
Japan	336	426	452	651
Mexico	119	176	--	--
Mozambique	12	16	--	--
Netherlands	--	--	18	23
Philippines	5	10	14	19
South Africa, Republic of	63	87	53	72
Spain	22	33	--	--
Sweden	364	561	44	61
Taiwan	4	7	6	8
Other	6	6	10	15
Total	2,014	3,088	1,355	1,978
Metal and alloys in crude form and scrap:				
Belgium-Luxembourg	--	--	2	13
Canada	9	12	--	--
France	3	11	1	7
Germany, West	25	96	15	36
India	68	84	(2)	1
Italy	11	17	(2)	2
Japan	50	80	23	37
Netherlands	318	374	81	27
Turkey	--	--	7	10
United Kingdom	186	119	93	93
Other	1	9	(2)	1
Total	671	802	222	227
Wire:				
Argentina	1	15	1	20
Australia	5	38	11	68
Brazil	8	116	11	119
Canada	20	194	27	205
France	14	91	20	127
Germany, West	r 7	56	21	148
India	4	44	6	54
Japan	32	244	22	124
Mexico	4	115	4	77
Netherlands	5	120	1	16
Philippines	1	14	1	18
Singapore	1	31	8	70
United Kingdom	1	111	4	132
Other	4	63	3	34
Total	107	1,252	140	1,212

See footnotes at end of table.

Table 8.—U.S. exports of molybdenum products—Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1970		1971	
	Quantity	Value	Quantity	Value
Powder:				
Canada	41	36	2	8
France	(2)	1	3	13
Germany, West	6	20	1	6
Japan	83	128	4	23
Mexico	7	11	1	4
South Africa, Republic of	10	14	6	8
Sweden	18	71	19	74
Switzerland	4	22	3	10
United Kingdom	11	43	2	10
Venezuela	146	173	--	--
Other	3	9	(2)	14
Total	329	528	41	170
Semifabricated forms, n.e.c.:				
Australia	(2)	(2)	(2)	4
Belgium-Luxembourg	--	--	303	242
Canada	3	27	8	47
France	18	138	4	98
Germany, West	1	19	3	53
India	4	24	(2)	1
Ireland	--	--	1	5
Italy	7	16	1	20
Japan	74	215	1	17
Mexico	1	8	2	11
Netherlands	16	99	39	206
Philippines	(2)	(2)	2	4
South Africa, Republic of	(2)	2	(2)	4
Switzerland	(2)	3	(2)	6
Taiwan	1	13	1	14
United Kingdom	5	56	35	76
Venezuela	1	6	223	380
Other	2	17	(2)	7
Total	133	643	623	1,195

r Revised.
1 Ferromolybdenum contains about 60 to 65 percent molybdenum.
2 Less than ½ unit.

Table 9.—U.S. import duties

Item	Articles	Rate of duty, Jan. 1, 1972 [1]
601.33	Molybdenum ore	12 cents per pound on molybdenum content.
603.40	Material in chief value molybdenum	10 cents per pound on molybdenum content plus 3 percent ad valorem.
607.40	Ferromolybdenum	Do.
	Molybdenum:	
628.70	Waste and scrap	10.5 percent ad valorem.[2]
628.72	Unwrought	10 cents per pound on molybdenum content plus 3 percent ad valorem.
628.74	Wrought	12.5 percent ad valorem.
	Molybdenum chemicals:	
417.28	Ammonium molybdate	10 cents per pound on molybdenum content plus 3 percent ad valorem.
418.26	Calcium molybdate	Do.
419.60	Molybdenum compounds	Do.
420.22	Potassium molybdate	Do.
421.10	Sodium molybdate	Do.
423.88	Mixtures of inorganic compounds, chief value molybdenum.	Do.
473.18	Molybdenum orange	5 percent ad valorem.

1 Not applicable to Communist countries.
2 Duty on waste and scrap temporarily suspended.

According to the U.S. Department of Commerce, imports for consumption of molybdenum material consisted of the following: molybdenum concentrate totalling 3.4 million pounds containing 853,514 pounds of molybdenum, valued at about $1.5 million; metal-bearing materials totaling 372,584 pounds containing 101,886 pounds of molybdenum, valued at $102,254; molybdenum waste and scrap totaling 98,804 pounds of molybdenum, valued at $192,606; wrought molybdenum products containing 27,593 pounds of molybdenum, valued at $270,298; and unwrought molybdenum products containing 7,420 pounds of molybdenum, valued at $36,927. Molybdenum chemicals and related products entering the United States include molybdenum compounds, inorganic compounds, molybdenum orange, and ammonium molybdate.

Chile supplied nearly all U.S. imports of molybdenum concentrate, and a small quantity came from Canada and the Philippines. Molybdenum compounds came from four countries compared with six countries in 1970. Japan supplied 80 percent of U.S. imports. The Netherlands and West Germany were the principal suppliers of U.S. imported molybdenum waste and scrap. The importation to the United States of wrought molybdenum products approximated that of 1970. Austria and Sweden supplied about 60 percent of the total, and the remainder came from four other countries. Unwrought molybdenum products were imported to the United States from three countries, and the United Kingdom supplied 50 percent of the total. Four countries shipped molybdenum orange to the United States, and Canada supplied 42 percent of the imports. United States imports of inorganic compounds and ammonium molybdate came from two countries—Italy and West Germany.

Table 10.—Molybdenum: World mine production by country

(Thousand pounds contained molybdenum)

Country [1]	1969	1970	1971 [p]
Canada (shipments)	[r] 29,651	33,772	28,324
Chile	10,675	12,566	13,889
Japan	[r] 591	584	586
Korea, Republic of (South)	287	254	234
Mexico	445	311	174
Norway	[r] 785	734	794
Peru	494	1,338	1,781
Philippines	[r] 35	71	[e] 50
U.S.S.R. [e]	16,700	17,000	17,600
United States	99,807	111,352	109,592
Total	[r] 159,470	177,982	173,024

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Argentina, Australia, China (People's Republic), North Korea, Nigeria, Romania, South-West Africa and Spain also may produce molybdenum, but available information is inadequate to make reliable estimates of output levels.

WORLD REVIEW

Australia.—Minefield Exploration N.L. discovered a complex mineral deposit on the Mt. Mulgine property in Western Australia containing 118 million tons of ore, having copper, gold, silver, bismuth, and molybdenum values. The company was reportedly seeking financial assistance to develop the deposit in return for equity in the venture.

Canada.—Output of molybdenum dropped more than 21 percent compared with that of 1970. Canadian molybdenum producers are dependent on large exports to foreign markets, mainly to Japan and to highly industrialized countries in Europe. Because of declining sales to these marketing areas, several mines were forced to curtail production and other high-cost operations were closed to reduce output and maintain molybdenum stocks at reasonable levels.

The Boss Mountain Division of Brynnor Mines Ltd. closed its Hendrix Lake molybdenum mine at yearend. Large molybdenum inventories at the mine and recent mine operating losses were the reason for suspending operations. The mine produced 534,500 tons of ore averaging 0.203 percent molybdenite, from which over 2 million pounds of molybdenum was recovered. Ore reserves were reported at 2.7 million tons averaging 0.25 percent molybdenite.

Molybdenite Corporation of Canada Ltd. ceased production at its northwest Quebec Province molybdenum facilities in April 1971. High milling costs, attributed to maintaining grade of concentrate as specified in a purchasing contract with Continental Ore Ltd., was the cause for its shutdown.

Placer Development Ltd. reduced molybdenum output at its Endako mine from 18.2 million pounds in 1970 to 14.4 million pounds in 1971. The curtailment of production was intended to reduce the large molybdenum inventory accumulated at the facility and to maximize the company's cash position. During 1971 over 9.0 million tons of ore was processed at the Endako facility at an average grade 0.162 percent molybdenite. Most of the ore came from a low-grade zone, which had an adverse effect on the mill recovery rate and unit cost per pound of molybdenum produced. For comparative purposes, grade was 0.02 percent lower than in 1970 and metallurgical recovery dropped from 82.39 to 81.60 percent. At yearend, minable ore reserves at the Endako pit totaled abut 195 million tons having a grade of 0.143 percent and at the Denak pit, 5.4 million tons having a grade of 0.232 percent molybdenite.

Despite the cutback and/or shutdown of mines, new molybdenum production capacity was in various stages of development.

At yearend Utah International, Inc., commenced production at a copper-molybdenum mine at Ruppert Inlet on Vancouver Island, British Columbia. The facility was designed to produce 230,000 tons of copper concentrate and 3.6 million pounds of molybdenum per year. Capital expenditures exceeded $70 million. Ore reserves were reported at 280 million tons averaging 0.52 percent copper and 0.029 percent molybdenite.

Placer Development Ltd. obligated $74 million for the development of a copper-molybdenum property (Gibraltar Mines Ltd.) located north of William Lake in British Columbia. Construction of plants and stripping of open-pit area were completed, and major utilities and mine and mill equipment were installed. At yearend, work on the project was 75 percent completed and startup scheduled for the second quarter 1972. The facility's designed capacity was rated at 30,000 tons of ore per day. Ore reserves were estimated at 358 million tons having an average grade of 0.373 percent copper and 0.016 percent molybdenite.

King Resources Co. reduced the operating schedule from a 7-day to a 5-day week at the Mount Copeland mine, northwest of Revelstoke, British Columbia. The 220-ton-per-day mill recovered 1.6 million pounds of molybdenum from ore having an average grade of 1.82 percent molybdenite.

Highmont Mining Corp. Ltd. was developing a copper-molybdenum deposit in the Highland Valley district of British Columbia. In a yearend progress report, company officials stated that an additional 21 mineral claims were purchased, a land reclamation permit was obtained, preparation of the plant and mine site was submitted for bid, and a purchase contract for mining and milling equipment negotiated. The open-pit mine will produce ore at a rate of 25,000 tons daily and generate metal sales estimated at $65 million annually. Tech Corporation Ltd. agreed to finance and manage the venture in return for a 45-percent interest in the company. Metallurgical recovery tests indicated a recovery of 92 percent for copper and 83 percent for molybdenum. The target date for start of production was late in 1973. Reserves were estimated at 145 million tons of ore containing an average of 0.27 percent copper and 0.045 percent molybdenite. Development of the ore deposit will cost $65 million.

Rio Algom Mines Ltd., manager of Lornex Mining Corp. Ltd., continued with development of a copper-molybdenum open-pit mine near Ashcroft, British Columbia. The throughput of the mine and mill facility was estimated at 1.4 million tons of ore annually from which 162,000 tons of copper and 2.5 million pounds of molybdenum will be recovered. The orebody was reported to contain 293 million tons averaging 0.427 copper and 0.014 percent molybdenite. A 5-year sales contract with Philipp Brothers Co. of New York was negotiated for its projected annual output of molybdenum. The copper concentrate was reportedly consigned to Japan for a 12-year period. Completion of the $138 million project was scheduled for the second quarter of 1972.

Hecla Mining Co. continued drilling on the Laird-Schaft Creek copper molybdenum deposit owned by Standard Mines Ltd. in northwest British Columbia. Reserves were reported to total 240 million tons of ore averaging 0.42 percent copper and 0.035 percent molybdenite. Small amounts of gold and silver values are present in the ore; to date, 66 core holes were drilled for a total of 72,000 feet. At yearend an extensive drilling program was reportedly approved for completion during 1972.

Among other copper-molybdenum and molybdenum deposits in various stages of development and exploration in Canada were: Bell Molybdenum Mines Ltd., near Alice Arm, British Columbia; Brameda Resources Ltd., 190 miles northwest of White Horse, Yukon; Bethlehem Copper Corp. Ltd., in the Cache Creek area; Cascade Molybdenum Mines Ltd., and Continental McKinney Mines Ltd., in the Rossland area; Della Mines Ltd., in the Cassiar district; Sileurian Chieftain Mining Company Ltd., in the Alice Arm area; Valley Copper Mines Ltd., in the Highland Valley area, all in British Columbia; and Radex Minerals Ltd., in the St. Lawrence area of Newfoundland.

Chile.—Chile ranks third among free world producers of molybdenum following Canada and United States with an annual production of approximately 13.9 million pounds. Almost all was exported in the form of molybdenite concentrate and molybdic oxide to the United States, Western Europe, and Japan. Output of molybdenum in 1971 came from three major copper porphyry mines: El Teniente, Chuquicamata, and El Salvador. Rio Blanco mine of Compañia Minera Andina, S.A. commenced copper production in 1970 but the molybdenum recovery circuit was not expected to be operational until mid-1972. Sociedad Minera El Teniente S.A., operator of the El Teniente mine, completed an expansion program that will increase molybdenum output from 4.5 to 5.0 million pounds annually. Milling capacity at the Chuquicamata facility was expanded to increase molybdenum output from 5.5 to 6.0 million pounds annually.

Japan.—At yearend, Japan Molybdenum Co. acquired title to land on which a molybdenite roasting plant will be constructed. AMAX will have a 34-percent interest in the venture, the remaining held by Japanese concerns. Completion date was rescheduled for 1973.

Mexico.—Development of the Hermo Sillo de Minera's S.A. molybdenum deposit in Sonora province by San Judas Molybdenum Corp. was delayed because of financing problems. Additional exploratory work had increased the ore reserves to 436,000 tons having an average molybdenite content of 0.93 percent.

The Netherlands.—AMAX was building an ammonium molybdate plant having a production capacity of 4.5 million pounds per year. The facility was scheduled for completion in mid-1972 and located adjacent to the company's roaster at Rozenburg near Rotterdam. Ammonium molybdate is a high-purity compound used in chemical and metallurgical applications.

Panama.—Canadian Javelin Ltd. discovered a large porphyry copper-molybdenum deposit in the Rio San Felix area, Chiriqui Province, western Panama. Seventy-five diamond core holes were drilled in an area of approximately 2,180 acres in the Cerro Colorado concession. Sixty-one holes encountered copper-molybdenum mineralization of significant thickness. The deposit reportedly was amenable to open-pit mining.

Peru.—Increased production of molybdenum was reported from the Toquepala mine of Southern Peru Copper Corp. (SPCC). The open-pit mine and concentrator was processing molybdenum-bearing copper porphyry ores at a rate of 30,000 tons per day. The short range outlook was for increased output from the Toquepala mine and the vast Cuajone deposit currently under investigation by the Government of Peru.

Yugoslavia.—The largest molybdenum deposit in Europe was described in a publication released by the University of Belgrade, Yugoslavia.[2] According to European terminology, the ore body was classified as subvolcanic hydrothermal and stock-work-impregnated type. The molybdenum deposit encompasses a 19-mile-long and 7-mile-wide area and was estimated to contain many billion tons of low-grade ore of about 0.1 percent molybdenite. Current exploration was limited to the Machkatica district; other areas of the huge mineral complex may contain higher grade ore.

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[2] Ilich, Dr. Miloje. Molybdenite Mineralization of the Surdulica Magmatic Complex. Univ. of Belgrade, Yugoslavia, 1971, 247 pp.

TECHNOLOGY

High-purity molybdenum metal was produced by a metallothermic reduction of molybdic oxide in a bomb-type chamber and the results were published.[3] Aluminum, silicon, and mixtures of aluminum and silicon were employed as reductants. Molybdenum metal yields of 85 to 93 percent were obtained during experimental runs. Subsequently, the metal was converted into sponge by induction heating or into ingots by direct electron-beam melting. The resulting molybdenum metal was of 99.98 percent purity.

A process was described to separate copper, lead, iron, phosphorus, bismuth, antimony, elemental sulfur, and insoluables from molybdenum concentrate without decomposing the contained molybdenite and rhenium.[4] Impure concentrate was heated with concentrated sulfuric acid to a temperature ranging from 260° to 290° C to oxidize the contaminant sulfides and activate the concentrate. Thence, two stages of leaching removes all impurities. Final upgrading was made by conventional froth flotation.

The preparation of molybdenum ingots by electroslag melting was compared with that of arc-cast materials and results were described.[5] Excellent surface conditions were obtained from electroslag ingots, hence, less waste resulted during a conditioning and fabrication process. Additional economies of production resulted from the ability to fabricate electroslag ingots at low temperatures. Sheet metal fabricated from electroslag ingots had superior mechanical properties to those prepared from similar arc-cast ingots.

Corrosion behavior of a thin molybdenum film was investigated in the environments of air, fluorochemical liquid coolant, and deionized water and results were described.[6] Molybdenum remains inert in a dry environment and corrodes in wet media. In addition, molybdenum forms a nonproctective, porous corrosion film and dissolves in deionized water at 85° C. The simultaneous presence of water and oxygen in these environments is the controlling factor on the corrosion of molybdenum films.

Studies of recrystallization characteristics of cold worked pure molybdenum metal were described.[7] On the basis of a constant amount of deformation strain, molybdenum metal exhibited slower rates of recrystallization, higher activation energies, and coarser grain sizes than in a simple tension. Deformation by rolling produced recrystallization effects resembling those of compression, while straining by drawing resulted in rates similar to those of tension.

A report on the practical effects of steaming techniques in copper-molybdenum separation was published.[8] Laboratory and plant tests were described and the study resulted in reduced consumption of sodium sulfide depressor and an improvement in molybdenum recovery at several Soviet and Bulgarian concentrators.

Patents were granted for a solvent extraction process to recover molybdenum values from a solution containing a mixture of ammonium molybdate and ammonium sulfate,[9] for the removal of impurities from molybdenite concentrate,[10] for producing lubricant-grade molybdenite from by-product concentrate,[11] for a solvent extraction process to recover molybdenum and other minerals from aqueous solutions containing such minerals,[12] for extracting

[3] Schmidt, F. A., R. M. Bergman, O. N. Carlson, and H. A. Wilhelm. Molybdenum Metal by the Bomb Reduction of Molybdic Oxide. J. Metals, v. 23, No. 8, August 1971, pp. 38–44.

[4] Speddin, H. R., J. D. Prater, P. B. Queneau, G. G. Foster, and W. S. Pickles. Acid Bake-Leach-Flotation Treatment of Offgrade Molybdenite. Metallurgical Transactions, v. 2, No. 11, November 1971, pp. 3115–3121.

[5] Calvert, E. D., R. A. Beall, and H. Kato. Electroslag Melted Molybdenum. J. of the Less-Common Metals, v. 23, No. 2, February 1971, pp. 129–151.

[6] Lee, L. H., and V. Y. Doo. Corrosion and Passivation of Thin Molybdenum Films. Electrochem. Sci., v. 118, No. 3, March 1971, pp. 443–446.

[7] Barto, R. L. and L. J. Ebert. Deformation Stress State Effects on the Recrystallization Kinetics of Molybdenum. Metallurgical Transactions, v. 2, No. 6, June 1971, pp. 1643–1649.

[8] Plaksa, N. E. Steam Treatment and Selective Flotation of Copper-Molybdenite Concentrates. Tsventnyie Metally, No. 1, 1971, pp. 79–82.

[9] Hendrickson, A. V. (assigned to American Metal Climax Inc.). Solvent Extraction Recovery of Molybdenum. Canadian Pat. 861,421, Jan. 19, 1971.

[10] Jennings, P. H., R. W. Stanley, and H. L. Ames (assigned to Brenda Mines Ltd.). Acid Leaching of Impurities from Molybdenum Concentrate. Canadian Pat. 878,999, Aug. 24, 1971.

[11] Castillo, C. O. (assigned to Kennecott Copper Corp.). A Process in Production of Lubricant Grade Molybdenite. U.S. Pat. 3,645,455, Feb. 29, 1971.

[12] Burrows, R. C. (assigned to Ashland Oil and Refining Co.). Solvent Extraction of Molybdenum. U.S. Pat. 3,558,288, Jan. 26, 1971.

high-purity molybdenum from technical grade molybdenum trioxide,[13] on a solvent extraction process for recovering molybdenum from a sulfuric acid leach solution [14], and on a method of recovering a low-molybdenum nickel product from molybdenum-containing nickel mattes or metallurgical intermediates or residues.[15]

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[13] Ritsko, J. E. (assigned to Sylvania Electric Products, Inc.). Solvent Extraction of High-Purity Molybdenum. U.S. Pat. 3,578,392, May 11, 1971.

[14] Chiola, V., P. R. Dodds, J. A. Powers, and C. D. Vanderpool (assigned to Sylvania Electric Products, Inc.). Solvent Extraction of Molybdenum From Sulfuric Acid Leach Solution. U.S. Pat. 3,598,519, Aug. 10, 1971.

[15] Mehl, E., B. Weisenbach, and P. Kawulka (assigned to Sherritt Gordon Mines Ltd). Recovering Low-Molybdenum Nickel Product From Molybdenum-Containing Nickel Mattes. U.S. Pat. 3,622,301, Nov. 23, 1971.

Natural Gas

By William B. Harper [1] and Leonard L. Fanelli [2]

Consumption of natural gas increased again in 1971, but at a much slower pace than in earlier years. The total use of natural gas amounted to 22.7 trillion cubic feet, 2.9 percent larger than in 1970. Production rose moderately to 22.5 trillion cubic feet, an increase of 2.6 percent. Pipeline imports, primarily from Canada, moved closer to the 1-trillion-cubic-foot mark, rising to 931.6 billion cubic feet, a 13.6-percent increase. Canada accounted for all but 2 percent of these imports by pipeline in 1970.

The export side of foreign trade consisted of pipeline exports of 30 billion cubic feet, of which a little more than half went to Mexico and the remainder to Canada. Another 50 billion cubic feet was liquified natural gas (LNG) from Alaska to Japan. Proved reserves of natural gas declined as additions to reserves from new discoveries and extensions of known fields and from revisions of previous estimates failed to equal natural gas withdrawals. The value of natural gas at the wellhead moved upward to 18.2 cents per thousand cubic feet from 17.1 cents in 1970.

Some 663,000 new residential gas users were added during 1971, so that by yearend there were 39,267,000 users of natural gas for cooking, heating, etc., a modest increase of 1.7 percent. The use of gas by residential users increased 2.8 percent.

Pipeline networks continued to expand, but at a slower rate in 1971. There were added, in 1971, 19,820 miles of natural gas pipelines, most of which were in the distribution category. Capital expenditures for new plant and equipment dropped slightly from $2,507 million in 1970 to $2,450 million in 1970 to $2,450 million in 1971.

Unlike earlier years, when expenditures were directed toward transportation and distribution facilities, more attention is being focused on liquefaction plants and LNG storage facilities; also gasification plants designed to use naphtha crude oil and natural gas liquid's as feedstocks to obtain a high British thermal unit (Btu) synthetic gas or SNG. Coal gasification is receiving impetus from the award of a contract of $24.8 million by the Department of the Interior to Bituminous Coal Research Inc., the research facility of the National Coal Association. The first phase of the project is directed toward a commercial process for converting coal to SNG. The final phase is to prepare a preliminary engineering design for a commercial plant. This project is being funded by The American Gas Association (AGA) and the Department of the Interior through its Office of Coal Research.

Meanwhile the inability to obtain additional gas supplies has compelled the transmission companies to notify distributors that the pipelines would be unable to supply any increased quantity of gas beyond what is specified in existing contracts. As a result an increasing number of gas company distributors either have served or are now serving notice to their resale accounts that the distributor could no longer make any further commitments for new gas sales until the supply situation improved. Action curtailing gas use has been taken in 26 States, of which 12 are located along the eastern seaboard and 9 are in the midwest.

Legislation and Government Programs.—Federal Power Commission (FPC) Area Rate Proceedings, *South Louisiana Area (AR61–2 reopened; and AR69–1)*.—Following a series of hearings, the FPC issued Opinion 598 on July 16, 1971, accepting with only a few changes the settlement proposal submitted by the United Distribution Companies (UDC) in (AR61–2 et al. and AR69–1).

Opinion 598 established base area rates in cents per thousand cubic feet (Mcf) at

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15.025 psia, subject to quality and tax adjustments, as follows:

	Contracts dated prior to Oct. 1, 1968 [1]	Contracts dated on or after Oct. 1, 1968, and new reservoirs discovered on or after Oct. 1, 1968 [2]
Gas subject to Louisiana production tax	22.375	26.0
Gas not subject to Louisiana production tax	21.375	26.0

[1] These rates will escalate 0.5 cent per Mcf on Oct. 1, 1973.
[2] These rates will escalate to 27.0 cents per Mcf on Oct. 1, 1974.

The base area rates will be reduced by 0.51 cent per Mcf for deliveries made closer to the well head than a central point in the field, the tailgate of a natural gas processing plant, or a point on the buyer's pipeline. A moratorium on filing rate increases above the applicable area rates was imposed until October 1, 1977, for contracts dated on and after October 1, 1968, and until October 1, 1976, for contracts dated prior to October 1, 1968.

The principal differences between the ordering section of FPC's Opinion 598 and the settlement proposal are as follows:

The settlement proposal provided for the option of discharging refund obligations through new reserve commitments over a 5-year period, with provisions for a 2-year extension under certain conditions; in the event of remaining undischarged refund obligations at the end of the 5-year period or any extension thereof, the settlement proposal provided for the right to petition for special relief upon a showing of a producer's efforts but inability to find gas to discharge its refund obligations in full. Additionally, the settlement proposal provided for the use of a corporate warranty contract commitment of reserves to gain refund credit where the producer had been granted a 2-year extension. Opinion 598 adopted a period of approximately 6 years for the discharge of refund obligations through commitment of new reserves.

Additionally, the Opinion does not determine the procedures for pipeline tracking of rate increases. The procedures for establishing the amount of reserves in new dedications would be established by later order. Certificates were not issued by the Opinion.

Other Southwest Area.—In October 1971, the FPC issued Opinion 607 determining rates for the Other Southwest Area. This area includes Mississippi, Arkansas, four counties in northwest Alabama, northern Louisiana, Texas Railroad Commission Districts 5, 6, and 9, and 56 counties in eastern and southeastern Oklahoma.

The base area rates established by Opinion 607, effective from October 1, 1968, through June 30, 1976, are as follows:

	Cents per thousand cubic feet	
	Contracts dated prior to Oct. 1, 1968 [1]	Contracts dated on or after Oct. 1, 1968 [1]
Other Oklahoma	19.40	23.75
Texas R.R. District 9	19.70	24.00
Northern Arkansas	18.80	23.00
Texas R.R. District 5	--	23.50
Texas R.R. District 6	19.10	23.50
Northern Louisiana [2]	20.60	25.00
Southern Arkansas	18.25	22.50
Mississippi-Alabama [2]	20.00	25.00
Federal Domain (offshore Mississippi)	--	26.00

[1] These rates will escalate 1 cent per Mcf on Oct. 1, 1974, for gas from the Federal domain (offshore Mississippi) and on Oct. 1, 1973, for gas from all other subareas.
[2] At 15.025 psia.

Appalachian and Illinois Basin Areas.—In January 1971 orders became final under a rulemaking proceeding (R-371) fixing ceiling rates and regulating jurisdictional sales in the area. The rates are shown in the following tabulation, in cents per Mcf:

	Pressure base	
	14.73 psia	15.325 psia
North subarea:		
Contracts dated prior to October 8, 1969	30.75	32.00
Contracts dated after October 7, 1969	32.75	34.00
South subarea:		
Contracts dated prior to October 8, 1969	29.00	30.00
Contracts dated after October 7, 1969	30.75	32.00
Minimum rate	19.25	20.00
Illinois Basin area rates:		
Area rate	23.50	[1] 24.00
Minimum rate	16.25	[1] 16.50

[1] At 15.025 psia.

Rocky Mountain Area.—The FPC in its Order 435 of July 15, 1971, established the following initial rates in cents per Mcf for sales of natural gas under contracts dated

Table 1.—Salient statistics of natural gas in the United States
(Million cubic feet unless otherwise specified)

	1967	1968	1969	1970	1971
Supply:					
Marketed production [1]	18,171,325	19,322,400	20,698,240	21,920,642	22,493,012
Withdrawn from storage	1,132,534	1,329,536	1,379,488	1,458,607	1,507,630
Imports	564,226	651,885	726,951	[2] 820,780	[2] 934,548
Total	19,868,085	21,303,821	22,804,679	24,200,029	24,935,190
Disposition:					
Consumption	18,172,894	19,459,939	20,922,800	22,045,799	22,676,581
Exports	81,614	93,745	51,304	69,813	80,212
Stored	1,317,363	1,425,075	1,498,988	1,856,767	1,839,398
Lost in transmission, etc	296,214	325,062	331,587	227,650	338,999
Total	19,868,085	21,303,821	22,804,679	24,200,029	24,935,190
Value at wellhead:					
Total thousand dollars	2,898,741	3,168,688	3,455,615	3,745,680	4,096,550
Average cents per Mcf	16.0	16.4	16.7	17.1	18.2

[1] Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.
[2] Includes imports of liquefied natural gas.

after June 17, 1970, in specified areas of the Rocky Mountain Area:

	15.025 psia
Aneth Field	22.50
San Juan Basin	24.00
Uinta-Green River Basin	23.75
Colorado-Julesburg Basin	23.50
Montana-Wyoming Area	22.75
Montana-Dakota Area	23.50

These rates are not subject to refund liability.

Also, on July 15, 1971, the FPC issued its rulemaking notice R–425 to determine (1) just and reasonable rates for Rocky Mountain area contracts dated before October 1, 1968, and (2) whether initial rates established between October 1, 1968, and June 17, 1970, should be certified at rates not in excess of those established in Order 435.

All natural gas producers with nationwide jurisdictional sales of more than 10 billion cubic feet annually and any Rocky Mountain pipeline purchasers also producing gas were ordered by the FPC to submit flowing gas costs and operational data on a 1969 test year basis. Subsequently, initial responses in R–425 were filed by producers, the State of New Mexico, El Paso Natural Gas Co., and other pipeline purchasers both interstate and intrastate in the Rocky Mountain area. In addition, the Associated Gas Distributors and the FPC staff filed responses in R–425.

Permian Basin Area (AR70–1 Permian II).—By way of background, this proceeding was initiated on July 17, 1970, at the same time as the FPC's R–389 rulemaking proceeding which was aimed at the establishment of new ceiling rates for the certification of new contracts in the Permian Basin Area. The rulemaking proceeding was subsequently expanded to a nationwide basis. Subsequent to a prehearing conference held in February 1971, the FPC held hearings on cost and rate design evidence, and noncost evidence. Hearings were conducted in 1971 and continued in 1972.

Sales, Small Producers.—Producers selling less than 10 billion cubic feet of natural gas annually and not affiliated with pipelines were relieved of complying with producer rate and certificate regulations by FPC Order 428, issued March 18, 1971. Under Order 428, price regulation of small producer sales would be carried out by surveilance of jurisdictional pipeline company purchases. This Order had a marked effect on small producer applications. Prior to issue of the Order, 670 small producer certificate applications had been submitted to the FPC for sales in the Permian Basin, South Louisiana, and Hugoton-Anardarko Basin Areas in response to the special regulatory treatment. By December 31, 1971, small producer applications submitted had increased to 2,092.

Coal Gasification.—The Department of the Interior awarded a $24.8 million contract to Bituminous Coal Research Inc., the research facility of the National Coal Association. The award was for the construction and operation of a pilot plant to develop a commercial process for converting coal to a high-Btu synthetic gas.

The first phase of the project will be directed toward developing a two-stage, high-pressure gasification process, designated Project BI–GAS. The final phase of the contract requires Bituminous Coal Research to prepare a preliminary engineering design for a commercial plant capable of producing 250 million cubic feet per day of high-Btu (approximately 1,000 Btu per ft ^{2}) finished gas to sell at prices estimated to range from $0.80 to $1.00 per million Btu depending on the price of coal and other factors. This project is being funded by the AGA and the Department of the Interior through the Office of Coal Research.

Pipeline Safety.—Until March 12, 1971, the interim Federal safety standards required by section 3(a) of the Natural Gas Pipeline Safety Act of 1968 (Public Law 90–481), were in effect with respect to design, installation, and testing of new gas pipelines. On that date, the new Federal safety standards (part 192) which were effective for existing pipelines, became effective also for the design, installation, and testing of new gas pipelines.

Three ammendments to the Federal safety standards, (part 192) were issued during 1971. The first was for control of corrosion of pipelines from external, internal, or atmospheric environmental causes and became effective August 1, 1971. The second amendment extended the time for completing confirmation or revision of the maximum allowable operating pressure for pipelines operating at more than 40 percent of specified minimum-yield strength. This second amendment was issued September 28, 1971. The third amendment extended to September 1, 1972, the requirements contained in the interim Federal standards for odorization of gas in transmission lines.

In addition to the three amendments outlined above, the Department of Transportation (DOT) in testimony before the Committees of Congress, has recommended that section 5(a) which permits certification for 2 years, be extended to 5 years. Also DOT recommends an amendment of the Department of Transportation act to permit the transfer of the liquid pipeline safety functions from the Federal Railroad Administration to the Office of the Secretary, DOT, where the liquid and gas pipeline functions could be carried out by a single organizational unit.

Data on leaks reported during the calendar year 1971 as required under title 49 of the Code of Federal Regulations are shown in table 2.

Table 2.—Leaks reported during 1971

Cause	Total number of leaks	Fatalities		Injuries		Estimated property damage (value)
		Employees	Non-employees	Employees	Non-employees	
Distribution:						
Corrosion	120	--	3	9	30	--
Damage by outside forces	575	--	13	8	138	--
Construction defect or material failure	121	--	16	4	111	--
Other causes	61	6	4	16	51	--
Total	877	6	36	37	330	$297,474
Transmission:						
Corrosion	55	1	--	6	--	--
Damage by outside forces	213	--	1	--	6	--
Construction defect or material failure	105	--	--	--	3	--
Other causes	37	1	--	8	1	--
Total	410	2	1	14	10	2,334,696
Grand total	1,287	8	37	51	340	2,632,170

DOMESTIC PRODUCTION

Gross production of natural gas in 1971 (the total amount of gas produced) aggregated 24.1 trillion cubic feet, or 1.3 percent above the 1970 total. Production derived from gas wells amounted to 18.9 trillion cubic feet compared with 18.6 trillion in 1970, a moderate increase of 1.8 percent. On the negative side there was a slight decline in the volume of gas withdrawn from oil wells. The volume of oil well gas, which is an associated-dissolved gas, was nominally lower—about 13 billion cubic feet in 1971 as indicated in table 8.

In the major gas-producing States, gains were made in Texas, Louisiana, and New Mexico. Although gross production in Oklahoma declined slightly, the amount of gas vented and flared was cut sharply from 129.6 billion cubic feet in 1970 to 39.8 billion cubic feet in 1971, a decrease of 69.3 percent. As a result the marketed production of natural gas in Oklahoma in 1971 increased to 1,684,260 million cubic feet from 1,594,943 million cubic feet or 5.6 percent. Marketed production in major producing States as indicated in table 8, increased in Alaska, Colorado and in Louisiana. In Louisiana the volume of flared and/or vented gas was again cut drastically, from 154 billion cubic feet to 103.6 billion, or 32.8 percent. In New Mexico increased production of gas well gas more than offset a decline in the withdrawal of associated-dissolved gas. Hence production increased a moderate 2.5 percent to 1,167,577 million cubic feet. Likewise, production in Texas increased 2.3 percent to 8,550,705 million cubic feet in 1971, largely because a 161.8-billion-cubic-foot increase in gas well gas production more than offset a decline in gas produced from oil wells.

Although the volumes of gas produced and then returned to the formation for repressuring and pressure maintenance decreased a moderate 4.8 percent to 1,310,458 million cubic feet, there has been a significant drop in the volumes of gas flared and/or vented as shown in table 8. In 1971, for example the volumes of gas flared was reduced from 489,460 million cubic feet in 1970 to 300,503 million cubic feet, or a decrease of 38.6 percent in 1971. Part of this reduction reflects action by States tightening controls on venting and flaring. Still another factor, however, is the intense demand coupled with the rise in prices for natural gas, which has provided the incentive to install facilities to move more gas to market.

The lack of incentive to stimulate exploration and drilling has had an impact on production growth. In 1971, for example, there were 25,851 exploratory and development wells drilled. This is about 9 percent below drilling activity in 1970. There were 437 exploratory gas wells drilled in 1971, a 9-percent decrease from the 1970 results. Development wells drilled in 1971 actually registered a moderate improvement of 1 percent over the results in 1970. Virtually all of the pickup, moreover, occurred in the last quarter of 1971.

Actually the major gas-producing States experienced a significant pickup in gas well completions in 1971 as shown in table 10. In Louisiana and Texas, completions in 1971 were well ahead of those of the preceding year. Also there was some improvement in New Mexico. On the negative side, there was a definite slowdown in Pennsylvania and West Virginia, both smaller gas producing States. Likewise in the midwest in district 2, drilling activity slackened in Ohio and in Oklahoma. Although drilling tapered off in Montana, Utah, and Wyoming, activity in Wells and Adams Counties in Colorado caused completions in 1971 to more than triple gas well completions in 1970.

CONSUMPTION AND USES

Consumption of natural gas totaled 22,676,581 million cubic feet in 1971, an increase of 2.9 percent over 1970, as shown in table 13. Gas delivered to consumers aggregated 19,637,212 million cubic feet, 3.3 percent above the comparable total of 19,018,462 million cubic feet in 1970. Included in the consumer category is the gas used for residential heating. In 1971, the total use of 4,971,690 million cubic feet rose only 2.8 percent as evidenced in table 12. This moderate rise is attributable to the relatively mild weather in the winter months of 1971.

Residential consumption of natural gas ranks second to industrial uses. Between 1962 and 1971 the number of househeating accounts grew from 22,880,000 to 31,794,000 or at an annual growth rate of 3.7 percent. Between 1970 and 1971, however the number increased only 3 percent.

This arrest in growth is readily understandable. Many gas distributors are either unwilling or unable to accept any new accounts until the natural gas supply problems of the pipeline transmission companies have been resolved.

Trends in the number of househeating

accounts stratified by Census Regions for the 1961, 1970, and 1971 years follow:

Region	Thousand customers			
	1961 r	1970 r	1971	Percent [1]
New England	468	734	768	47.1
Middle Atlantic	2,737	3,762	3,867	49.6
East North Central	5,039	7,439	7,698	85.0
West North Central	2,219	2,903	2,980	91.9
South Atlantic	1,727	2,591	2,697	80.5
East South Central	1,280	1,693	1,727	96.2
West South Central	3,615	4,265	4,338	98.9
Mountain	1,205	1,650	1,716	97.4
Pacific	4,590	5,820	6,003	98.0
Total	22,880	[2]30,856	31,794	81.3

r Revised.
[1] Proportion of residential gas customers using gas for heating.
[2] Data may not add to total shown because of independent rounding.

Source: American Gas Association.

Pipeline networks transporting all types of utility gas continued to expand but at a slower pace than in earlier years. During 1971, 20,000 miles of line were added as compared with a net increase of 23,200 in 1970 and 30,000 during 1969. Most of the growth has been in distribution lines, in the interval between 1961 and the end of 1971. Of the net increase of 275,800 miles, distribution mileage accounted for nearly 201,000 miles, or 73 percent.

Shown below is a table on pipeline mileage, in thousand miles, for selected years.

Residential use accounted for 25.3 percent of the total gas delivered to consumers or about the same as in 1970 (see table 12.)

Gas used for commercial purposes amounted to 2,173 billion cubic feet. This volume was 5.6 percent larger than in 1970. There was a net increase of 88,000 commercial accounts during 1971, whereas the net gain between 1969 and 1970 was 31,000 accounts, less than half the most recent increase. (see table 12.) Some of this spread, however, may be attributable to classification.

By far the largest category in the consumer-use category is the industrial group. About 40 percent is consumed by industry. As shown in table 12, industrial use in 1971 accounted for 8,163 billion cubic feet, which is about 3.5 percent larger than in 1970. Most of this industrial gas is used as fuel, such as the more than 1 trillion cubic feet used as refinery fuel alone as shown in the footnote in table 12. In addition to use as fuel, natural gas is used by the chemical industry as a feedstock. Also as footnoted, more than 64 billion cubic feet was used for carbon black production in 1971.

Consumption of natural gas by the electric utilities continued to rise in 1971, but at a slower pace. For example, between 1969 and 1970 gas use increased more than 407 billion cubic feet, nearly 12 percent. But in 1971, gas consumption rose about 100 billion cubic feet, only about 2.5 percent. Here again mild weather had an impact on natural gas demand.

In addition to gas delivered to consumers, there are three categories of gas-use separately classified in table 13, namely, lease and plant fuel, pipeline fuel, and extraction losses. Gas used as lease and plant fuel (oil- and gas field use) increased 1 percent. The amount of gas used as pipeline fuel increased nearly 3 percent. Conversely, the loss of gas in gas processing plants decreased, even though more gas was processed in 1971 than in 1970, as shown in table 14. In 1971 these plants processed nearly 19,253 billion cubic feet of natural gas, an increase of 743,498 million cubic feet over the 18,509 billion cubic feet produced in 1970.

Production of natural gas liquids and ethane in 1971 increased from 605,916,000 barrels to 617,815,000 barrels an increase of 11,899,000 barrels or 2 percent as indicated in table 14. At the same time, even though the value of gas processed increased, the extraction loss or shrinkage decreased from 906,413 million cubic feet to 883,127 million, a 2.6-percent reduction.

This reversal suggests that the rising price trend for natural gas promises to become an increasingly important factor in determining the extent of the extraction of some natural gas liquids.

	1961	1965	1968	1969	1970	1971
Field and gathering	56.7	61.7	64.4	64.9	66.6	66.5
Transmission	191.9	r 211.3	234.5	248.1	252.6	256.9
Distribution	410.4	r 494.5	562.7	r 578.6	r 595.6	611.3
Total	659.0	r 767.5	861.6	r 891.6	r 914.8	934.7

r Revised.

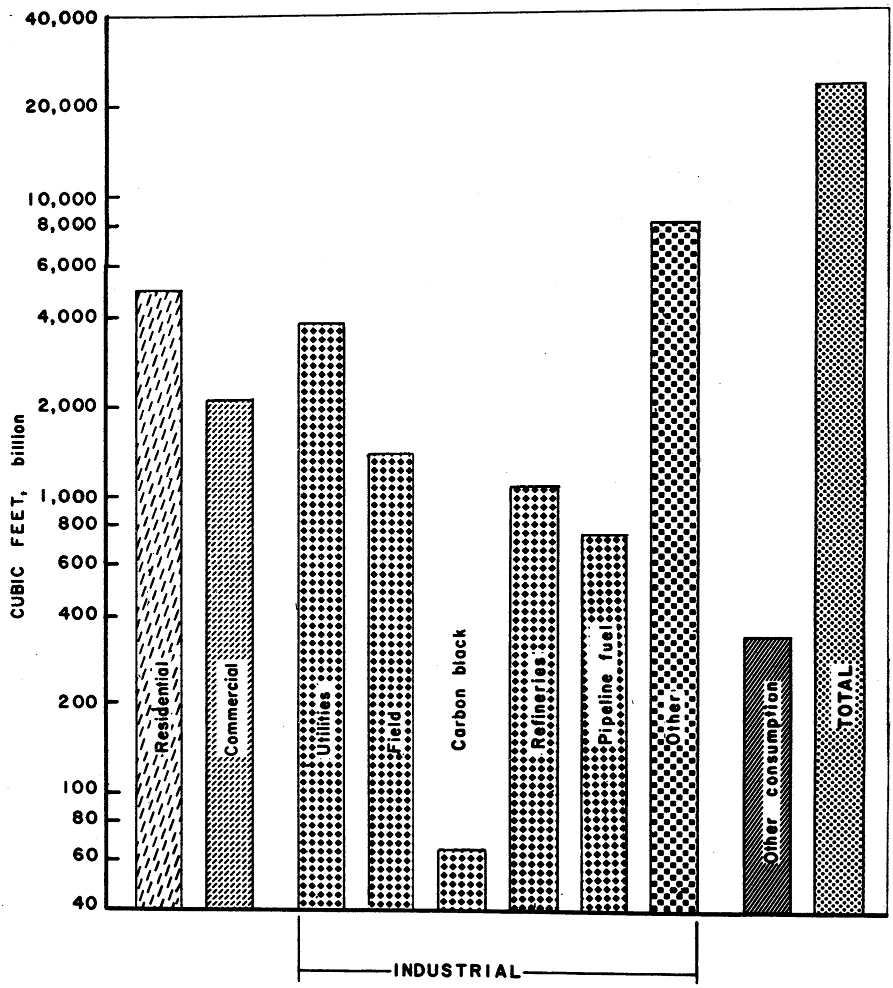

Figure 1.—Disposition of natural gas consumed in the United States by principle use.

Although there has been a marked growth in natural gas use ever since long-distance natural gas transmission lines became a reality, the supply situation is becoming more and more critical for pipeline transmission companies and for gas utilities at the distribution level. The flattening in the growth curves of consumption discussed above are decidedly noticeable in the results among the consumption sectors between 1970 and 1971. Some of this impact can be attributed to the general slowdown in industrial activity. But at the same time, curtailment of new business by the transmission companies because they are unable to obtain new gas supplies has become a major consideration. Some pipeline transmission companies notified their customers, the gas distributing utilities, that additional gas is not available. In other instances the transmission companies are establishing priorities on deliveries of gas to industrial customers.

The gas-distributing utilities are taking similar steps. First, new industrial and commercial accounts were curtailed; residential business remained unaffected. Later, new residential business was curtailed. Hence under these circumstances there is every reason to expect a marked slowdown in the growth in new natural gas use over the near term, particularly in nonresidential use.

Estimated capital expenditures in 1971 approximated $2.4 billion in 1971 which was $88 million less than in 1970. Increases in expenditures for production and for storage facilities, both above and underground, aggregating $141 million, were more than offset by reduced outlays for transmission, distribution and other general capital expenditures, totaling $229 million in 1971.

RESERVES

Production of natural gas exceeded by a wide margin, new discoveries of gas, so that proved reserves in the 50 States fell in 1971; from 290.7 trillion cubic feet at yearend 1970 to 278.8 trillion cubic feet at yearend 1971 or a decline of 4.1 percent according to the Committee on Natural Gas Reserves of the AGA. The total of proved reserves added by the discovery of new fields, by revisions of previous resources estimates, and by the extensions of old fields, has been in a downtrend since 1967. In fact, this trend was arrested only in 1970 because the reserves committee of AGA included for the first time an estimate of 26 trillion cubic feet for new gas discovered in 1968 in the Permo-Triassic Reservoir at Prudhoe Bay, Alaska. Excluding Alaska, proved reserves dropped from 259.6 to 247.4 trillion cubic feet, or a decline of 4.7 percent, by the end of 1971 as shown in table 15.

Additions to reserves reported for the United States in 1971, including Alaska, aggregated 9.8 trillion cubic feet. This consisted of 1.3 trillion for new field discoveries and 3.4 trillion for new reservoir discoveries in old fields; extensions of older fields added another 6.4 trillion. Conversely the AGA reserves committee revised downward its revisions of previous estimates. These negative revisions shown as minus numbers in table 15, totaled 1.2 trillion cubic feet.

In addition to explorations for new resources in the lower 48 States and Alaska, American companies are involved, either independently or with Canadian companies, in exploring and drilling for oil and gas in Canada's Arctic Islands and the Maritime Provinces. Wildcat drilling brought in a new gas well on Sable Island off eastern Canada in 1971. Also, new gas discoveries in Trinidad and Tobago have opened new markets for gas as LNG to be exported to the United States.

On balance, there were some increases in the reserves of natural gas in Alabama, Alaska, Colorado, Illinois, Michigan, Ohio, Pennsylvania and some of the other States which produce small amounts of gas. These net increases, however, aggregated only 825 billion cubic feet. On the negative side, reserves of major gas-producing States declined sharply. Texas gas reserves dropped from 106.3 to 101.5 trillion cubic feet, a decline of nearly 4.9 trillion cubic feet; in Louisiana, reserves dropped from 82.9 to 78.6 trillion cubic feet, a decrease of 4.3 trillion cubic feet. Reserves in Oklahoma were 1.2 trillion cubic feet lower and those in Kansas declined 789.9 billion cubic feet from 13.3 to 12.5 trillion cubic feet.

On a more optimistic note, some new reserves resulting from drilling on acreage leased in the December 1970 Federal lease sale in offshore Louisiana are not included in the 1971 reserves report described below because of insufficient data to estimate proved reserves.[3] These volumes, however, will be reported when adequate data are available to the AGA's reserves committee.

The Potential Gas Committee (PGC) reports natural gas reserves in three categories: probable, possible, and speculative. Briefly, "probable" refers to the unproved portions of existing fields; "possible" is production that will result from new field

[3] American Gas Association, American Petroleum Institute, and the Canadian Petroleum Association. Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada and United States Productive Capacity as of December 31, 1971. V. 26, May 1972, 248 pp.

discoveries in areas of established production; and "speculative" is commercial natural gas that will result from new field discoveries in areas where sediments are present but have no prior production history. The PGC's estimate of potential supply of natural gas in the United States, excluding the State of Hawaii, the island territories of the United States, and their adjacent offshore areas, is shown in the tabulation below: [4]

Estimated Potential Supply of Natural Gas
(Trillion cubic feet at 14.73 psia and 60° F)

	Probable	Possible	Speculative	Total
48 States	218	326	307	851
Alaska	39	61	227	327
Total	257	387	534	1,178

Dedicated Reserves.—The FPC collects data on "dedicated reserves" in its Forms 15 and 15A. These reserves are the volumes of remaining salable gas reserves committed to control by or possessed by a pipeline company. Some 96 companies file reports with the FPC and of the total, some 56 companies control dedicated reserves aggregating 161.3 trillion cubic feet of natural gas or 65.2 percent of total proven reserves in the lower 48 States as estimated by AGA. There are no dedicated reserves reported for Alaska.

The 9 year comparison shown in the following tabulation in trillion cubic feet indicates that the relationship of dedicated

[4] A more detailed description of the three categories is available in Section III of the Potential Gas Agency (PGA) report cited in footnote 5, p. 10.

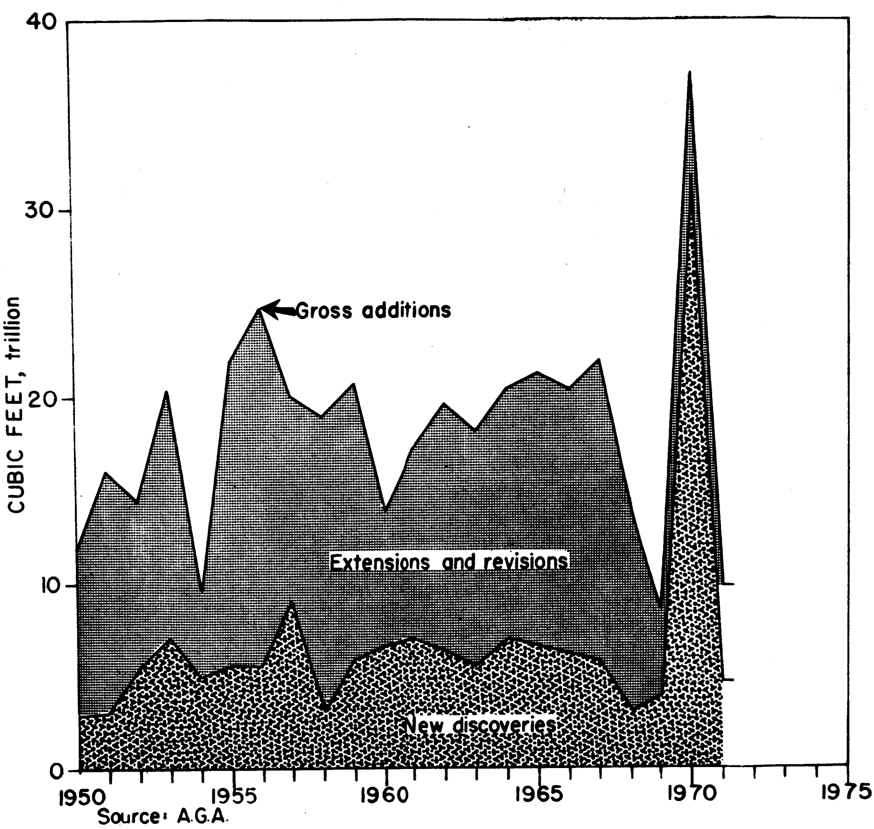

Figure 2.—Trends in annual gross additions to natural gas reserves.

domestic reserves of interstate pipeline companies to total domestic proved reserves as reported by the AGA, adheres closely to 68 percent.

Year end	Dedicated reserves	Total reserves lower 48 States	Dedicated reserves, percent of proved reserves in the lower 48 States
1963	188.5	274.5	68.7
1964	189.2	279.4	67.7
1965	192.1	284.5	67.5
1966	195.1	286.4	68.1
1967	198.1	289.3	68.4
1968	195.0	282.1	69.1
1969	187.6	269.9	69.5
1970	173.7	259.6	66.9
1971	p 161.3	247.4	65.2

p Preliminary.

But in 1970 dedicated reserves of natural gas declined at a faster rate than total proved reserves in the lower 48 States, exclusive of Alaska, and this accelerated rate of decline continued in 1971.

The following tabulation demonstrates the 5 year trend in dedicated gas reserves and production and purchases by the 56 companies mentioned above. As compared with 1970, dedicated reserves of natural gas, by the 1971 yearend, had declined 12.4 trillion cubic feet.

Potential Supply of Natural Gas in the United States.—In October 1971, the PGC published its third biennial report on the potential supply of natural gas.[5] The work by the PGC is supported by three industry associations: the AGA, the Independent Natural Gas Association of America (INGAA), and the American Petroleum Institute (API).

Domestic reserves, production and purchases of pipeline companies reporting to the Federal Power Commission [1]

(Trillions of cubic feet at 14.73 Psia at 60°F)

	1967	1968	1969	1970	1971 p
Number of companies	68	64	65	66	56
Gas reserves at yearend:					
Company-owned	22.2	21.7	18.6	17.2	16.5
Independent producer contracts	179.9	177.0	172.9	156.5	144.8
Total	202.1	198.7	191.5	173.7	161.3
Annual production and purchases:					
Company-owned	1.0	1.1	1.1	1.0	.9
Independent producer contracts	11.0	11.7	12.7	13.1	13.2
Total	12.0	12.8	13.8	14.1	14.1

p Preliminary.
[1] Reporting on FPC Forms 15 and 15A gas supply reports.

PRODUCTIVE CAPACITY

The daily productive capacity for natural gas at the end of 1971 is estimated to be 94,017 million cubic feet according to the AGA. This compares with 99,266 million per day as of December 31, 1970. Productive capacity in nonassociated gas fell to 75,371 million from 79,528 million cubic feet. Likewise, capacity in associated-dissolved gas was reduced to 18,646 million cubic feet from 19,738 million a day as of December 31, 1970.[6] Compared with that of 1970, daily productive capacity had dropped 5.2 billion cubic feet or almost 5.3 percent by the end of 1971, as shown in table 16.

[5] Potential Gas Agency. Potential Supply of Natural Gas in the United States as of December 31, 1970. Mineral Resources Inst., Colo. Sch. Mines Foundation, Inc., Golden, Colo.

[6] 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 which 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.

STORAGE

The development of additional underground storage capacity for natural gas, after a slackening in 1970, moved at a faster pace in 1971. Total reservoir capacity increased 7.6 percent from 5,178 million cubic feet in 1970 to 5,575 million cubic feet by yearend 1971. The number of underground storage facilities expanded from 325 to 333 in 1971, these facilities are found in 26 States.

Originally most of these reservoirs were depleted fields which contained dry gas. Of the 333 reservoirs, for example, 264 or 79 percent were the dry-gas type and as evidenced in table 17, most of these dry-gas reservoirs are located in the northeastern United States, primarily in the oldest of oil provinces. The second largest concentration is found in the midwest. In Pennsylvania, where oil production dates back to 1859, some 66 dry-gasfields have been converted to storage facilities. West Virginia has 31 dry-gas reservoirs and there are 16 in each of New York, Kansas, and Kentucky. In Michigan, where oil production began on a small scale in the early 1900's, there are 28 of the dry-gas-type reservoirs.

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 minus 258° F (− 161° C) it occupies only 1/620th the space necessary for conventional vapor storage.

There are 17 liquefied natural gas facilities for peak shaving purposes with liquefaction capacity aggregating nearly 111 million (110.95) cubic feet per day. Daily liquefaction capacities range from 20 million cubic feet per day to 500,000 cubic feet, but most of these facilities range between 2 million and 8 million cubic feet per day.

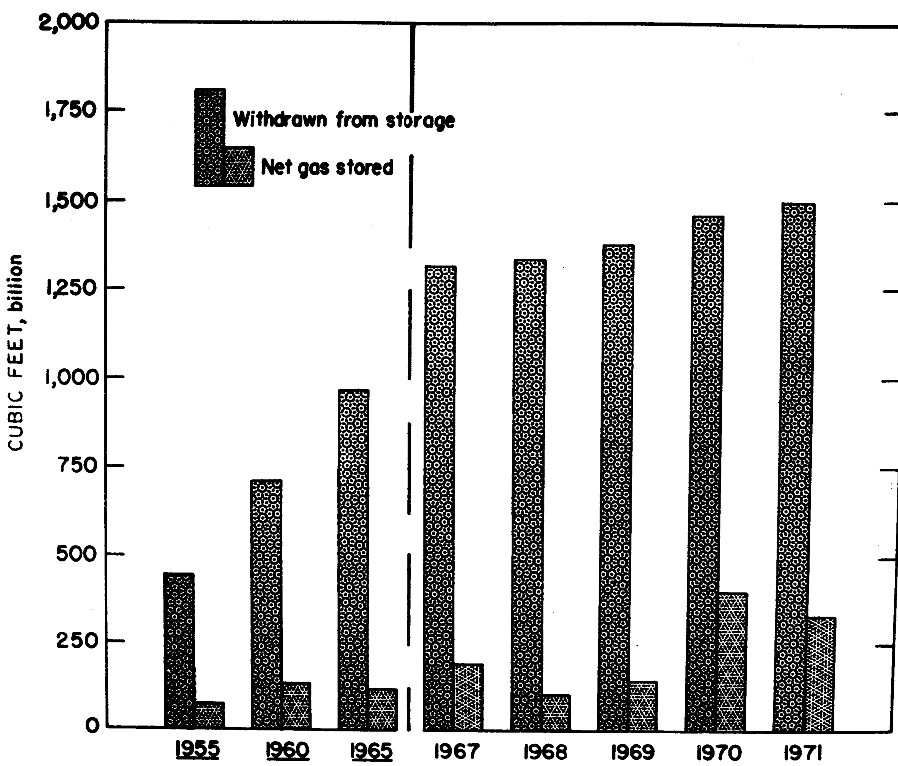

Figure 3.—Trends in net gas stored underground in U.S. storage fields.

For peak shaving purposes, relatively small quantities of gas are stored for use during the high-consuming, low-temperature winter months. Furthermore, the regasification rate is rapid so when the occasion demands it LNG storage could be depleted in less than 1 week.

During 1971, the total amount of gas moved into storage aggregated 1,839,398 million cubic feet, as shown in table 18. Over the same period, 1,507,630 million cubic feet was drawn down, leaving a net stored of 331,768 million cubic feet in 1971.

Where depleted fields, whether oil or gas, are not available, other types of underground storage come into use. As an example, water sands or acquifers have been enlisted into service. There are 44 acquifers in eight States in which natural gas is stored. Illinois is the leader with 19; Indiana ranks second with 11 acquifers. Acquifer storage accounts for 19 percent of the storage total and 15 percent of the maximum daily output.

Development of storage reservoirs has been a factor in the growth of natural gas demand, particularly in the residential house heating market in which there is a high degree of seasonal variation. Furthermore, the concentration of storage relatively close to the largest markets for residential heating is another very large plus value. Pennsylvania, for example, had 593.8 billion cubic feet of natural gas stored in 66 dry-gas reservoirs at the end of 1971. In Illinois, there were 475.6 billion cubic feet; Michigan was a close third with 416.8 billion cubic feet of stored gas. Both Ohio and West Virginia had about 370 billion cubic feet of gas stored and in the aggregate, these five States accounted for 2,225.8 billion cubic feet or 63 percent of the total gas in storage as shown in table 17.

VALUE AND PRICE

Prices of Intrastate Gas.—On July 14, 1971, in the FPC's Permian Basin Area Rate Proceeding (AR70–1), the Pipeline Group [7] in the Permian Basin Area filed a motion requesting the FPC to update its staff's investigation on intrastate sales in the Permian Basin Area. This motion was granted September 2, 1971. The FPC directed that the staff's investigation be updated for all intrastate sales of natural gas under contracts dated on and after July 1, 1970.

On September 8, 1971, 69 gas producers representing all of the gas producers whose individual total jurisdictional sales of natural gas are currently in excess of 10 billion cubic feet annually, were directed to respond to this updated investigation.

All addressees first responded as to whether or not they had executed intrastate gas sales contracts within the scope of the investigation. Sales contracts included those for annual volumes of 100 million cubic feet of gas or more; also plant residue gas sales.

The results of this survey are composited in table 3.

The initial report by the FPC staff shows annual volumes of 384 billion cubic feet under intrastate contracts dated since July 1, 1970. Of this total, 137 billion cubic feet or 35 percent was in the Permian Basin Area. The report shows, also, that there were price increases on a weighted average basis, in all but the Rocky Mountain Area. Another observation; intrastate sales dated after July 1, 1970 in Texas Gulf Coast area as reported, were 75 billion cubic feet whereas, as indicated in the table below, intrastate contracts dated 1969 aggregated nearly 147.6 billion cubic feet.

Wellhead Prices.—The value of the production of marketed natural gas at the wellhead aggregated $4,096,650,000 as of yearend 1971. This value is based on a marketed production of 22,493,012,000 Mcf with an average value at the wellhead of 18.2 cents per Mcf. In 1970, marketed production totaled 21,920,642,000 Mcf with value of $3,745,680,000 or 17.1 cents per Mcf as indicated in table 5.

Averages, however, are misleading. Two States, Texas and Louisiana, account for 73.9 percent of marketed production in 1971. For Louisiana, the average in 1971 was 20.2 cents per Mcf; in Texas, 16.1 cents. Higher than average prices are in evidence in those States either where intrastate sales are the dominant factor or where gas production is strategically located near large markets, such as in New York, Penn-

[7] El Paso Natural Gas Co., Cities Service Gas Co., Natural Gas Pipeline Co. of America, Northern Natural Gas Co., and Transwestern Pipeline Co.

Table 3.—Prices and volumes of intrastate gas for selected intervals

Area	1969			First half 1970			7/1/70 and later		
	Annual volume (billion cubic feet)	Current price [1] Weighted average (cents per thousand cubic feet)	Current price [1] Range (cents per thousand cubic feet)	Annual volume (billion cubic feet)	Current price [1] Weighted average (cents per thousand cubic feet)	Current price [1] Range (cents per thousand cubic feet)	Annual volume (billion cubic feet)	Current price [1] Weighted average (cents per thousand cubic feet)	Current price [1] Range (cents per thousand cubic feet)
Permian Basin	146.0	14.57	8.26–23.99	103	21.47	15.60–23.07	137	23.90	8.96–28.50
South Louisiana	10.0	20.38	19.50–23.68	72	22.98	20.50–30.00	25	26.22	20.25–39.56
Texas Gulf Coast	148.0	19.39	12.05–22.13	38	18.39	10.50–24.38	75	22.19	11.00–30.11
Hugoton-Anadarko	6.0	17.32	15.00–19.33	13	21.55	18.00–24.04	45	22.65	9.25–35.36
Other Southwest	7.0	17.85	12.27–21.45	12	18.69	14.00–21.53	52	25.21	4.40–28.92
Rocky Mountain	.7	11.57	9.75–12.00	8	18.05	6.83–19.01	20	17.32	6.00–25.00
California	9.0	31.26	25.00–35.25	1	30.43	25.00–31.00	11	34.09	27.00–37.00
Michigan	1.0	38.00	35.70–43.72	4	36.00	36.00	19	40.87	36.00–48.30
Total	327.7	--	--	251	--	--	384	--	--

[1] Inclusive of tax reimbursement, additive and deductive adjustments for gathering and Btu.

Table 4.—Weighted average rates and range of rates for intrastate sales under contracts dated on and after July 1, 1970

Area	Annual volume (thousand cubic feet)	Contract rates [1]		Contract rate plus tax reimbursement [2]		Current price [3]	
		Weighted average [4]	Range	Weighted average [4]	Range	Weighted average [4]	Range
		(cents per thousand cubic feet)		(cents per thousand cubic feet)		(cents per thousand cubic feet)	
South Louisiana	[5] 24,810,447	26.02	17.20–29.50	26.16	19.50–29.50	26.22	20.25–39.56
Other Southwest	[6] 52,054,725	24.37	11.00–27.00	24.44	11.17–27.56	25.21	4.40–28.92
Hugoton-Anadarko	[6] 45,180,872	20.86	14.00–25.00	21.09	14.21–25.00	22.65	9.25–35.36
Texas Gulf Coast	[6] 75,039,994	21.42	13.00–26.25	21.46	13.00–26.25	22.19	11.00–30.11
Appalachian	[5] 21,509,808	39.68	36.00–44.12	39.68	36.00–44.12	41.21	36.00–48.30
Rocky Mountain [7]	[8] 20,283,981	16.89	9.75–25.00	16.90	9.75–25.00	17.32	6.00–25.00
Texas District No. 1	[6] 3,102,535	20.00	20.00	20.00	20.00	23.31	20.80–27.58
California	11,078,410	34.21	28.50–37.00	34.22	30.00–37.00	34.09	27.00–37.00
Permian Basin	[6] 137,322,482	24.06	11.00–26.50	24.07	11.00–26.50	23.90	8.96–28.50
Total	390,383,254	--	--	--	--	--	--

[1] Rate stated in the contract.
[2] Rate stated in the contracts plus the current tax reimbursement received or contractually due.
[3] Current price received inclusive of tax reimbursement, additive and deductive adjustments for gathering and Btu. It does not include any allowance with respect to take or pay contractual provisions.
[4] The term "weighted average" is defined as the sum of the annual volume of each contract multiplied by the applicable rate of each contract in an area or subarea and divided by the total annual volume of all contracts in the area or subarea.
[5] Rates, prices, and volumes at 15.025 psia.
[6] Rates, prices, and volumes at 14.65 psia.
[7] Includes Montana, Wyoming, Utah, and Colorado.
[8] Rates, prices, and volumes converted from 15.025 psia to 14.65 psia.

Source: FPC Docket R-389A. Nationwide Investigation, Sept. 8, 1971.

Table 5.—Quantity and value of marketed production of natural gas in the United States

State	1970 Quantity (million cubic feet) [1]	1970 Value (thousands)	1970 Average wellhead value cents, per Mcf	1971 Quantity (million cubic feet) [1]	1971 Value (thousands)	1971 Average wellhead value cents, per Mcf
Alabama	627	$87	13.9	355	$54	15.1
Alaska	111,576	27,448	24.6	121,618	28,945	23.8
Arizona	1,101	188	17.1	868	153	17.8
Arkansas	181,351	29,560	16.3	172,154	29,426	17.1
California	649,117	208,367	32.1	612,629	199,717	32.6
Colorado	105,804	15,553	14.7	108,537	16,932	15.6
Florida	--	--	--	903	270	29.9
Illinois	4,850	761	15.7	498	88	17.6
Indiana	153	36	23.7	537	132	24.6
Kansas	899,955	125,994	14.0	885,144	127,267	14.4
Kentucky	77,892	19,161	24.6	72,723	18,253	25.1
Louisiana	7,788,276	1,503,137	19.3	8,081,907	1,632,545	20.2
Maryland	813	202	24.9	214	52	24.4
Michigan	38,851	10,373	26.7	25,662	6,776	26.4
Mississippi	126,031	23,190	18.4	118,805	24,830	20.9
Missouri	87	21	24.5	22	5	24.8
Montana	42,705	4,399	10.3	32,720	3,959	12.1
Nebraska	5,991	1,024	17.1	3,496	612	17.5
New Mexico	1,138,980	162,874	14.3	1,167,577	175,137	15.0
New York	3,358	1,017	30.3	2,202	661	30.0
North Dakota	34,889	5,722	16.4	33,864	5,655	16.7
Ohio	52,113	14,123	27.1	79,903	27,007	33.8
Oklahoma	1,594,943	248,811	15.6	1,684,260	273,945	16.3
Pennsylvania	76,841	21,439	27.9	76,451	20,770	27.7
Tennessee	64	13	19.9	89	20	22.1
Texas	8,357,716	1,203,511	14.4	8,550,705	1,376,664	16.1
Utah	42,781	6,460	15.1	42,418	7,084	16.7
Virginia	2,805	864	30.8	2,619	822	31.4
West Virginia	242,452	61,583	25.4	234,027	60,613	25.9
Wyoming	338,520	49,762	14.7	380,105	58,156	15.3
Total	21,920,642	3,745,680	17.1	22,493,012	4,096,550	18.2

[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.

sylvania, and West Virginia. In California, where the average wellhead value is 32.6 cents per Mcf, virtually all of the natural gas produced is sold in the intrastate market. Also, in Ohio, where marketed production increased in 1971 from 52 million Mcf to nearly 80 million Mcf, or 53 percent, the average value jumped from 27.1 cents to 33.8 cents, a 24.7-percent gain. This increase reflects in large part sales of the new gas in 1971 at higher prices in the intrastate market.

The increase in wholesale prices for gas also has been significant, particularly in those markets which 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 FPC residential heating provides a significant market for natural gas. Shown below is a 5-year historical series of average wholesale natural gas prices in the 15 large metropolitan areas, in cents per thousand cubic feet:

Standard metropolitan statistical area	7/1/67	7/1/69	7/1/70	7/1/71	1/1/72 [1]
Baltimore	42.32	41.98	43.98	52.60	52.60
Boston	60.37	68.64	65.76	76.17	78.14
Chicago	30.03	29.63	31.93	36.04	40.05
Cleveland	42.76	40.50	44.64	49.09	51.32
Detroit	37.11	38.82	39.91	41.48	46.39
Los Angeles	31.24	31.60	34.63	38.78	39.55
Minneapolis	35.20	36.29	36.80	42.59	43.97
Newark	42.23	43.90	43.45	47.18	51.04
New York	41.51	41.52	42.51	45.98	49.74
Philadelphia	40.76	43.20	43.42	46.90	50.96
Pittsburgh	38.85	38.37	43.44	49.78	51.90
St. Louis	33.74	33.77	37.26	47.62	47.86
San Francisco	28.68	30.81	33.67	35.17	35.29
Washington, D.C	48.39	47.13	51.06	61.64	61.78

[1] Reflects contingent rates in effect subject to subsequent reduction and refund.

Table 6.—Average price of residential heating gas, by area, 1965–1972

(cents per 10 therms)

Standard metropolitan statistical area	January 1965	January 1966	January 1967	January 1968	January 1969	January 1970	January 1971	January 1972
Atlanta	0.824	0.824	0.824	0.824	0.824	0.824	0.824	1.009
Baltimore	1.298	1.189	1.284	1.255	1.265	1.332	1.327	1.513
Boston	1.447	1.420	1.416	1.426	1.436	1.499	1.568	1.802
Buffalo	.896	.867	.878	.870	.905	.932	1.028	1.218
Chicago	.909	.926	.932	.944	.895	.965	1.021	1.100
Cincinnati	--	.764	.757	.771	.752	.799	.812	.943
Cleveland	.735	.734	.736	.729	.732	.747	.858	.896
Dallas	.725	.724	.727	.740	.755	.847	.849	.863
Detroit	.855	.852	.850	.850	.850	.866	.873	.953
Houston	--	.767	.767	.772	.871	.875	.928	.957
Kansas City	--	.582	.575	.569	.609	.681	.669	.717
Milwaukee	--	1.067	1.067	1.067	1.101	1.247	1.272	1.350
Minneapolis–St. Paul	--	.860	.823	.810	.851	.877	.913	.998
New York	1.361	1.362	1.305	1.290	1.299	1.320	1.363	1.568
Philadelphia	1.373	1.370	1.380	1.379	1.380	1.381	1.430	1.459
Pittsburgh	.758	.806	.796	.809	.845	.880	.970	1.018
St. Louis	.822	.839	.839	.838	.842	.916	.979	1.093
San Francisco–Oakland	.599	.599	.610	.608	.610	.622	.714	.762
Seattle	.969	1.182	1.157	1.150	1.150	1.159	1.159	1.249
Washington, D.C	1.185	1.095	1.347	1.287	1.315	1.362	1.360	1.505
United States average	.820	.835	.831	.838	.844	.874	.920	1.010

Source: Bureau of Labor Statistics, Monthly release, "Retail Prices and Indexes of Fuels and Utilities," table 7; U. S. average table 2.

Comparing July 1, 1970, prices with those prevailing at yearend 1971, wholesale rates in 4 of the 14 cities increased by 7 cents or more per Mcf. From July 1, 1971, to end of the year, rates increased nominally or were unchanged in four cities; rates increased by 4 to 5 cents in four other cities and from 1 to 2 cents in the remaining areas.

Comparing the trend of wholesale prices of natural gas with other fossil fuels such as bituminous coal and middle distillate and residual fuel oil, the percent increase in gas prices, despite the recent spurt upward, was less than the other fuels shown in the tabulation below, in the 1965–1971 period:

	1968–1971	1965–1971
Natural gas [1]	19.6	16.3
Bituminous coal [2]	87.5	109.2
Middle distillate fuel oil	7.7	19.4
Residual fuel oil	61.3	43.3

[1] Based on sales for resale by major interstate pipeline companies.
[2] Based on Bureau of Labor Statistics Wholesale Price Indexes.

The wholesale prices for gas for cities shown above, 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 deliveries are made at the California border.

At the retail level, the Bureau of Labor Statistics (BLS) compiles price information for fuels and energy, relative to development of the BLS Consumers Price Index. Average prices for fuels and energy are published monthly for 20 Standard Metropolitan Statistical Areas indicated in table 6.[8]

Retail Prices.—At the retail level, gas is sold in units either of 1,000 cubic feet Mcf or of therms. A therm contains 100,000 Btu. For illustrative purposes 1 cubic foot of natural gas contains about 1,000 Btu, so that 1 therm would contain about 100 cubic feet of natural gas and 100 therms about 10,000 cubic feet or 10 Mcf.[9] Since both the average wellhead value and the FPC wholesale price series are on an Mcf basis, the BLS retail price series shown in table 5 has been converted from 100 therms to 10 therms so that the retail price approximates 1,000 cubic feet or 1 Mcf.

Although retail prices of natural gas have been moving upward for some time now, significant increases are a recent development as indicated in table 6. 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 cents or 9 percent higher than in 1965. Between the end of 1970, and the end of 1971, however, the retail price of gas in Boston jumped from 1.568 cents to 1.802 cents or 14.9 percent; New York from 1.363 to 1.568 or 15 percent; Baltimore from 1.327 to 1.513, or 14 percent. Further increases are a foregone conclusion in light of actions taken by the FPC in opinions and orders related to area pricing.

In examining these retail prices it should be recognized that the 100-therm price is a "block price" for gas used for heating. The rate structure of utilities is broken into block meter rates. The first block contains a minimum charge. In January 1971, monthly bills for 10 therms for uses other than heating ranged from $1.56 in Cincinnati to $5.18 in Boston. Most bills (15 cities) cluster between $2 to $3 monthly. Minimum charges are a standard characteristic of gas distributors' rate schedules. In those areas where gas for househeating is a major consideration in terms of gas used, the block meter rate, after the block containing the minimum charge, would be lower per therm. The prices shown in table 6 are not true "bill" prices, but "heating block(s)" prices.

FOREIGN TRADE

On the export side of the equation, Japan is by far our most important customer. In 1971, exports of liquefied natural gas in LNG tankers totaled 50,230,855 Mcf valued at $26,189,891, according to the U.S. Bureau of the Census. In addition, U.S. pipelines exported 30 billion cubic feet to Canada and Mexico in 1971, 18 percent above 1970 exports. Exports to Canada increased by one-third to 14.3 billion cubic feet. Exports to Mexico were 15.8 billion cubic feet, a 7.5-percent increase over the 1970 level. The

[8] BLS monthly release, "Retail Prices and Indexes of Fuels and Utilities."
[9] It should be noted that the Btu value of natural gas dry has been 1,031 Btu per cubic foot in 1969, 1970, and 1971, and not a flat 1,000 Btu as used in the retail price comparison above.

Table 7.—Natural gas imports via pipeline: Volume, value, and unit cost, 1970–1971

Importing companies	Point of entry	Gas volume (thousand cubic feet at 14.73 psia and 60° F)		Percent change	Value		Average price (cents per thousand cubic feet)	
		1971	1970		1971	1970	1971	1970
IMPORTS FROM CANADA								
Interstate companies:								
El Paso Natural Gas Co	Sumas, Wash	189,134,499	174,098,302	8.6	$51,587,768	$43,904,065	27.28	25.22
Do	Eastport, Idaho	51,217,089	49,158,929	4.2	12,961,023	11,865,108	25.31	24.14
Great Lakes Gas Transmission Co	Noyes, Minn	[1] 99,101,385	48,933,800	102.5	31,205,588	13,911,500	31.49	28.43
Michigan Wisconsin Pipe Line Co	do	18,250,000	1,533,641	1,090.0	5,866,606	490,765	32.15	32.00
Midwestern Gas Transmission Co	do	119,483,497	121,751,727	[2] (1.9)	35,617,678	34,363,600	29.81	28.22
Pacific Gas Pipeline Co	Eastport, Idaho	354,001,740	304,481,244	16.3	89,958,676	72,584,839	25.41	23.84
Tennessee Gas Pipeline Co	Niagara Falls, N.Y	19,170,554	28,142,586	[2] (31.9)	8,417,655	10,835,483	43.91	38.50
Total interstate		850,358,764	728,100,229	16.8	235,614,994	187,955,360	27.71	25.81
Intrastate companies:								
ICG Transmission Ltd	Near Sprague, Manitoba (Canada)	[3] 7,152,989	--	--	3,329,708	--	46.55	--
The Montana Power Co	Whitlash, Mont	16,020,505	17,429,429	[2] (8.1)	2,850,228	2,947,257	17.79	16.91
Do	Babb, Mont	28,627,116	25,130,768	13.9	6,541,137	5,622,699	22.85	22.37
The St. Lawrence Gas Co., Inc	Massena, N.Y	5,946,086	5,495,012	8.2	3,312,039	2,934,134	55.70	53.40
Vermont Gas Systems, Inc	Highgate Falls, Vt	2,819,689	2,532,311	11.4	1,783,333	1,516,795	63.25	59.90
Total intrastate		60,566,385	50,587,520	19.7	17,816,445	13,020,885	29.41	25.74
Subtotal Canada		910,925,149	778,687,749	17.0	253,431,439	200,976,245	27.82	25.81
IMPORTS FROM MEXICO								
Interstate company:								
Texas Eastern Transmission Corp	McAllen, Tex	20,651,695	41,302,499	[2] (50.0)	3,405,267	6,810,386	16.49	16.49
Intrastate company:								
City of Roma, Texas	Roma, Tex	37,706	33,731	11.8	9,519	8,516	25.25	25.25
Subtotal Mexico		20,689,401	41,336,230	[2] (49.9)	3,414,786	6,818,902	16.51	16.50
Grand total imports		931,614,550	820,023,979	13.6	256,846,225	207,795,147	27.57	25.34

[1] In addition to this amount 240,055,570 thousand cubic feet (Mcf) were received from Trans-Canada Pipe Lines Ltd. for transportation and redelivery to Trans-Canada at St. Clair and Sault Ste. Marie, Mich.

[2] Figures in parentheses denote decreases.

[3] In addition to this amount 1,962,492 Mcf were received from Trans-Canada Pipe Lines Ltd. for transportation and redelivery at Rainy River, Ontario, Canada, for consumption in Canada.

Source: Federal Power Commission.

rise in exports was accompanied by an increase in total value, from $9 million in 1970 to $11.8 million in 1971, or 28.6 percent.

The National Energy Board of Canada issued a license to Westcoast Transmission Co., Ltd., to increase exports of natural gas to El Paso Natural Gas Co. by 76 million cubic feet per day (27,740 million cubic feet per year) over a 20-year period. Westcoast Transmission received a second license allowing deliveries of 733 million cubic feet per day starting November 1, 1971, and 809 million cubic feet per day beginning November 1, 1972, an annual rate of 295.3 billion cubic feet.

Imports of natural gas via pipelines from Canada and Mexico and exports of liquefied natural gas by LNG tankers to Japan from Alaska constitute most of the foreign trade of the United States in natural gas. The remaining trade is limited primarily to exports to and imports from Mexico. Also, small amounts of natural gas were imported as LNG from Algeria and Canada.

In 1971, imports of natural gas by pipeline from Canada established new records; to 910.9 billion cubic feet, a volume 132.2 billion or 17 percent greater than in 1970. On a daily average basis, imports of Canadian gas in 1971 averaged nearly 2,496 million cubic feet per day as compared with 2,133 million per day in 1970.

Imports from Canada have increased eightfold in the 12-year period 1960–1971; from 109,855 million cubic feet in 1960 to 910,925 million cubic feet by yearend 1971, and the end of the uptrend is not in sight. It is expected that imports of natural gas from Canada will top 1 trillion cubic feet in 1972, or 2,740 million cubic feet per day.

As to future imports other than via pipelines, the FPC has approved the import by the Distrigas Corp. of 15.4 billion cubic feet of liquefied natural gas annually from Algeria over a 20-year period beginning in 1971. The import of 1 billion cubic feet per day of natural gas from Algeria, as requested by the El Paso Natural Gas Co., was still awaiting approval by the FPC at the end of 1971.

Seven out of every 10 cubic feet of gas imported into the United States from Canada enters the United States west of the Rocky Mountains. Most of the gas enters the United States at Eastport, Idaho, and at Sumas, Wash. In the midwest the gas crosses the border at Noyes, Minn. and is picked up by three pipelines serving the midwest as indicated in table 7.

Imports from Mexico however, were reduced sharply to 20.7 billion cubic feet from 41.3 billion cubic feet in 1970, nearly a 50-percent reduction. All of the curtailment was in natural gas entering the United States by pipeline at McAllen, Tex.

WORLD REVIEW

Production of natural gas continued to climb in 1971, but the widest gains were made outside the United States. Although production of natural gas in 1971 in the United States was triple that of the Soviet Union, the world's second largest gas producer, the yearly gains made by the U.S.S.R. are steadily narrowing that gap. In 1971, production in the U.S. increased 2.6 percent or 572,370 million cubic feet to 22,493 billion cubic feet. At the same time, production in the Soviet Union increased 385,000 million cubic feet or 5 percent to 7,448 billion cubic feet. Likewise, natural gas production in Canada, the third largest producing country, totaled 2,498 billion cubic feet, an increase of 9 percent over the 2,295 billion produced in 1970.

The most spectacular growth in production is occurring in the Netherlands, which ranks fourth in world production. In 1971, marketed production was 1,535 billion cubic feet, 38.6 percent higher than in 1970 when volumes reached 1,107 billion cubic feet.

These gains in Europe, particularly, are understandable. The Netherlands accounts for more than half of Europe's known natural gas reserves. Furthermore, more than one-third of the Netherlands output is exported and, based on long-term agreements, half of output will be reserved for exports to neighboring countries by 1975.

Although the Netherlands enjoys a strong market now, the Soviet Union is generally expected over the longer term to become the largest supplier of natural gas to Western Europe by pipeline. At the present time, however, the only western recipient of Soviet gas is Austria, where deliveries began in September 1968. Exports of natural gas to neighboring countries by the U.S.S.R. are to be made through a network of gas pipelines through Czechoslovakia, Poland, Bulgaria, and East Germany to Austria, Italy, West Germany, Finland, and eventually, France and Switzerland.

According to agreement a natural gas transmission line with an annual capacity of 28 billion cubic meters (989 billion cubic feet) will begin to deliver gas from the Soviet Union, to the countries described above, sometime in 1973. Austria, Italy, West Germany, and Finland provided the U.S.S.R. with credits for the purchase from these countries of large-diameter pipe and related equipment. Natural gas transmission lines in the Soviet Union aggregated about 40,389 miles at the end of 1970 and plans are to construct about 16,500 miles of additional main lines during the 1971–1975 period.

In Romania, the world's fifth-largest producing country, production of natural gas increased from 875,443 million to 935,269 million cubic feet, a gain of 6.8 percent.

Table 8.—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]
1970						
Alaska	130,491	87,363	217,854	111,576	71,470	34,808
Arkansas	128,241	55,409	183,650	181,351	2,073	226
California	296,001	431,244	727,245	649,117	75,629	2,499
Colorado	93,221	21,936	115,157	105,804	2,227	7,126
Illinois	198	4,774	4,972	4,850	--	122
Indiana	153	--	153	153	--	--
Kansas	752,934	151,541	904,475	899,955	1,807	2,713
Kentucky	77,695	197	77,892	77,892	--	--
Louisiana	6,811,334	1,264,823	8,076,157	7,788,276	133,792	154,089
Maryland	813	--	813	813	--	--
Michigan	23.774	16,264	40,038	38,851	378	809
Mississippi	123,737	33,283	157,020	126,031	23,756	7,233
Montana	37,684	10,618	48,302	42,705	394	5,203
Nebraska	3,990	2,319	6,309	5,991	318	--
New Mexico	832,771	309,118	1,141,889	1,138,980	--	2,909
New York	3,358	--	3,358	3,358	--	--
North Dakota	140	54,611	54,751	34,889	--	19,862
Ohio	39,694	12,419	52,113	52,113	--	--
Oklahoma	1,429,408	381,596	1,811,004	1,594,943	86,432	129,629
Pennsylvania	76,716	398	77,114	76,841	273	--
Texas	7,165,388	2,233,138	9,398,526	8,357,716	940,505	100,305
Utah	21,609	51,777	73,386	42,781	27,753	2,852
Virginia	2,805	--	2,805	2,805	--	--
West Virginia	239,787	3,194	242,981	242,452	529	--
Wyoming	301,310	64,192	365,502	338,520	8,563	18,419
Other States [3]	1,406	1,581	2,987	1,879	452	656
Total	18,594,658	5,191,795	23,786,453	21,920,642	1,376,351	489,460
1971						
Alabama	2	661	663	355	--	308
Alaska	125,169	103,003	228,172	121,618	72,674	33,880
Arizona	873	342	1,215	868	--	347
Arkansas	120,454	54,429	174,883	172,154	995	1,734
California	293,254	385,990	679,244	612,629	66,040	575
Colorado	84,303	29,037	113,340	108,537	1,960	2,843
Florida	--	1,258	1,258	903	--	355
Illinois	498	3,997	4,495	498	--	3,997
Indiana	537	--	537	537	--	--
Kansas	729,262	160,330	889,592	885,144	1,779	2,669
Kentucky	72,546	177	72,723	72,723	--	--
Louisiana	7,011,666	1,306,885	8,318,551	8,081,907	133,080	103,564
Maryland	214	--	214	214	--	--
Michigan	10,968	15,482	26,450	25,662	788	--
Mississippi	107,727	28,809	136,536	118,805	12,641	5,090
Missouri	22	--	22	22	--	--
Montana	31,195	6,941	38,136	32,720	499	4,917
Nebraska	3,028	2,026	5,054	3,496	--	1,558
New Mexico	861,520	308,880	1,170,400	1,167,577	--	2,823
New York	2,202	--	2,202	2,202	--	--
North Dakota	146	52,346	52,492	33,864	--	18,628
Ohio	61,845	18,058	79,903	79,903	--	--
Oklahoma	1,425,847	383,239	1,809,086	1,684,260	85,027	39,799
Pennsylvania	74,081	2,370	76,451	76,451	--	--
South Dakota	--	9	9	--	9	--
Tennessee	99	398	497	89	--	408
Texas	7,327,186	2,191,458	9,518,644	8,550,705	897,717	70,222
Utah	26,571	47,689	74,260	42,418	28,916	2,926
Virginia	2,619	--	2,619	2,619	--	--
West Virginia	232,205	2,109	234,314	234,027	287	--
Wyoming	319,097	72,914	392,011	380,105	8,046	3,860
Total	18,925,136	5,178,837	24,103,973	22,493,012	1,310,458	300,503

[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.
[3] Alabama, Arizona, Florida, Missouri, South Dakota, and Tennessee.

Source: Figures based on reports received from State agencies and Bureau of Mines estimates.

Table 9.—Marketed production, interstate shipments, and total consumption of natural gas in the United States in 1971

(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
New England:							
Connecticut	--	160,212	97,323	62,889	--	1,455	61,434
Maine, New Hampshire, Vermont	--	12,435	--	12,435	--	347	12,088
Massachusetts	--	194,531	36,071	158,460	96	1,913	156,451
Rhode Island	--	102,544	76,838	25,706	--	44	25,662
Total	--	469,722	210,232	259,490	96	3,759	255,635
Middle Atlantic:							
New Jersey	--	853,285	511,779	341,506	157	14,581	326,768
New York	2,202	1,004,774	254,365	750,409	7,419	28,642	716,550
Pennsylvania	76,451	2,155,052	1,390,196	764,856	18,777	20,362	802,168
Total	78,653	4,013,111	2,156,340	1,856,771	26,353	63,585	1,845,486
East North Central:							
Illinois	498	2,537,661	1,199,376	1,338,285	87,592	8,394	1,242,797
Indiana	537	2,074,282	1,494,970	579,312	6,877	5,976	566,996
Michigan	25,662	839,385	14,236	825,149	6,876	−8,640	852,575
Ohio	79,903	3,098,756	2,064,911	1,033,845	20,083	6,539	1,087,126
Wisconsin	--	409,134	60,039	349,095	--	963	348,132
Total	106,600	8,959,218	4,833,532	4,125,686	121,428	13,232	4,097,626
West North Central:							
Iowa	--	1,377,917	1,022,972	354,945	7,786	2,520	344,639
Kansas	885,144	2,148,750	2,370,594	−221,844	184	16,386	646,730
Minnesota	--	600,050	239,456	360,594	--	9,152	351,442
Missouri	22	1,709,375	1,273,536	435,839	1,445	5,311	429,105
Nebraska	3,496	1,430,865	1,218,806	212,059	3,626	−12,344	224,273
North Dakota	33,864	10,540	6,618	3,922	--	617	37,169
South Dakota	--	36,607	4,613	31,994	--	162	31,832
Total	922,526	7,314,104	6,136,595	1,177,509	13,041	21,804	2,065,190
South Atlantic:							
Delaware	--	28,938	2,006	26,932	189	291	26,452
Florida	903	336,912	--	336,912	--	914	336,901
Georgia	--	1,451,190	1,097,561	353,629	--	11,050	342,579
Maryland, District of Columbia	214	887,732	693,404	194,328	2,312	3,859	188,371
North Carolina	--	916,766	752,345	164,421	--	3,854	160,567
South Carolina	--	1,076,171	916,766	159,405	--	3,142	156,263
Virginia	2,619	1,024,162	876,573	147,589	2,039	4,155	144,014
West Virginia	234,027	1,456,042	1,491,297	−35,255	29,246	−19,793	189,319
Total	237,763	7,177,913	5,829,952	1,347,961	33,786	7,472	1,544,466

East South Central:							
Alabama	355	3,324,993	3,045,698	279,295	183	−6,787	286,254
Kentucky	72,723	4,007,330	3,810,758	196,572	16,220	2,582	250,493
Mississippi	118,805	6,622,133	6,350,901	271,232	860	9,639	379,538
Tennessee	89	4,287,786	4,014,046	273,740	--	8,818	265,011
Total	191,972	18,242,242	17,221,403	1,020,839	17,263	14,252	1,181,296
West South Central:							
Arkansas	172,154	2,886,765	2,703,083	183,682	566	19,063	336,207
Louisiana	8,081,907	1,140,338	7,050,301	−5,909,963	69,864	23,084	2,078,996
Oklahoma	1,684,260	1,535,753	2,517,696	−981,943	20,968	13,853	667,496
Texas	8,550,705	566,763	4,217,195	−3,650,432	2,398	84,859	4,813,016
Total	18,489,026	6,129,619	16,488,275	−10,358,656	93,796	140,859	7,895,715
Mountain:							
Arizona	868	1,539,074	1,322,591	216,483	--	4,038	213,313
Colorado	108,537	307,246	119,777	187,469	−594	3,079	293,521
Idaho	--	504,589	453,035	51,554	--	1,458	50,096
Montana	32,720	85,814	18,964	66,850	6,804	3,745	89,021
Nevada	--	67,965	--	67,965	--	1,454	66,511
New Mexico	1,167,577	941,843	1,774,348	−832,505	--	11,894	323,178
Utah	42,418	261,708	176,992	84,716	155	1,754	125,225
Wyoming	380,105	97,716	340,703	−242,987	6,774	2,256	128,088
Total	1,732,225	3,805,955	4,206,410	−400,455	13,139	29,678	1,288,953
Pacific:							
Alaska	121,618	--	50,231	−50,231	--	3,582	67,805
California	612,629	1,611,970	--	1,611,970	11,624	36,126	2,176,849
Oregon	--	443,716	340,884	102,832	--	1,935	100,897
Washington	--	592,324	431,704	160,620	1,242	2,715	156,663
Total	734,247	2,648,010	822,819	1,825,191	12,866	44,358	2,502,214
Total United States	22,493,012	[1] 58,759,894	[2] 57,905,558	854,336	331,768	338,999	22,676,581

[1] Includes receipts from Canada of 405,219 million cubic feet (Mmcf) into Idaho; 249,935 Mmcf into Minnesota; 189,134 Mmcf into Washington; 44,647 Mmcf into Montana; 19,171 Mmcf into New York; and 2,820 Mmcf into Vermont; and from Mexico 20,689 Mmcf into Texas; and imports of 2,933 Mmcf into Massachusetts from Canada and Algeria.

[2] Includes deliveries into Canada of 14,236 Mmcf from Michigan; 113 Mmcf from Montana, and into Mexico 11,126 Mmcf from Texas; and 4,659 Mmcf from Arizona; and exports of 50,231 Mmcf to Japan from Alaska.

Table 10.—Gas wells and condensate wells in the United States

PAD district and State	Completed during 1970 [1]	Completed during 1971 [1]	Producing as of Dec. 31, 1970	Producing as of Dec. 31, 1971 [2]
District 1:				
Maryland	--	--	16	14
New York	17	7	600	600
Pennsylvania	250	199	16,239	16,586
Florida	--	--	--	--
Virginia	--	--	115	115
West Virginia	553	496	20,702	21,025
Total	820	702	37,672	38,340
District 2:				
Illinois	5	16	8	14
Indiana	4	2	50	50
Kansas	108	112	8,660	8,585
Kentucky	111	135	6,913	7,413
Michigan	19	33	1,235	1,171
Missouri	--	1	11	2
Nebraska	2	1	35	29
North Dakota	1	1	29	29
Ohio	683	608	7,789	8,179
Oklahoma	321	238	8,168	8,507
Tennessee	4	23	15	20
Total	1,258	1,170	32,913	33,999
District 3:				
Alabama	5	6	2	--
Arkansas	36	29	1,008	1,013
Louisiana	539	621	9,690	[3] 8,822
Mississippi	12	13	325	400
New Mexico	159	186	8,848	9,388
Texas	774	810	23,417	23,280
Total	1,525	1,665	43,290	42,903
District 4:				
Colorado	47	148	861	928
Montana	74	33	739	1,056
Utah	10	6	173	178
Wyoming	45	43	800	840
Total	176	230	2,573	3,002
District 5:				
Alaska	5	1	51	40
Arizona	--	2	r 4	5
California	56	60	980	962
Nevada	--	--	--	--
Total	61	63	1,035	1,007
Total United States	3,840	3,830	117,483	119,251

r Revised.
[1] Source: American Association of Petroleum Geologists and American Petroleum Institute.
[2] Based on State estimates and reports.
[3] Only wells assigned allowables by the Louisiana Department of Conservation.

Table 11.—Interstate pipeline movements of natural gas in the United States in 1971

(Billion cubic feet at 14.73 psia)

State and region	Net receipt (+) or delivery (−)	Moved from (receipts)						Moved to (deliveries)					
		State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity
New England:													
Connecticut	62.9	N.Y.	139.0	Mass.	21.2	--	--	R.I.	97.3	--	--	--	--
Maine, New Hampshire, Vermont	12.4	Mass.	9.6	Canada	2.8	--	--	--	--	--	--	--	--
Massachusetts	158.5	N.Y.	114.8	R.I.	71.6	Algeria	1.4	Conn.	21.2	N.H.	9.6	--	--
	--	Canada	1.5	--	--	--	--	--	--	--	--	--	--
Rhode Island	25.7	Conn.	97.3	--	--	--	--	Mass.	71.6	--	--	--	--
Total	259.5	N.Y.	253.8	Algeria	1.4	Canada	4.3	--	--	--	--	--	--
Middle Atlantic:													
New Jersey	341.5	Pa.	852.8	--	--	--	--	N.Y.	511.3	--	--	--	--
New York	750.4	N.J.	511.3	Pa.	473.6	Canada	19.2	Conn.	139.0	Mass.	114.8	--	--
Pennsylvania	764.9	W. Va.	832.9	Md.	680.4	Ohio	607.0	N.J.	852.8	N.Y.	473.6	Del.	28.9
Total	1,856.8	W. Va.	832.9	Md.	680.4	Ohio	607.0	Conn.	139.0	Mass.	114.8	Del.	28.9
	--	Canada	19.2	--	--	--	--	--	--	--	--	--	--
East North Central:													
Illinois	1,338.3	Mo.	1,099.3	Iowa	661.5	Ky.	598.6	Ind.	846.2	Wis.	174.9	--	--
Indiana	579.3	Ky.	1,049.8	Ill.	846.2	--	--	Ohio	1,316.7	--	--	--	--
Michigan	825.1	Ohio	779.3	Wis.	60.0	--	--	Canada	14.2	--	--	--	--
Ohio	1,033.8	Ky.	1,377.4	Ind.	1,316.7	--	--	Mich.	779.3	W. Va.	273.8	Pa.	607.0
Wisconsin	349.1	Minn.	234.2	Ill.	174.9	--	--	Mich.	60.0	--	--	--	--
Total [1]	4,125.7	Ky.	3,025.8	Mo.	1,099.3	Iowa	661.5	Pa.	607.0	W. Va.	273.8	Canada	14.2
	--	Minn.	234.2	--	--	--	--	--	--	--	--	--	--
West North Central:													
Iowa	354.9	Nebr.	1,205.2	Mo.	172.3	--	--	Ill.	661.5	Minn.	349.7	S. Dak.	11.3
Kansas	−221.8	Okla.	2,120.8	--	--	--	--	Nebr.	1,394.0	Mo.	895.8	Colo.	52.9
Minnesota	353.4	Iowa	349.7	Canada	249.9	S. Dak.	.4	Wis.	234.2	N. Dak.	5.2	--	--
Missouri	435.8	Kans.	895.8	Ark.	811.2	Okla.	.5	Ill.	1,099.3	Iowa	172.3	--	--
Nebraska	212.1	Kans.	1,394.0	Wyo.	31.9	Colo.	2.8	Iowa	1,205.2	S. Dak.	11.3	--	--
North Dakota	3.9	--	--	Minn.	5.2	--	--	Mont.	1.3	--	--	--	--
South Dakota	32.0	Mont.	10.2	Iowa	11.3	Nebr.	11.3	--	--	Wyo.	.5	Minn.	.4
Total [1]	1,177.6	Okla.	2,121.3	Ark.	811.2	Canada	249.9	Ill.	1,760.8	Wis.	234.2	Colo.	50.1
	--	Wyo.	31.4	Mont.	8.9	--	--	--	--	--	--	--	--

Table 11.—Interstate pipeline movements of natural gas in the United States in 1971—Continued

(Billion cubic feet at 14.73 psia)

State and region	Net receipt (+) or delivery (−)	Moved from (receipts)						Moved to (deliveries)					
		State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity
South Atlantic:													
Delaware	26.9	Pa.	28.9	--	--	--	--	Md.	2.0	--	--	--	--
Florida	336.9	Ala.	327.9	Ga.	9.1	--	--	--	--	--	--	--	--
Georgia	353.6	Ala.	1,451.2	--	--	--	--	S.C.	1,076.2	Tenn.	12.3	Fla.	9.1
Maryland, District of Columbia	194.3	Va.	872.4	W. Va.	.2	Del.	2.0	Pa.	680.4	--	--	--	--
North Carolina	164.4	S.C.	916.8	--	--	--	--	Va.	752.3	--	--	--	--
South Carolina	159.4	Ga.	1,076.2	--	--	--	--	N.C.	916.8	--	--	--	--
Virginia	147.6	N.C.	752.3	W. Va.	261.0	Tenn.	6.7	Md.	857.7	D.C.	14.8	--	--
West Virginia	−35.3	Ky.	785.0	Ohio	273.8	--	--	Pa.	832.9	--	--	Va.	261.0
	--	--	--	--	--	--	--	Md.	.2	--	--	--	--
Total [1]	1,348.0	Ala.	1,779.1	Ky.	785.0	Ohio	273.8	Pa.	1,484.4	Tenn.	5.6	--	--
East South Central:													
Alabama	279.3	Miss.	3,308.2	--	--	--	--	Ga.	1,451.2	Tenn.	1,249.8	Fla.	327.9
Kentucky	196.6	Tenn.	4,007.3	--	--	--	--	Ohio	1,377.4	Ind.	1,049.8	W. Va.	785.0
	--	--	--	--	--	--	--	Ill.	598.6	--	--	--	--
Mississippi	271.2	La.	4,720.4	Ark.	1,884.7	--	--	Ala.	3,308.2	Tenn.	3,025.6	--	--
Tennessee	273.7	Miss.	3,025.6	Ala.	1,249.8	Ga.	12.3	Ky.	4,007.3	Va.	6.7	--	--
Total	1,020.8	La.	4,720.4	Ark.	1,884.7	--	--	Ohio	1,377.4	Ga.	1,438.9	Ind.	1,049.8
	--	--	--	--	--	--	--	W. Va.	785.0	Ill.	598.6	Fla.	327.9
	--	--	--	--	--	--	--	Va.	6.7	--	--	--	--
West South Central:													
Arkansas	183.7	La.	2,119.7	Tex.	616.6	Okla.	143.2	Miss.	1,884.7	Mo.	811.2	--	--
Louisiana	−5,910.0	Tex.	930.1	--	--	--	--	Miss.	4,720.4	Ark.	2,119.7	--	--
Oklahoma	−981.9	Tex.	1,364.2	--	--	--	--	Kans.	2,120.8	--	--	Ark.	143.2
	--	--	--	--	--	--	--	Colo.	81.6	Mo.	.5	--	--
Texas	−3,650.4	--	--	--	--	--	--	Okla.	1,354.2	La.	930.1	N. Mex.	749.3
	--	Mexico	9.6	--	--	--	--	Ark.	616.6	--	--	--	--
Total [1]	−10,358.7	Mexico	9.6	--	--	--	--	Miss.	6,605.1	Kans.	2,120.8	Mo.	811.7
	--	--	--	--	--	--	--	N. Mex.	749.3	Colo.	81.6	--	--
Mountain:													
Arizona	216.5	N. Mex.	1,529.9	Utah	4.6	--	--	Calif.	1,272.4	Nev.	40.9	--	--
	--	--	--	--	--	--	--	Mexico	4.7	--	--	--	--
Colorado	187.5	Wyo.	106.5	Okla.	81.6	Kans.	52.9	Utah	102.7	--	--	Nebr.	2.8
	--	N. Mex.	52.0	--	--	--	--	--	--	--	--	--	--
Idaho	51.6	Canada	405.2	Utah	37.3	--	--	Wash.	389.8	Nev.	27.0	Oreg.	24.1
Montana	67.0	Canada	44.6	Wyo.	31.2	N. Dak.	1.3	S. Dak.	10.2	--	--	Canada	.1
Nevada	68.0	Ariz.	40.9	Idaho	27.0	--	--	--	--	--	--	--	--
New Mexico	−832.5	Tex.	749.3	--	--	--	--	Ariz.	1,529.9	--	--	Colo.	52.0
Utah	84.7	Wyo.	73.9	Colo.	102.7	--	--	Idaho	87.3	--	--	Ark.	4.6

Wyoming	−243.0	--	--	--	--	S. Dak.	.5	Utah	73.9	Colo.	106.5	Nebr.	31.9
	--	--	--	--	--	--	--	Mont.	31.2	--	--	--	--
Total [1]	−400.5	Tex.	749.3	Canada	449.8	Okla.	81.6	Calif.	1,272.4	Wash.	389.8	Nebr.	34.7
	--	Kans.	52.9	N. Dak.	1.3	--	--	S. Dak.	10.2	Oreg.	24.1	Mexico	4.7
	--	--	--	--	--	--	--	Canada	.1	--	--	--	--
Pacific:													
Alaska	−50.2	--	--	--	--	--	--	Japan	50.2	--	--	--	--
California	1,612.0	Ariz.	1,272.4	Oreg.	339.6	--	--	--	--	--	--	--	--
Oregon	102.8	Wash.	418.3	Idaho	24.1	--	--	Calif.	339.6	--	--	--	--
Washington	160.6	Idaho	389.8	Canada	189.1	--	--	Oreg.	418.3	--	--	--	--
Total	1,825.2	Ariz.	1,272.4	Idaho	413.9	Canada	189.1	Japan	50.2	--	--	--	--
Total United States	854.4	--	--	--	--	--	--	--	--	--	--	--	--
Foreign:													
Canada	--	--	912.5	--	--	--	--	--	14.3	--	--	--	--
Mexico	--	--	20.7	--	--	--	--	--	15.8	--	--	--	--
Japan	--	--	--	--	--	--	--	--	50.2	--	--	--	--
Algeria	--	--	1.4	--	--	--	--	--	--	--	--	--	--

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

Table 12.—Quantity and value of natural gas delivered to consumers in 1971, by type of consumer and by State

State and region	Residential: Number of consumers	Residential: Quantity (million cubic feet) [3]	Residential: Value (thousands)	Commercial: Number of consumers	Commercial: Quantity (million cubic feet) [3]	Commercial: Value (thousands)	Industrial [1]: Quantity (million cubic feet) [3] [4]	Industrial [1]: Value (thousands)	Electric utilities: Quantity (million cubic feet) [5]	Electric utilities: Value (thousands)	Other consumers [2]: Quantity (million cubic feet) [3]	Other consumers [2]: Value (thousands)	Total: Quantity (million cubic feet) [3]	Total: Value (thousands)
New England:														
Connecticut	371	31,878	$65,956	29	11,912	$19,941	13,352	$15,448	87	$34	4,161	$5,010	61,390	$106,389
Maine, New Hampshire, Vermont	66	5,591	11,481	5	3,062	4,941	2,697	2,521	196	90	542	448	12,088	19,481
Massachusetts	987	83,434	176,797	64	32,419	54,010	25,453	27,235	9,915	4,323	4,575	5,042	155,796	267,407
Rhode Island	153	12,160	23,493	10	4,185	6,838	6,157	5,898	2,791	1,401	345	495	25,638	38,125
Total	1,577	133,063	277,727	108	51,578	85,730	47,659	51,102	12,989	5,848	9,623	10,995	254,912	431,402
Middle Atlantic:														
New Jersey	1,604	143,197	278,661	175	58,278	85,785	82,485	60,956	39,985	18,953	1,952	1,929	325,897	446,284
New York	3,859	352,085	527,071	268	123,908	162,815	116,557	89,865	98,573	43,668	21,550	21,226	712,673	844,645
Pennsylvania	2,216	304,327	389,539	148	99,501	102,088	347,706	226,357	9,748	4,845	10,513	8,631	771,795	731,460
Total	7,679	799,609	1,195,271	591	281,687	350,688	546,748	377,178	148,306	67,466	34,015	31,786	1,810,365	2,022,389
East North Central:														
Illinois	2,864	462,644	495,954	213	203,578	160,623	406,676	228,145	125,874	49,091	6,846	3,259	1,205,618	937,072
Indiana	1,019	162,747	175,767	102	76,486	67,537	282,459	144,337	31,440	12,167	1,498	1,189	554,630	400,997
Michigan	1,929	343,773	365,431	166	141,821	123,952	273,184	154,349	69,777	33,074	4,396	3,095	832,951	679,901
Ohio	2,473	460,820	453,447	190	168,482	139,672	398,731	246,017	20,809	10,321	21,309	16,003	1,070,151	865,460
Wisconsin	776	109,758	138,734	64	44,221	44,044	155,935	89,974	29,216	13,030	3,441	1,321	342,571	287,103
Total	9,061	1,539,742	1,629,333	735	634,588	535,828	1,516,985	862,822	277,116	117,683	37,490	24,867	4,005,921	3,170,533
West North Central:														
Iowa	566	92,231	94,721	67	57,419	42,720	101,108	39,735	72,329	23,073	1,719	700	324,806	200,949
Kansas	598	98,644	70,728	58	49,412	24,360	174,789	49,990	174,639	56,234	6,834	2,112	504,318	203,424
Minnesota	609	102,325	121,050	54	51,395	44,457	105,715	47,255	59,092	17,432	25,046	13,575	343,573	243,769
Missouri	1,001	153,384	155,838	86	73,168	52,242	108,231	46,972	67,972	20,799	16,366	6,006	419,121	281,857
Nebraska	325	57,678	53,179	50	36,647	24,334	55,312	20,244	48,913	15,261	10,614	3,407	209,164	116,425
North Dakota	52	8,502	9,344	8	9,059	6,930	1,641	727	375	150	--	--	19,577	17,151
South Dakota	76	12,436	13,704	10	8,819	6,226	5,480	1,923	3,319	1,172	1,773	856	31,827	23,881
Total	3,227	525,200	518,564	333	285,919	201,269	552,276	206,846	426,639	134,121	62,352	26,656	1,852,386	1,087,456
South Atlantic:														
Delaware	78	8,172	13,296	5	3,010	3,826	11,297	7,117	3,973	1,895	--	--	26,452	26,134
Florida	342	13,242	33,595	29	20,514	25,150	97,963	43,300	195,511	78,009	4,964	1,931	332,194	181,985
Georgia	743	88,319	100,065	56	37,499	32,099	142,209	73,522	63,470	20,437	4,382	3,519	335,879	229,642
Maryland, District of Columbia	829	87,617	132,389	64	35,495	42,168	47,781	34,355	9,423	3,326	5,493	4,856	185,809	217,094
North Carolina	294	30,434	40,721	44	18,748	20,848	76,640	41,002	20,927	10,045	7,583	5,028	154,332	117,644
South Carolina	231	19,607	28,822	24	13,713	13,795	79,256	39,152	39,834	17,726	658	357	153,068	99,852
Virginia	463	49,488	75,321	46	25,913	28,867	48,284	27,425	4,204	1,560	8,759	5,676	136,648	138,849

West Virginia	355	55,629	52,180	29	19,802	14,613	86,153	44,800	385	133	3,304	2,336	165,273	114,062
Total	3,335	352,508	476,389	297	174,694	181,366	589,583	310,673	337,727	133,131	35,143	23,703	1,489,655	1,125,262
East South Central:														
Alabama	539	54,867	65,072	41	35,902	23,659	163,370	63,878	9,987	3,216	755	377	264,881	156,202
Kentucky	525	84,197	74,093	51	32,697	23,836	71,484	38,530	8,910	2,976	9,655	6,083	206,943	145,518
Mississippi	341	40,196	37,945	44	21,136	13,865	143,631	47,398	103,353	31,626	4,717	2,302	313,033	133,136
Tennessee	394	46,992	45,864	51	40,224	31,938	127,702	56,955	18,082	4,973	3,838	1,892	236,838	141,622
Total	1,799	226,252	222,974	187	129,959	93,298	506,187	206,761	140,332	42,791	18,965	10,654	1,021,695	576,478
West South Central:														
Arkansas	381	48,737	38,356	50	29,715	16,492	149,497	46,045	86,429	24,459	1,117	379	315,495	125,731
Louisiana	838	79,893	66,791	71	32,517	17,787	1,006,462	273,758	361,339	87,083	34,998	9,869	1,515,209	455,288
Oklahoma	641	75,238	65,758	67	37,528	20,265	126,567	34,300	240,802	51,532	4,450	2,172	484,585	174,027
Texas	2,681	237,387	235,725	246	97,702	57,253	1,933,233	477,509	1,167,821	333,997	44,721	13,327	3,480,864	1,117,811
Total	4,541	441,255	406,630	434	197,462	111,797	3,215,759	831,612	1,856,391	497,071	85,286	25,747	5,796,153	1,872,857
Mountain:														
Arizona	443	32,619	39,991	41	21,392	15,210	60,477	28,243	68,440	28,608	4,212	2,333	187,140	114,385
Colorado	558	84,864	63,309	72	61,377	36,680	76,428	23,081	60,174	15,826	1,428	561	284,271	139,457
Idaho	75	8,455	12,632	11	6,779	7,450	28,293	13,835	--	--	1,453	866	44,980	34,783
Montana	140	25,379	23,729	18	15,734	10,762	36,800	13,174	1,075	355	2,375	1,088	81,363	49,108
Nevada	81	7,994	12,087	40	5,939	5,541	10,492	6,022	37,011	16,766	5,075	2,969	66,511	43,385
New Mexico	232	32,396	30,906	23	16,989	11,213	78,840	25,465	49,163	17,944	16,771	5,652	194,159	91,180
Utah	256	49,849	43,518	15	8,489	5,399	58,017	19,378	2,381	721	15	11	118,751	69,027
Wyoming	76	19,463	13,760	11	12,891	6,420	50,446	13,721	2,981	859	1,181	288	86,962	35,048
Total	1,861	261,019	239,932	231	149,590	98,675	399,793	142,919	221,225	81,079	32,510	13,768	1,064,137	576,373
Pacific:														
Alaska	18	6,893	10,553	3	7,534	7,790	10,628	6,749	10,260	4,381	6,722	2,642	42,037	32,115
California	5,704	630,998	652,452	362	226,859	176,723	623,006	272,877	561,658	204,444	12,826	4,887	2,055,347	1,311,383
Oregon	193	21,217	33,947	25	12,417	17,123	58,964	30,249	340	148	1,146	667	94,084	82,134
Washington	272	33,934	48,661	35	20,412	23,147	95,974	42,325	--	--	200	104	150,520	114,237
Total	6,187	693,042	745,613	425	267,222	224,783	788,572	352,200	572,258	208,973	20,894	8,300	2,341,988	1,539,869
Total United States	39,267	4,971,690	5,712,433	3,341	2,172,699	1,883,434	8,163,562	3,342,113	3,992,983	1,288,163	336,278	176,476	19,637,212	12,402,619

[1] Includes refinery fuel use of 1,062,938 million cubic feet.
[2] Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.
[3] Quantities in million cubic feet at 14.73 psia.
[4] Includes 63,699 million cubic feet used for carbon black production.
[5] Source, Federal Power Commission.

Table 13.—Consumption of natural gas in 1971, by use and by State

State and region	Delivered to consumers		Extraction loss		Lease and plant fuel		Pipeline fuel		Total	
	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)	Quantity (million cubic feet) [1]	Value (thousands)
New England:										
Connecticut	61,390	$106,389	--	--	--	--	44	$14	61,434	$106,403
Maine, New Hampshire, Vermont	12,088	19,481	--	--	--	--	--	--	12,088	19,481
Massachusetts	155,796	267,407	--	--	--	--	655	233	156,451	267,640
Rhode Island	25,638	38,125	--	--	--	--	24	9	25,662	38,134
Total	254,912	431,402	--	--	--	--	723	256	255,635	431,658
Middle Atlantic:										
New Jersey	325,897	446,284	--	--	--	--	871	204	326,768	446,488
New York	712,673	844,645	--	--	460	$248	3,417	844	716,550	845,737
Pennsylvania	771,795	731,460	55	$17	2,419	1,130	27,899	8,091	802,168	740,698
Total	1,810,365	2,022,389	55	17	2,879	1,378	32,187	9,139	1,845,486	2,032,923
East North Central:										
Illinois	1,205,618	937,072	13,520	2,799	407	106	23,252	5,185	1,242,797	945,162
Indiana	554,630	400,997	--	--	--	--	12,366	2,869	566,996	403,866
Michigan	832,951	679,901	2,013	529	2,145	414	15,466	4,346	852,575	685,190
Ohio	1,070,151	865,460	--	--	4,302	1,514	12,673	3,359	1,087,126	870,333
Wisconsin	342,571	287,103	--	--	--	--	5,561	1,396	348,132	288,499
Total	4,005,921	3,170 533	15,533	3,328	6,854	2,034	69,318	17,155	4,097,626	3,193,050
West North Central:										
Iowa	324,806	200,949	--	--	--	--	19,833	3,689	344,639	204,638
Kansas	504,318	203,424	39,741	6,796	27,972	6,154	74,699	14,193	646,730	230,567
Minnesota	343,573	243,769	--	--	--	--	7,869	1,983	351,442	245,752
Missouri	419,121	281,857	--	--	--	--	9,984	2,306	429,105	284,163
Nebraska	209,164	116,425	599	106	1,275	265	13,235	2,171	224,273	118,967
North Dakota	19,577	17,151	3,592	801	13,990	2,252	10	2	37,169	20,206
South Dakota	31,827	23,881	--	--	--	--	5	1	31,832	23,882
Total	1,852,386	1,087,456	43,932	7,703	43,237	8,671	125,635	24,345	2,065,190	1,128,175
South Atlantic:										
Delaware	26,452	26,134	--	--	--	--	--	--	26,452	26,134
Florida	332,194	181,985	180	49	294	58	4,233	876	336,901	182,968
Georgia	335,879	229,642	--	--	--	--	6,700	1,461	342,579	231,103
Maryland, District of Columbia	185,809	217,094	--	--	451	216	2,111	458	188,371	217,768
North Carolina	154,332	117,644	--	--	--	--	6,235	1,322	160,567	118,966
South Carolina	153,068	99,852	--	--	--	--	3,195	716	156,263	100,568
Virginia	136,648	138,849	--	--	213	78	7,153	1,588	144,014	140,515

West Virginia	165,273	114,062	10,939	2,932	3,043	952	10,064	3,361	189,319	121,307
Total	1,489,655	1,125,262	11,119	2,981	4,001	1,304	39,691	9,782	1,544,466	1,139,329
East South Central:										
Alabama	264,881	156,202	281	57	476	178	20,616	4,536	286,254	160,973
Kentucky	206,943	145,518	6,133	1,270	2,212	447	35,205	7,745	250,493	154,980
Mississippi	313,033	133,136	1,217	269	5,840	1,045	59,448	12,781	379,538	147,231
Tennessee	236,838	141,622	--	--	1,524	434	26,649	5,756	265,011	147,812
Total	1,021,695	576,478	7,631	1,596	10,052	2,104	141,918	30,818	1,181,296	610,996
West South Central:										
Arkansas	315,495	125,731	2,563	592	6,433	1,242	11,716	2,566	336,207	130,131
Louisiana	1,515,209	455,288	195,072	56,376	292,589	59,688	76,126	16,139	2,078,996	587,491
Oklahoma	484,585	174,027	55,914	12,133	101,126	15,978	25,871	4,657	667,496	206,795
Texas	3,480,864	1,117,811	448,288	135,831	784,773	138,120	99,091	18,233	4,813,016	1,409,995
Total	5,796,153	1,872,857	701,837	204,932	1,184,921	215,028	212,804	41,595	7,895,715	2,334,412
Mountain:										
Arizona	187,140	114,385	--	--	50	8	26,123	4,467	213,313	118,860
Colorado	284,271	139,457	4,152	855	3,231	604	1,867	349	293,521	141,265
Idaho	44,980	34,783	--	--	--	--	5,116	1,212	50,096	35,995
Montana	81,363	49,108	750	122	6,148	824	760	88	89,021	50,142
Nevada	66,511	43,385	--	--	--	--	--	--	66,511	43,385
New Mexico	194,159	91,180	53,810	9,578	46,114	5,672	29,095	4,946	323,178	111,376
Utah	118,751	69,027	3,822	768	2,115	368	537	118	125,225	70,281
Wyoming	86,962	35,048	12,802	2,317	20,348	2,991	7,976	1,388	128,088	41,744
Total	1,064,137	576,373	75,336	13,640	78,006	10,467	71,474	12,568	1,288,953	613,048
Pacific:										
Alaska	42,037	32,115	99	26	8,459	1,751	17,210	4,664	67,805	38,556
California	2,055,347	1,311,383	27,585	11,862	75,241	22,422	18,676	6,518	2,176,849	1,352,185
Oregon	94,084	82,134	--	--	--	--	6,813	2,184	100,897	84,318
Washington	150,520	114,237	--	--	--	--	6,143	1,450	156,663	115,687
Total	2,341,988	1,539,869	27,684	11,888	83,700	24,173	48,842	14,816	2,502,214	1,590,746
Total United States	19,637,212	12,402,619	883,127	246,085	1,413,650	265,159	742,592	160,474	22,676,581	13,074,337

[1] Quantities in million cubic feet at 14.73 psia.

Table 14.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States in 1970–71, 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
1970										
Arkansas	1,848	37,816	3,235	3,426	543	26	17,857	12,749	−20	34,581
California, Alaska	19,044	444,700	30,165	27,076	137,594	177	173,086	71,870	4,732	414,535
Colorado	2,287	82,736	3,405	1,970	4,960	82	72,394	102	−177	79,331
Kansas	27,363	1,445,817	38,843	7,574	1,347	139	1,345,207	52,483	224	1,406,974
Kentucky, Illinois	13,788	429,691	20,739	1,815	--	--	405,058	1,978	101	408,952
Louisiana	136,911	5,237,519	193,209	78,554	109,490	2,730	4,239,292	618,752	−4,508	5,044,310
Michigan	1,775	139,571	2,330	1,993	11,203	101	124,334	--	−390	137,241
Mississippi, Alabama	1,136	50,509	1,495	1,502	9,054	242	35,892	2,115	209	49,014
Montana, Utah	2,842	59,193	4,525	5,035	20,752	991	27,819	--	71	54,668
Nebraska	486	3,697	555	248	20	--	2,755	--	119	3,142
New Mexico	35,605	1,101,442	52,647	52,878	6,279	2,348	808,377	170,674	8,239	1,048,795
North Dakota	2,344	36,830	4,490	4,703	7,889	115	18,572	214	847	32,340
Oklahoma	42,842	1,183,273	58,926	53,428	87,305	573	857,305	124,523	1,213	1,124,347
Pennsylvania	53	1,418	79	11	49	--	1,279	--	--	1,339
Texas	301,688	7,808,476	466,016	323,546	r 929,719	19,798	r 5,241,719	r 776,483	51,195	7,342,460
West Virginia, Florida	8,751	169,695	12,891	774	28	--	153,963	2,039	--	156,804
Wyoming	7,153	276,926	12,863	9,651	15,143	483	226,371	13,376	−961	264,063
Total	605,916	18,509,309	906,413	574,184	r 1,341,375	27,805	r 13,751,280	r 1,847,358	60,894	17,602,896
1971										
Arkansas	1,552	31,387	2,563	3,663	436	27	15,812	8,886	--	28,824
California, Alaska	17,865	431,605	27,684	24,512	193,284	437	123,825	56,955	4,908	403,921
Colorado	2,582	97,420	4,152	2,481	6,818	236	83,941	102	−310	93,268
Kansas	28,602	1,451,438	39,741	7,755	1,509	63	1,343,300	59,384	−314	1,411,697
Kentucky, Illinois	13,020	341,750	19,653	1,025	--	--	318,002	2,730	340	322,097
Louisiana	144,695	5,994,431	195,072	98,786	120,771	2,388	4,890,254	691,788	−4,628	5,799,359
Michigan	1,528	141,784	2,013	1,989	480	--	137,374	--	−72	139,771
Mississippi, Alabama	1,078	44,732	1,498	1,349	7,067	--	33,268	1,428	122	43,234
Montana, Utah	2,861	57,105	4,572	4,628	18,585	1,731	27,260	--	329	52,533
Nebraska	490	2,848	599	235	13	--	1,843	154	4	2,249
New Mexico	37,034	1,124,139	53,810	54,695	5,809	2,437	834,340	161,100	11,948	1,070,329
North Dakota	2,124	33,252	3,592	4,960	6,960	93	17,064	264	319	29,660
Oklahoma	41,737	1,123,614	55,914	48,313	86,190	401	819,797	110,680	2,319	1,067,700
Pennsylvania	39	1,112	55	--	--	--	1,057	--	--	1,057
Texas	306,721	7,938,550	448,288	305,216	894,667	20,738	5,487,688	754,698	27,255	7,490,262
West Virginia, Florida	7,899	145,206	11,119	3,899	28	--	128,438	1,722	--	134,087
Wyoming	7,988	292,434	12,802	9,481	12,387	108	246,743	12,162	−1,249	279,632
Total	617,815	19,252,807	883,127	572,987	1,355,004	28,659	14,510,006	1,862,053	40,971	18,369,680

r Revised.

Table 15.—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 December 31, 1970	Changes in reserves during 1971						Reserves as of December 31, 1971			
		Revisions	Extensions	New field discoveries	New reservoir discoveries in old fields	Net change in underground storage [1]	Production [2]	Total gas	Nonassociated	Associated-dissolved	Underground storage [3]
Alabama	162,009	3,800	--	14,533	1,010	--	844	180,508	164,163	16,345	--
Alaska	31,130,751	388,175	--	--	--	--	153,585	31,365,341	4,967,421	26,397,920	--
Arkansas	2,580,674	−81,121	84,377	13,553	9,124	−2,629	173,863	2,430,115	2,285,347	111,200	33,568
California [4]	6,299,759	−80,765	56,530	105	32,090	11,131	589,351	5,729,499	2,342,432	3,175,368	211,699
Colorado	1,628,846	120,707	152,355	17,343	1,685	−615	101,998	1,818,323	1,633,067	161,553	23,703
Illinois	415,414	208	--	--	--	85,526	2,195	498,953	1,052	10,381	487,520
Indiana	82,674	−345	--	--	--	5,245	896	86,678	1,503	3,069	82,106
Kansas	13,325,091	33,815	61,817	3,523	3,652	−2,432	890,268	12,535,198	12,155,456	285,512	94,230
Kentucky	977,842	526	28,139	1,174	4	13,980	65,373	956,292	770,838	47,768	137,686
Louisiana [4]	82,956,688	−1,543,772	2,242,596	659,588	2,389,171	35,699	8,114,116	78,625,854	64,874,754	13,577,840	173,260
Michigan	939,671	−15,544	--	85,970	--	36,455	30,070	1,016,482	179,479	184,541	652,462
Mississippi	1,333,905	−150,857	53,814	10,662	945	775	131,812	1,117,432	959,318	148,296	9,818
Montana	1,099,923	−238,388	173,797	5,528	--	17,548	33,847	1,024,561	715,195	127,032	182,334
Nebraska	58,168	1,838	264	137	663	3,627	5,264	59,433	19,511	20,674	19,248
New Mexico	13,290,023	505,171	354,730	41,386	1,596	−1,880	1,123,072	13,067,954	10,514,218	2,551,246	2,490
New York	125,961	−1,619	400	2,800	800	12,936	2,186	139,092	22,852	107	116,133
North Dakota	567,354	−28,120	4,316	688	--	--	40,555	503,683	5,441	498,242	--
Ohio	993,458	--	122,700	18,000	--	16,892	82,678	1,068,372	485,754	129,723	452,895
Oklahoma	16,954,267	−142,252	440,250	85,348	22,522	17,385	1,664,702	15,712,818	12,276,743	3,197,242	238,833
Pennsylvania	1,377,502	−2,244	56,150	10,000	--	30,848	76,325	1,395,931	767,412	12,712	615,807
Texas [4]	106,352,993	−3,791	2,094,864	318,503	877,841	−1,865	8,166,437	101,472,108	74,871,418	26,509,194	91,496
Utah	1,065,160	−63,121	14,331	928	7,242	155	42,741	981,954	559,592	420,787	1,575
Virginia	32,511	--	1,250	--	--	--	2,686	31,075	31,075	--	--
West Virginia	2,436,378	--	169,011	3,600	4,000	16,646	217,851	2,411,784	1,962,281	56,777	392,726
Wyoming	4,243,331	70,486	143,259	23,205	8,196	4,115	361,100	4,131,492	3,369,062	714,543	47,887
Other States [5]	316,055	−187	119,756	1,000	--	10,759	2,697	444,686	18,233	179,701	246,752
Total	290,746,408	−1,227,400	6,374,706	1,317,574	3,360,541	310,301	22,076,512	278,805,618	195,953,617	78,537,773	4,314,228

[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.
[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, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 16.—Estimated productive capacity of natural gas in the United States, December 31, 1971

(Million cubic feet per day)

State	Productive capacity: Non-associated	Productive capacity: Associated-dissolved	Productive capacity: Total
Alabama	41	6	47
Alaska	615	93	708
Arkansas	670	98	768
California [1]	1,425	940	2,365
Colorado	436	42	478
Illinois	--	5	5
Indiana	--	2	2
Kansas	7,341	224	7,565
Kentucky	194	10	204
Louisiana [1]	24,689	4,427	29,116
Michigan	156	63	219
Mississippi	301	70	371
Montana	162	35	197
Nebraska	8	8	16
New Mexico	2,974	1,255	4,229
New York	4	--	4
North Dakota	1	113	114
Ohio	233	54	287
Oklahoma	7,379	1,962	9,341
Pennsylvania	198	2	200
Texas [1]	26,692	8,802	35,494
Utah	122	48	170
Virginia	10	--	10
West Virginia	668	7	675
Wyoming	1,048	366	1,414
Other States [2]	4	14	18
Total	75,371	18,646	94,017

[1] Includes offshore productive capacity.
[2] Includes Arizona, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 17.—Underground storage statistics, December 31, 1971

(Million cubic feet at 14.73 psia at 60° F)

State	Number of reservoirs	Dry gas	Oil and gas	Oil	Water	Other	Number of wells	Total gas in storage reservoirs (million cubic feet)	Total reservoir capacity (million cubic feet)
Arkansas	5	5	--	--	--	--	22	9,894	42,510
California	6	3	3	--	--	--	163	136,344	290,471
Colorado	6	4	1	--	--	[1] 1	55	15,093	28,431
Illinois	29	8	1	1	19	--	1,286	475,612	814,249
Indiana	26	15	--	--	11	--	831	66,187	150,812
Iowa	6	--	--	--	6	--	251	138,027	214,858
Kansas	16	16	--	--	--	--	743	79,972	106,584
Kentucky	20	16	--	--	4	--	997	60,965	199,149
Louisiana	5	5	--	--	--	--	102	141,107	220,075
Maryland	1	1	--	--	--	--	59	29,587	64,770
Michigan	31	28	1	1	--	[2] 1	2,329	416,791	748,209
Minnesota	1	--	--	--	1	--	35	3,706	3,706
Mississippi	3	2	--	--	--	[2] 1	25	9,318	10,238
Missouri	1	--	--	--	1	--	73	29,020	45,000
Montana	5	5	--	--	--	--	133	136,195	213,152
Nebraska	1	1	--	--	--	--	15	8,189	39,270
New Mexico	1	1	--	--	--	--	22	--	52,150
New York	16	16	--	--	--	--	731	101,357	133,503
Ohio	21	21	--	--	--	--	2,924	371,543	500,429
Oklahoma	11	10	1	--	--	--	189	217,428	317,025
Pennsylvania	66	66	--	--	--	--	2,135	593,832	752,698
Texas	17	6	5	6	--	--	172	64,474	110,114
Utah	1	--	--	--	1	--	8	1,575	1,575
Washington	1	--	--	--	1	--	54	13,956	15,150
West Virginia	33	31	2	--	--	--	1,157	368,030	422,562
Wyoming	4	4	--	--	--	--	12	34,952	78,628
Total	333	264	14	8	44	3	14,523	3,523,154	5,575,318

[1] Coal.
[2] Salt.

Source: American Gas Association.

Table 18.—Natural gas stored and withdrawal statistics

(Million cubic feet at 14.73 psia)

State	1970 Total stored	1970 Total withdrawn	1970 Net stored	1971 Total stored	1971 Total withdrawn	1971 Net stored
Alabama	1,153	587	566	992	809	183
Arkansas	1,467	1,261	206	1,674	1,108	566
California	80,260	52,235	28,025	89,373	77,749	11,624
Colorado	8,757	5,630	3,127	5,839	6,433	−594
Delaware	391	602	−211	189	--	189
Illinois	190,661	112,468	78,193	214,871	127,279	87,592
Indiana	35,065	25,040	10,025	33,816	26,939	6,877
Iowa	46,301	42,068	4,233	53,186	45,400	7,786
Kansas	52,966	47,068	5,898	49,267	49,083	184
Kentucky	38,968	28,592	10,376	46,139	29,919	16,220
Louisiana	110,680	48,170	62,510	132,263	62,399	69,864
Maryland	10,421	8,069	2,352	11,746	9,434	2,312
Massachusetts	770	570	200	937	841	96
Michigan	344,524	317,397	27,127	296,475	289,599	6,876
Mississippi	12,489	8,579	3,910	8,149	7,289	860
Missouri	10,957	9,744	1,213	11,741	10,296	1,445
Montana	20,891	10,415	10,476	18,668	11,864	6,804
Nebraska	3,074	3,856	−782	5,982	2,356	3,626
New Jersey	1,447	1,008	439	1,626	1,469	157
New Mexico	398	241	157	--	--	--
New York	45,802	39,541	6,261	48,026	40,607	7,419
Ohio	182,405	173,067	9,338	188,916	168,833	20,083
Oklahoma	57,142	45,726	11,416	66,666	45,698	20,968
Pennsylvania	335,966	246,978	88,988	303,286	284,509	18,777
Texas	36,805	37,729	−924	36,850	34,452	2,398
Utah	547	439	108	883	728	155
Virginia	2,175	193	1,982	2,286	247	2,039
Washington	6,688	1,348	5,340	7,442	6,200	1,242
West Virginia	209,292	184,862	24,430	190,785	161,539	29,246
Wyoming	8,305	5,124	3,181	11,325	4,551	6,774
Total	1,856,767	1,458,607	398,160	1,839,398	1,507,630	331,768

Table 19.—Natural gas: Production, by country

(Million cubic feet)

Country [1]	1969 Gross production [2]	1969 Marketed production [3]	1970 Gross production [2]	1970 Marketed production [3]	1971 [p] Gross production [2]	1971 [p] Marketed production [3]
North America:						
Barbados	108	91	116	[e] 100	129	100
Canada	[r] 2,287,433	1,977,838	2,624,247	2,295,278	2,825,306	2,497,538
Mexico	609,056	417,085	665,026	481,106	633,416	478,552
Trinidad	137,503	69,297	121,060	66,687	109,814	65,066
United States	22,698,240	20,698,240	23,786,453	21,920,642	24,103,973	22,493,012
South America:						
Argentina	247,294	188,133	270,683	212,452	286,654	229,323
Bolivia	28,409	3,920	29,000	[e r] 1,300	82,451	1,427
Brazil	44,080	[e] 8,000	44,638	[e] 8,000	41,566	[e] 8,300
Chile	263,790	79,952	269,392	94,325	282,038	[e] 98,000
Colombia	103,882	44,767	104,894	46,736	111,288	51,186
Ecuador	5,849	[e] 500	10,176	[e] 500	9,620	500
Peru	74,452	17,453	74,818	16,822	67,227	16,935
Venezuela	1,673,013	314,092	1,710,200	348,630	1,680,252	368,230
Europe:						
Austria	52,379	50,331	67,027	66,992	66,790	64,293
Bulgaria	[4] 18,537	18,537	[e 4] 19,000	19,000	[4] 15,300	15,300
Czechoslovakia [5]	41,989	[r] 41,847	48,239	40,400	[e] 45,838	[e] 40,612
France	346,223	229,756	363,174	242,964	374,334	252,428
Germany, West	314,722	310,732	446,987	[e] 440,000	542,614	522,275
Hungary [6]	[4] 114,242	114,242	[4] 122,506	122,506	[4] 130,946	130,946
Italy	[4] 422,335	422,335	[4] 463,953	463,953	[4] 472,842	472,842
Netherlands	773,176	762,687	1,118,375	1,107,427	1,546,740	1,535,439
Poland [5]	138,503	138,503	[4] 183,014	183,014	[4] 190,275	190,275
Romania	[4] 843,064	843,064	[4] 875,443	875,443	[4] 935,269	935,269
U.S.S.R. [7]	[e] 6,860,000	6,456,903	[e] 7,520,000	7,063,000	[e] 7,900,000	7,447,800
United Kingdom	[4] 178,673	178,673	[4] 391,958	391,958	[4] 672,529	672,529
Yugoslavia	[4] 25,784	25,784	[4] 34,502	34,502	[4] 40,646	40,646

See footnotes at end of table.

Table 19.—Natural gas: Production, by country—Continued

(Million cubic feet)

Country [1]	1969		1970		1971 [p]	
	Gross production [2]	Marketed production [3]	Gross production [2]	Marketed production [3]	Gross production [2]	Marketed production [3]
Africa:						
Algeria	350,000	105,520	[e] 340,000	102,377	[e] 350,000	104,699
Angola	14,000	766	28,749	[e] 1,500	[e] 33,100	[e] 1,700
Congo (Brazzaville)	[e] 121	97	[e] 96	[e] 36	[e] 90	[e] 35
Egypt, Arab Republic of	[e] 28,000	2,507	[e] 37,000	[e] 3,000	31,000	3,000
Gabon	900	847	1,900	762	10,594	1,059
Libya	666,525	(8)	683,900	(8)	556,531	12,000
Morocco	[4] 1,484	1,484	[4] 1,539	1,539	[4] 1,680	1,680
Nigeria	145,714	2,252	285,804	3,920	458,169	3,946
Tunisia	[4] 329	329	[4] 316	316	[4] 327	327
Asia:						
Afghanistan	[4] 71,653	71,653	[e] [4] 72,000	[e] 72,000	91,217	91,217
Bahrain	33,440	10,906	25,406	12,305	25,364	17,902
Brunei	123,266	7,655	126,654	7,965	[e] 120,000	[e] 8,000
Burma	[4] 2,900	2,900	[4] 3,400	3,400	[4] 1,628	1,628
India	[e] 55,000	25,744	50,288	23,873	52,971	25,921
Indonesia	[r] 100,967	[r] 42,138	108,435	44,438	121,158	44,449
Iran	892,583	98,201	1,094,194	396,333	1,305,228	551,330
Iraq	196,000	31,617	[e] 200,000	27,720	[e] 220,000	30,722
Israel	[4] 4,873	4,873	[4] 4,753	4,753	[4] 4,370	4,370
Japan	77,890	[9] 76,173	83,311	[9] 82,682	85,936	[9] 85,156
Kuwait [10]	514,563	191,627	569,680	203,782	643,053	[e] 220,000
Oman	[e] 20,000	(8)	[e] 20,000	(8)	[e] 21,500	(8)
Pakistan [11]	116,921	116,921	133,856	133,856	107,680	107,680
Qatar	125,687	37,290	127,000	[e] 39,000	159,418	46,480
Saudi Arabia [10]	637,689	93,758	710,940	104,182	[e] 915,000	108,857
Taiwan	[4] 31,553	31,553	[4] 32,400	32,400	[4] 39,239	39,239
Trucial States:						
Abu Dhabi	233,841	23,740	266,200	26,700	365,543	39,749
Dubai	[e] 3,000	[e] 700	[e] 25,000	[e] 6,000	[e] 36,000	[e] 10,000
Oceania:						
Australia	[4] 9,375	9,375	[4] 53,061	53,061	[4] 79,049	79,049
New Zealand	[4] 2	2	[4] 3,769	3,769	10,627	8,592
Total	42,761,012	34,403,390	46,454,532	37,935,406	49,014,329	40,277,610

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Albania, People's Republic of China, Cuba, East Germany, Malaysia (Sarawak), Mongolia, Spain, Syrian Arab Republic, Thailand, and Turkey, produce crude oil and presumably produce natural gas, but available information is inadequate to ascertain output levels and the share of gross production that is marketed. Of these countries, only People's Republic of China is regarded as being a significant gas producer.

[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 oil and/or gasfields as a fuel by producers even though the latter is not actually sold.

[4] Gross production not reported, marketed output has been reported in lieu of a gross production estimate because the quantity flared, vented and reinjected is believed to be small.

[5] Marketed production reported includes gas produced from coal mines as follows in million cubic feet: Czechoslovakia: 1969—10,064, 1970—11,442, 1971—[e] 11,654; Poland: 1969—9, 1970—not available, 1971—not available.

[6] Available statistics used for both gross and marketed output comprise marketable production plus gas used for repressuring, but excludes gas vented and/or flared; reportedly gas used for repressuring constituted only 0.4 percent of the 1968 total shown. Information is inadequate to make a reliable estimate of gas vented or flared but it is believed to be small if any.

[7] Marketed production reported includes gas produced from coal and oil shale as follows in million cubic feet: 1969—61; 1970—not available; 1971—not available.

[8] No marketed production reported; there may be some small field use, but available information is inadequate to make reliable estimates.

[9] Includes gas reinjected, if any.

[10] Data for both Kuwait and Saudi Arabia each include ½ of the total output recorded for the former Kuwait-Saudi Arabia Neutral Zone.

[11] Reported sales; presumably excludes fuel use in fields and pipeline system.

Natural Gas Liquids

By S. O. Wood, Jr.[1] and Leonard L. Fanelli [2]

Production of natural gas liquids from gas-processing plants increased to a new high of 617.8 million barrels, 12 million barrels above 1970 output. The value of 1971 output was $1,386 million, $111 million or 8.7 percent higher than that of 1970.

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 (LP) gases (butane, propane, and butane-propane mixtures), isobutane, mixed gases, natural gasoline, plant condensate, and finished products including gasoline, special naphthas, jet fuel, kerosine, distillate fuel oil, and miscellaneous finished products.

Continued demand for petrochemical feedstock along with increased producing capacity contributed to the 7.1-million-barrel, 9.7-percent, increase in ethane production. The largest volume increase, however, was in propane production, 9.6 million barrels. Isopentane production increased 1.7 million barrels, a rate increase of 44.0 percent. Plant condensate production declined 6.2 million barrels, a decrease of 19.0 percent.

Increased production coupled with a continued low level of industrial activity and a mild winter resulted in propane stocks attaining a record high of 63.3 million barrels in October 1971. Total LP gases stocks at that time were 93.4 million barrels, compared with 1970 stocks of 70.6 million barrels.

The average unit value for natural gas liquids production was $2.24 per barrel, a 6.7-percent increase from the comparable 1970 value. Unit value changes by groups from 1970 to 1971 were as follows: LP gases and ethane, up 9.5 percent to $1.84 per barrel, natural gasoline and isopentane, up 5.6 percent to $3.00 per barrel; plant condensate, up 6.0 percent to $3.37 per barrel; finished gasoline and naphthas, up 7.2 percent to $4.34 per barrel, and other products, down 4.0 percent to $2.62 per barrel.

Data presented in this chapter were compiled from operating reports of natural gasoline plants, cycling plants, and fractionators that process natural gas and include all natural gas liquids except the small volume, considered to be insignificant in the 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 LP gases 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 districts.

Components of natural gas liquids used in this chapter are defined as follows:

Ethane.—Includes ethane only. All other LP gases mixed with ethane are reported in their respective product classification.

Propane.—Includes all products covered by the Natural Gas Processors Association (NGPA) specifications for commercial and HD–5 propane.

Butane-Propane Mix.—Includes all products covered by NGPA specifications for commercial butane-propane mixtures.

Butane.—Includes all products covered by NGPA specifications for commercial butane, except those that contain 80 percent or more isobutane.

[1] Petroleum engineer, Division of Fossil Fuels.
[2] Survey statistician, Division of Fossil Fuels.

Isobutane.—Includes all products covered by NGPA specifications for commercial butane, which contains 80 percent or more isobutane.

Isopentane.—Includes segregated isopentane.

Natural Gasoline.—A hydrocarbon mixture used primarily for blending or further processing into finished gasoline.

Plant Condensate.—Includes those liquids, mostly pentanes and heavier, recovered and separated at raw natural gas inlet separators and scrubbers.

Gasoline.—Includes all products within the gasoline range for shipments as motor fuel.

Special Naphtha.—Includes all hexanes and heptanes.

Jet Fuel.—Includes all aviation turbine engine fuel for both military (JP–4 and JP–5) and commercial use.

Kerosine.—Includes all grades of kerosine or range oil.

Distillate Fuel Oil.—Includes all light oil for shipment as fuel, including diesel fuel oil.

Other Products.—All products not otherwise classified.

Production of natural gas liquids is reported by States, however production for Louisiana and Texas is also reported by districts. Louisiana is divided into an Inland district and a Gulf Coast district. The Gulf Coast district includes Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, and Washington Parishes and all parishes in the State south of these. All parishes not included in the Gulf Coast district are in the Inland district.

The Bureau of Mines producing districts in Texas correspond, with one exception, to groupings of Texas Railroad Commission districts:

Bureau of Mines districts	Railroad Commission districts
Gulf Coast	Nos. 2 and 3.
West Texas	Nos. 7C, 8 and 8A.
East Proper	Part of No. 6 (East Texas field in Cherokee, Smith, Upshur, Rusk, and Gregg Counties).
Panhandle	No. 10.
Rest of State:	
North	Nos. 7B and 9.
Central	No. 1.
South	No. 4.
Other East Texas	Nos. 5 and 6 (exclusive of East Proper).

The Bureau of Mines also groups refineries by geographical refining districts. These refining districts may be combined to correspond with the PAD districts.

PAD *disrict* *Refining district*

1.—*East Coast*—District of Coumbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof, and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York and all counties east thereof.

1.—*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.

2.—*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.

2.—*Indiana-Illinois-Kentucky* — Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.

2.—*Oklahoma-Kansas, Missouri* — Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

2. — *Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.

3.—*Texas Inland*—Texas, except Texas Gulf Coast district.

3.—*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Galveston, Waller, Fort Bend, Brazoria, Wharton, Harris, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.

3.—*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George Hancock, Harrison, and Jackson; and in Alabama: Mobile and Baldwin Counties.

3.—*North Louisiana-Arkansas* — Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast District.

3.—*New Mexico*—New Mexico.

4.—*Rocky Mountains*—Montana, Idaho, Wyoming, Utah, and Colorado.

5.—*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

Some data in the chapter are based on the Bureau of Mines refining districts, and others refer to the PAD districts. Maps showing the PAD and Bureau of Mines refining districts appear in the Crude Petroleum and Petroleum Products chapter of this Bureau of Mines Minerals Yearbook volume.

Recovery of finished petroleum products recovered from gas-processing plants, such as gasoline, kerosine, distillate fuel oil and jet fuel, was small in terms of volume and values. These products accounted for only 1.5 percent of the yield and 2.4 percent of the value of natural gas liquids production.

DOMESTIC PRODUCTION

Growth in the volume of natural gas processed coupled with improved operations resulted in further increases in natural gas liquids output in 1971. Production in the United States of natural gas liquids at natural gas processing plants, totaled 617.8 million barrels, a 2.0-percent increase over that of 1970.

Historic production of natural gas liquids is shown in figure 1. Figure 2 illustrates the relative importance of the principal components of natural gas liquids. LP gases production increased 3.4 percent to 337.1 million barrels and accounted for 54.6 percent of natural gas liquids output. Propane production totaled 212.1 million barrels, a 4.7-percent rise. Production of the butanes aggregated 120.8 million barrels or a decrease of 2.3 percent. Distribution percentages of LP gases produced in 1971 were:

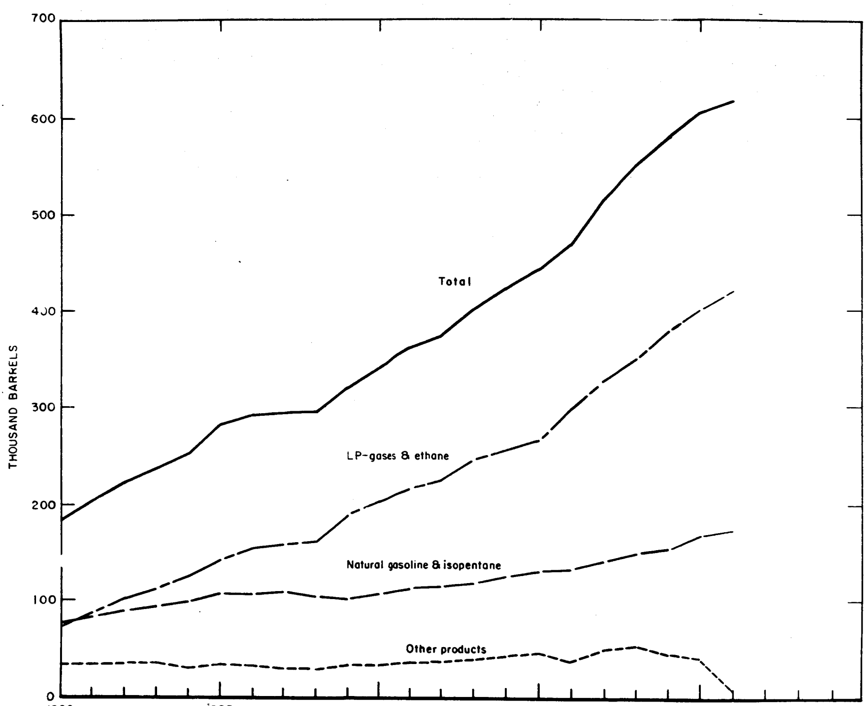

Figure 1.—Production of natural gas liquids in the United States.

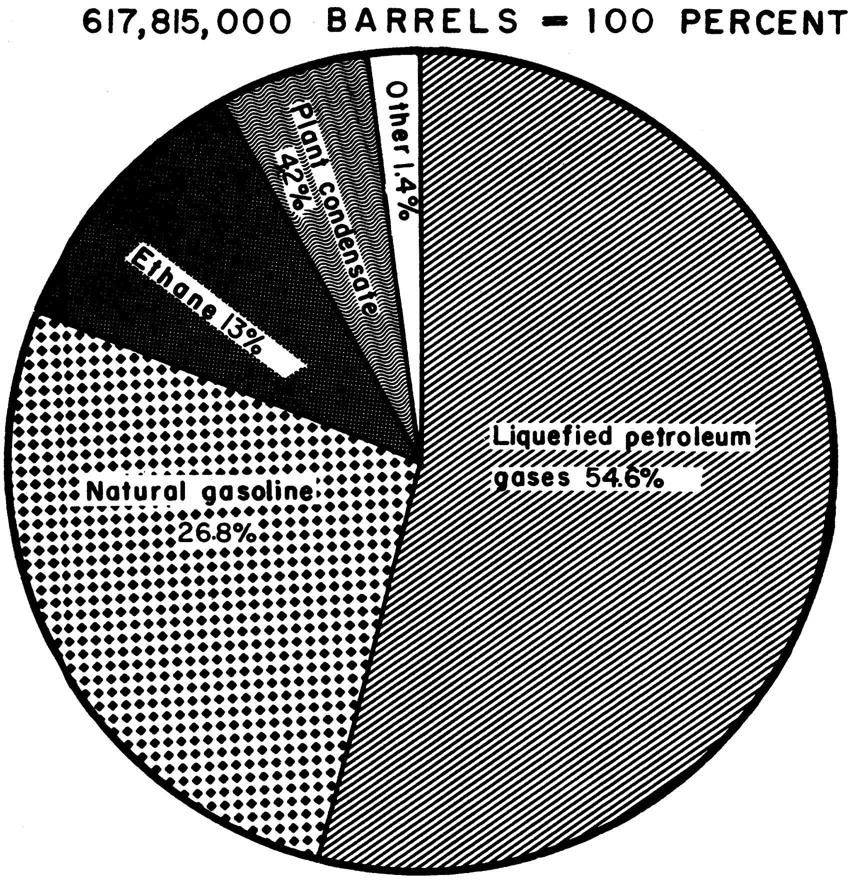

Figure 2.—The relative production of natural gas liquids, 1971.

propane, 62.9; normal butane, 17.2; isobutane, 9.6; butane-propane mix, 1.2; and other butanes, 9.1.

Natural gasoline and isopentane production was 165.3 million barrels, virtually unchanged from 1970, and accounted for 26.8 percent of natural gas liquids output. Ethane production, 80.5 million barrels, amounted to 13.0 percent of the natural gas liquids.

RESERVES

The American Gas Association, Inc. (AGA), Reserves Committee estimated proved reserves of natural gas liquids at yearend 1971 to be 7,304 million barrels. Proved reserves declined for the fourth consecutive year. According to AGA data, the yearend reserve to 1971 production ratio was 9.8:1, compared with 13.4:1 in 1967. Reserve additions from the discovery of new fields and new reservoirs totaled 119 million barrels of which 90 million barrels were in South Louisiana, principally offshore. Texas accounted for 42 percent, and Louisiana accounted for 34 percent of the Nation's proved natural gas liquids reserves at yearend 1971. Reserves increased in seven of the 23 States reported; however, the overall change in reserves was a decrease of 5 percent.

PRODUCTIVE CAPACITY

According to the AGA, estimated productive capacity of natural gas liquids at yearend 1971 was 3,022,000 barrels per day, a decline of 83,000 barrels per day from yearend 1970. Although estimated productive capacity increased in six states—Alabama, Colorado, Michigan, Montana, Texas, and Wyoming, declines in other States more than offset the gains. States experiencing the largest declines in productive capacity were, in barrels per day: Louisiana, 37,000; Oklahoma, 27,000; and Kansas, 22,000.

As natural-gas-liquids production is a function of natural-gas production and processing, productive capacity is dependent upon the rate of production of gas 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.[3] Although productive capacity estimates determined in accordance with the above definition are theoretical, they are useful in determining potential availability.

Capacity of natural gas processing plants continued to increase. The yearend daily capacity was 75.14 billion cubic feet, an increase of 0.91 billion cubic feet during the year according to the Oil and Gas Journal annual survey.[4] The 1.2-percent capacity growth rate in 1971 was significantly less than the 5.1-percent average annual increase for the 1965–70 period. The trend toward fewer, but larger capacity plants continued. At yearend 1971 there were 805 processing plants with an average throughput capacity of 93.3 million cubic feet per day, compared with 833 plants having an average throughput capacity of 89.1 million cubic feet per day in 1970.

Natural gas processing throughput capacity increased in six States. Louisiana had the largest increase, 1,289 million cubic feet per day. The number of plants, however, decreased from 142 to 136. Texas had the greatest decrease in throughput capacity, 456 million cubic feet per day, and the number of plants decreased from 386 to 374.

Texas and Louisiana combined had 510 plants with a throughput capacity of 53,427 million cubic feet per day. They accounted for 63 percent of the plants and 71 percent of U.S. throughput capacity.

CONSUMPTION AND USES

Consumption and use statistics on natural gas liquids include liquefied refinery gases (LRG) and imports unless stated otherwise. LRG production information and import data are included in the Crude Petroleum and Petroleum Products chapter of this Bureau of Mines Minerals Yearbook volume.

The input of natural gas liquids into refineries for blending was 284.9 million barrels, a 2.4-percent increase from the 1970 level. Included in this use category were plant condensate, LP gases, natural gasoline, and isopentane. Condensate used at refineries increased 14.6 percent to 39.0 million barrels of which 13.3 million barrels were imports. Refinery input of LPG was down slightly, principally from a decrease in the volume of isobutane. As indicated below, 56.4 percent of natural gas liquids used at

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[3] American Gas Association, American Petroleum Institute, and Canadian Petroleum Association. Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada and United States Productive Capacity as of Dec. 31, 1971. V. 26, May 1972, p. 108.

[4] Cantrell, Ailleen. 1972 Survey of Gas-Processing Plants. The Oil and Gas J., v. 70, No. 28, July 10, 1972, p. 91.

refineries for blending was natural gasoline. The following is a tabulation of natural gas liquids refinery inputs, in 1,000 barrels:

	1970	1971	Percent change
Condensate	34,051	39,020	+14.6
Isopentane	3,868	5,541	+43.3
LPG	80,307	79,695	-.8
Natural gasoline	160,108	160,681	+.4
	278,334	284,937	+2.4

Domestic demand for liquefied gases was 369.0 million barrels. Of this amount 249.8 million barrels was for LPG produced at natural gas processing plants, and the remaining 119.2 million barrels was LRG from refineries. Of the LRG demand 68 percent, 87 million barrels, was for fuel, and 32 percent was for chemical use.

According to the United States Tariff Commission Interim Report, production of ethylene, the principal market for ethane, decreased slightly in 1971 to 18.3 billion pounds. Previously ethylene production had increased from 5.9 billion pounds in 1960 to 18.5 billion pounds in 1970.

Shipments of finished petroleum products from natural-gas-processing plants totaled 9.2 million barrels. Motor gasoline accounted for 54 percent of these shipments; distillate fuel oil, 15 percent; kerosine, 14 percent; and other products, 17 percent.

STOCKS

Natural-gas-liquids stocks reached an all time high of 107.4 million barrels as of October 31, 1971. Stocks at natural-gas-processing plants and terminals (including underground) were 101.1 million barrels, an increase of 23.3 million barrels from October 31, 1970. This increase resulted principally from higher propane (18.5 million barrels) and isobutate (3.5 million barrels) inventories.

At yearend 1971, total natural-gas-liquids stocks were 94.0 million barrels, a decrease of 7 percent from the October 1971 level but 36 percent higher than stocks at yearend 1970. The increase resulted principally from increased domestic production and imports, a low level of economic growth, and a mild winter.

PRICES AND VALUE

The average unit value of natural gas liquids was $2.24 per barrel, $0.14 or 6.7 percent higher than in 1970. An increase in average unit values for LP gases and ethane was virtually nationwide, and for domestic output average unit value increased 9.5 percent to $1.84 per barrel. LP gases and ethane value was 55.5 percent of total natural-gas-liquids value. An increase in unit value for natural gasoline and isopentane was also virtually nationwide and averaged 5.6 percent. Output of natural gasoline and isopentane was valued at $3.00 per barrel and accounted for 35.8 percent of total natural-gas-liquids value.

Plant condensate average unit value increased $0.19 to $3.37 per barrel, an increase of 6.0 percent. Coupled with a production decrease of 6.2 million barrels, however, plant condensate accounted for only 6.3 percent of total natural-gas-liquids value. The average unit value of finished gasoline and naphtha increased 7.2 percent to $4.34 per barrel. Production decreased, however, and total value was virtually the same as in 1970. The average unit value for other products decreased 4.0 percent to $2.62 per barrel. These products including kerosine, jet fuel, and distillate fuel accounted for only 0.7 percent of total value of natural gas liquids.

According to the U.S. Department of Agriculture, 50 percent of the farms in the United States used LP gas during the summer of 1971. Average prices, applicable to tank cars and transport trucks, paid by farmers was 15.6 cents per gallon, 6.1 percent higher than in 1970. The number of farms by geographic divisions and average prices for LP gas are shown below:

Geographic division	Farms using LP gas (thousands)	Average price per gallon (cents)
New England	13	21.4
Middle Atlantic	45	19.5
East North Central	233	16.6
West North Central	408	14.5
South Atlantic	159	19.0
East South Central	195	18.7
West South Central	291	13.6
Mountain	58	15.0
Pacific	36	19.0
Total United States	1,438	15.6

Source: U.S. Department of Agriculture, Crop Reporting Board, Statistical Reporting Service.

The producer's tank cars and transport trucks net contract prices (after discounts and summer-fill allowances) for propane declined, after the heating season, in April. Prices were stable during the summer months. In late October, however, there was a softening of prices, principally attributed to a record high stock inventory. Propane price data for New York harbor and Philadelphia, Oklahoma, and Baton Rouge, La., are presented in table 15.

FOREIGN TRADE

Plant condensate and LP gases imports increased 84 percent, from 21.2 million barrels to 39.0 million barrels. This significant increase was attributed principally to changes in the Oil Import Administration regulations. The changes provided that on and after October 1, 1970, natural gas liquids produced in the Western Hemisphere from Western Hemisphere crude and gas could be imported without being subject to quotas. Plant condensate imports increased almost sixfold to 13.3 million barrels, and LP gases imports increased about one-third to almost 25.7 million barrels. Canada was the major source of imports, accounting for 99.8 percent of plant condensate and 84.6 percent of LP gases. Venezuela was the source of the remaining 0.2 percent of plant condensate and 12.4 percent of LP gases. Other countries that exported more than 100,000 barrels of LP gases to the United States were Saudi Arabia, Netherlands Antilles, and Iran.

The distribution pattern of natural gas liquids imports in thousand barrels was as follows:

PAD district	LP gases	Plant condensate	Total
1	4,775	538	5,313
2	10,859	4,580	15,439
3	794	--	794
4	3,060	4,672	7,732
5	6,167	3,531	9,698
Total	25,655	13,321	38,976

LP gases exports from the United States totaled 9,379,000 barrels, a decrease of 553,000 barrels from those of 1970. The value of these exports in 1971 was $29.2 million, down from $31.7 million in 1970. Almost 97 percent of LP gases exports were to Mexico; Canada received 1 percent; and the remaining 2 percent was distributed among more than 20 countries. LP gases exports were butane, 9.8 percent; propane, 22.6 percent; and butane-propane mixtures, 67.6 percent.

Table 1.—Natural gas liquids production, stocks,[1] and shipments from natural gas processing plants, by product and month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1971	Total 1970
All products, total:														
Production	52,275	48,170	52,356	50,774	52,330	49,801	51,213	52,265	50,412	52,102	50,659	55,458	617,815	605,916
Stocks	53,996	46,885	47,661	56,147	67,682	77,186	88,170	95,827	99,249	101,084	96,259	88,421	88,421	65,992
Shipments	64,271	55,281	51,580	42,288	40,795	40,297	40,229	44,608	46,990	50,267	55,484	63,296	595,386	598,476
Ethane:														
Production	6,190	5,989	6,427	6,310	6,488	6,473	6,898	7,228	6,632	7,232	7,119	7,538	80,524	73,434
Stocks	1,331	1,511	1,844	2,066	2,083	2,034	2,110	2,372	2,310	2,739	3,076	3,365	3,365	1,319
Shipments	6,178	5,809	6,094	6,088	6,471	6,522	6,822	6,966	6,694	6,803	6,782	7,249	78,478	74,297
Liquefied petroleum gases:														
Production	28,738	26,381	28,679	27,688	28,366	26,599	27,144	28,046	27,686	28,525	27,963	31,295	337,110	326,177
Stocks	47,243	40,347	41,199	49,252	60,540	70,394	80,972	88,312	91,999	93,447	88,242	80,294	80,294	59,276
Shipments	40,771	33,277	27,827	19,635	17,078	16,745	16,566	20,706	23,999	27,077	33,168	39,243	316,092	318,700
Isopentane:														
Production	351	378	349	341	343	320	607	585	520	557	588	626	5,565	3,865
Stocks	7	11	8	6	8	5	20	17	22	28	29	31	31	7
Shipments	351	374	352	343	341	323	592	588	515	551	587	624	5,541	3,868
Natural gasoline:														
Production	13,520	12,247	13,396	13,138	13,788	13,816	13,888	13,843	13,136	13,165	12,537	13,258	159,732	161,274
Stocks	4,186	3,884	3,447	3,705	3,688	3,599	3,742	3,816	3,601	3,698	3,745	3,647	3,647	4,316
Shipments	13,650	12,549	13,833	12,880	13,805	13,905	13,745	13,769	13,351	13,068	12,490	13,356	160,401	160,316
Plant condensate:														
Production	2,646	2,389	2,629	2,487	2,484	1,849	1,851	1,828	1,789	1,899	1,886	2,017	25,754	31,972
Stocks	589	499	536	573	795	671	820	793	781	651	661	594	594	507
Shipments	2,564	2,479	2,592	2,450	2,262	1,973	1,702	1,855	1,801	2,027	1,878	2,084	25,667	32,012
Other products, total:														
Production	830	786	876	810	861	744	825	735	649	724	566	724	9,130	9,194
Stocks	640	633	627	545	568	483	506	517	536	519	506	490	490	567
Shipments	757	793	882	892	838	829	802	724	630	741	579	740	9,207	9,283
Motor gasoline:														
Production	479	438	465	433	456	406	429	429	381	422	303	382	5,023	5,347
Stocks	243	295	308	262	275	172	146	156	189	198	208	227	227	198
Shipments	434	386	452	479	443	509	455	419	348	418	288	363	4,994	5,457
Special naphthas:														
Production	30	24	27	25	27	24	27	25	24	23	24	49	329	384
Stocks	9	8	8	7	8	7	7	9	10	9	9	11	11	9
Shipments	30	25	27	26	26	25	27	23	23	24	24	47	327	386
Kerosine:														
Production	110	100	116	94	113	96	111	124	107	105	74	93	1,243	1,077
Stocks	307	239	235	199	206	235	283	295	279	260	230	201	201	284
Shipments	87	168	120	130	106	67	63	112	123	124	104	122	1,326	1,042
Distillate fuel oil:														
Production	119	114	129	127	129	124	111	103	84	113	101	116	1,370	1,441
Stocks	63	71	60	57	57	46	45	39	41	43	43	38	38	58
Shipments	114	106	140	130	129	135	112	109	82	111	102	120	1,390	1,433

Jet fuel:														
Production	--	--	--	2	3	3	1	--	--	--	--	--	9	21
Stocks	3	3	3	5	8	10	11	6	4	3	3	2	2	3
Shipments	--	--	--	--	--	1	--	5	2	1	--	1	10	37
Miscellaneous products:														
Production	92	110	139	129	133	91	146	54	53	61	64	84	1,156	924
Stocks	15	17	13	15	14	13	14	12	13	11	14	11	11	15
Shipments	92	108	143	127	134	92	145	56	52	63	61	87	1,160	928

[1] At plants and terminals.

Table 2.—Natural gas liquids production at natural gas processing plants, by State and month

(Thousand barrels)

State	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Arkansas	147	131	146	139	140	132	131	124	118	122	110	112	1,552
California and Alaska	1,579	1,441	1,553	1,500	1,503	1,484	1,495	1,476	1,424	1,418	1,331	1,661	17,865
Colorado	210	191	220	233	226	193	160	209	218	241	240	241	2,582
Illinois and Kentucky	860	984	1,105	1,140	1,111	1,029	961	1,153	1,135	1,113	1,126	1,303	13,020
Kansas	2,641	2,286	2,202	2,081	2,249	1,761	2,070	2,239	3,367	2,629	1,625	3,452	28,602
Louisiana	12,505	11,371	12,505	11,990	12,057	11,876	12,178	12,315	10,936	11,785	12,202	12,975	144,695
Michigan	134	119	127	134	122	108	116	103	106	135	106	218	1,528
Mississippi and Alabama	88	76	84	108	103	101	98	96	85	88	75	76	1,078
Montana, Nebraska, North Dakota	229	239	269	252	270	257	266	261	261	281	270	302	3,157
New Mexico	3,018	2,871	3,093	3,071	3,211	3,086	3,090	3,071	3,046	3,065	3,115	3,297	37,034
Oklahoma	3,632	3,178	3,635	3,353	3,522	3,250	3,373	3,456	3,363	3,616	3,548	3,811	41,737
Texas	25,821	23,783	25,816	25,479	26,444	25,067	25,794	26,316	24,856	26,033	25,314	25,998	306,721
Utah	187	192	207	199	203	186	187	196	187	191	191	192	2,318
West Virginia, Florida, Pennsylvania	547	707	768	489	503	619	650	631	640	648	682	1,054	7,938
Wyoming	677	601	626	606	666	652	644	619	670	737	724	766	7,988
Total United States	52,275	48,170	52,356	50,774	52,330	49,801	51,213	52,265	50,412	52,102	50,659	55,458	617,815

Table 3.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States, by State

(Million cubic feet at 14.73 p.s.i.a. and 60° F., unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand 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	Un-accounted for	Total
1970:										
Arkansas	1,848	37,816	3,235	3,426	543	26	17,857	12,749	−20	34,581
California and Alaska	19,044	444,700	30,165	27,076	137,594	177	173,086	71,870	4,732	414,535
Colorado	2,287	82,736	3,405	1,970	4,960	82	72,394	102	−177	79,331
Kansas	27,363	1,445,817	38,843	7,574	1,347	139	1,345,207	52,483	224	1,406,974
Kentucky and Illinois	13,788	429,691	20,739	1,815	--	--	405,058	1,978	101	408,952
Louisiana	136,911	5,237,519	193,209	78,554	109,490	2,730	4,239,292	618,752	−4,508	5,044,310
Michigan	1,775	139,571	2,330	1,993	11,203	101	124,334	--	−390	137,241
Mississippi and Alabama	1,136	50,509	1,495	1,502	9,054	242	35,892	2,115	209	49,014
Montana and Utah	2,842	59,193	4,525	5,035	20,752	991	27,819	--	71	54,668
Nebraska	486	3,697	555	248	20	--	2,755	--	119	3,142
New Mexico	35,605	1,101,442	52,647	52,878	6,279	2,348	808,377	170,674	8,239	1,048,795
North Dakota	2,344	36,830	4,490	4,703	7,889	115	18,572	214	847	32,340
Oklahoma	42,842	1,183,273	58,926	53,428	87,305	573	857,305	124,523	1,213	1,124,347
Pennsylvania	53	1,418	79	11	49	--	1,279	--	--	1,339
Texas	301,688	7,808,476	466,016	323,546	r 929,719	19,798	r 5,241,719	r 776,483	51,195	7,342,460
West Virginia and Florida	8,751	169,695	12,891	774	28	--	153,963	2,039	--	156,804
Wyoming	7,153	276,926	12,863	9,651	15,143	483	226,371	13,376	−961	264,063
Total	605,916	18,509,309	906,413	574,184	r 1,341,375	27,805	r 13,751,280	r 1,847,358	60,894	17,602,896
1971:										
Arkansas	1,552	31,387	2,563	3,663	436	27	15,812	8,886	--	28,824
California and Alaska	17,865	431,605	27,684	24,512	193,284	437	123,825	56,955	4,908	403,921
Colorado	2,582	97,420	4,152	2,481	6,818	236	83,941	102	−310	93,268
Kansas	28,602	1,451,438	39,741	7,755	1,509	63	1,343,300	59,384	−314	1,411,697
Kentucky and Illinois	13,020	341,750	19,653	1,025	--	--	318,002	2,730	340	322,097
Louisiana	144,695	5,994,431	195,072	98,786	120,771	2,388	4,890,254	691,788	−4,628	5,799,359
Michigan	1,528	141,784	2,013	1,989	480	--	137,374	--	−72	139,771
Mississippi and Alabama	1,078	44,732	1,498	1,349	7,067	--	33,268	1,428	122	43,234
Montana and Utah	2,861	57,105	4,572	4,628	18,585	1,731	27,260	--	329	52,533
Nebraska	490	2,848	599	235	13	--	1,843	154	4	2,249
New Mexico	37,034	1,124,139	53,810	54,695	5,809	2,437	834,340	161,100	11,948	1,070,329
North Dakota	2,124	33,252	3,592	4,960	6,960	93	17,064	264	319	29,660
Oklahoma	41,737	1,123,614	55,914	48,313	86,190	401	819,797	110,680	2,319	1,067,700
Pennsylvania	39	1,112	55	--	--	--	1,057	--	--	1,057
Texas	306,721	7,938,550	448,288	305,216	894,667	20,738	5,487,688	754,698	27,255	7,490,262
West Virginia and Florida	7,899	145,206	11,119	3,899	28	--	128,438	1,722	--	134,087
Wyoming	7,988	292,434	12,802	9,481	12,387	108	246,743	12,162	−1,249	279,632
Total	617,815	19,252,807	883,127	572,987	1,355,004	28,659	14,510,006	1,862,053	40,971	18,369,680

r Revised.

Table 4.—Natural gas liquids production and value at natural gas processing plants, by State and product

(Thousand barrels and thousand dollars)

State	No. of operating companies [1]	LP gases and ethane			Natural gasoline and isopentane			Plant condensate		
		Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]
Arkansas	3	1,035	$2,650	$2.56	441	$1,446	$3.28	37	$112	$3.02
California and Alaska	17	6,820	16,793	2.46	10,434	33,284	3.19	611	2,261	3.70
Colorado	7	1,653	3,190	1.93	929	2,462	2.65	--	--	--
Illinois and Kentucky	4	12,402	27,319	2.20	605	1,969	3.25	13	46	3.52
Kansas	13	23,215	39,001	1.68	5,346	12,135	2.27	39	113	2.90
Louisiana	40	90,271	166,099	1.84	41,148	124,267	3.02	6,323	23,079	3.65
Michigan	4	975	2,623	2.69	549	1,499	2.73	4	14	3.44
Mississippi and Alabama	6	531	1,286	2.42	489	1,495	3.06	50	149	2.98
Montana, Nebraska, North Dakota	7	2,403	4,835	2.01	754	2,235	2.96	--	--	--
New Mexico	11	27,082	43,331	1.60	9,719	27,796	2.86	195	589	3.02
Oklahoma	34	27,540	56,732	2.06	12,986	37,140	2.86	1,119	3,435	3.07
Texas	73	210,435	380,887	1.81	78,266	240,277	3.07	16,022	53,193	3.32
Utah	4	1,808	2,730	1.51	510	1,566	3.07	--	--	--
West Virginia, Florida, Pennsylvania	6	5,990	11,794	1.97	942	2,873	3.05	1,006	2,696	2.68
Wyoming	14	5,474	10,127	1.85	2,179	6,232	2.86	335	1,183	3.53
Total	142	417,634	769,397	1.84	165,297	496,676	3.00	25,754	86,870	3.37

State	No. of operating companies [1]	Finished gasoline and naphtha			Other products [3]			Total		
		Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]
Arkansas	3	--	--	--	39	128	3.28	1,552	4,336	2.79
California and Alaska	17	--	--	--	--	--	--	17,865	52,338	2.93
Colorado	7	--	--	--	--	--	--	2,582	5,652	2.19
Illinois and Kentucky	4	--	--	--	--	--	--	13,020	29,334	2.25
Kansas	13	--	--	--	2	5	2.44	28,602	51,254	1.79
Louisiana	40	4,328	18,913	4.37	2,625	7,166	2.73	144,695	339,524	2.35
Michigan	4	--	--	--	--	--	--	1,528	4,136	2.71
Mississippi and Alabama	6	--	--	--	8	27	3.32	1,078	2,957	2.74
Montana, Nebraska, North Dakota	7	--	--	--	--	--	--	3,157	7,070	2.24
New Mexico	11	--	--	--	38	80	2.10	37,034	71,796	1.94
Oklahoma	34	21	84	3.99	71	197	2.77	41,737	97,588	2.34
Texas	73	1,003	4,213	4.20	995	2,298	2.31	306,721	680,868	2.22
Utah	4	--	--	--	--	--	--	2,318	4,296	1.85
West Virginia, Florida, Pennsylvania	6	--	--	--	--	--	--	7,938	17,363	2.19
Wyoming	14	--	--	--	--	--	--	7,988	17,542	2.20
Total	142	5,352	23,210	4.34	3,778	9,901	2.62	617,815	1,386,054	2.24

[1] A producer operating in more than one State is counted once in arriving at U.S. total.
[2] Represents average unit value of sales throughout the year.
[3] Includes kerosine, jet fuel, distillate fuel, etc.

Source: Company reports and Bureau of Mines estimates.

Table 5.—Natural gas liquids production at natural gas processing plants, by product and PAD district

(Thousands of barrels)

States and P.A.D. Districts	Ethane	Liquefied petroleum gases						Natural gasoline and isopentane	Plant con-densate	Finished gasoline and naphtha	All other products [1]	Total
		Propane	Normal butane	Other butanes	Butane-propane mixture	Isobutane	Total					
District 1:												
Georgia, Florida, West Virginia	(2)	2,973	699	377	--	247	4,296	(2)	1,006	--	--	7,900
Pennsylvania	--	20	9	--	--	--	29	9	--	--	--	38
Total District	--	2,993	708	377	--	247	4,325	9	1,006	--	--	7,938
District 2:												
Michigan	--	648	47	268	--	12	975	594	4	--	--	1,573
Kansas	2,608	13,632	4,278	1,141	2	1,554	20,607	5,346	39	--	2	28,602
Nebraska	--	236	133	--	--	--	369	121	--	--	--	490
North Dakota	--	1,027	591	55	--	--	1,673	451	--	--	--	2,124
Oklahoma	465	18,048	5,140	2,283	158	1,446	27,075	12,986	1,119	21	71	41,737
Other States [3]	[2] 8,729	4,236	654	--	--	448	5,338	[2] 1,493	13	--	--	12,975
Total District	11,802	37,827	10,843	3,747	160	3,460	56,037	20,991	1,175	21	73	87,501
District 3:												
Alabama and Mississippi	--	224	175	--	132	--	531	489	50	--	8	1,078
Arkansas	--	635	263	--	--	137	1,035	441	37	--	39	1,552
Louisiana:												
Gulf	23,358	36,528	12,299	784	133	11,534	61,278	39,853	5,447	1,658	1,325	132,919
Inland	1,253	2,354	913	266	252	597	4,382	1,295	876	2,670	1,300	11,776
Total	24,611	38,882	13,212	1,050	385	12,131	65,660	41,148	6,323	4,328	2,625	144,695
New Mexico	2,760	13,622	4,837	4,065	134	1,664	24,322	9,719	195	--	38	37,034
Texas:												
Gulf	14,837	14,579	4,715	661	881	4,331	25,167	19,500	2,627	170	151	62,452
West	10,436	45,619	8,487	9,154	375	2,386	66,021	21,417	3,557	--	283	101,714
East (field)	248	3,005	1,490	624	44	379	5,542	1,900	23	--	25	7,738
Panhandle	1,029	15,038	3,143	7,306	19	1,797	27,303	11,162	42	--	7	39,542
Other	14,782	28,404	7,755	2,180	1,871	4,861	45,071	24,287	9,773	833	529	95,275
Total	41,331	106,645	25,590	19,925	3,190	13,754	169,104	78,266	16,022	1,003	995	306,721
Total District	68,702	160,008	44,077	25,040	3,841	27,686	260,652	130,063	22,627	5,331	3,705	491,080
District 4:												
Colorado	--	1,021	40	592	--	--	1,653	929	--	--	--	2,582
Montana and Utah	--	1,267	816	--	--	86	2,169	692	--	--	--	2,861
Wyoming	20	3,469	912	920	--	153	5,454	2,179	335	--	--	7,988
Total District	20	5,757	1,768	1,512	--	239	9,276	3,800	335	--	--	13,431
District 5	--	5,558	427	45	172	618	6,820	10,434	611	--	--	17,865
Total United States	80,524	212,143	57,823	30,721	4,173	32,250	337,110	165,297	25,754	5,352	3,778	617,815

[1] Includes jet fuel, kerosine, distillate, and other.
[2] PAD District 1 data included with PAD District 2, Other States.
[3] Other States includes Florida, Georgia, Illinois, Kentucky, and West Virginia for ethane and natural gasoline and isopentane only.

Table 6.—Production of natural gasoline, by vapor pressure and PAD district

(Thousand barrels)

Reid vapor pressure	District 1	District 2	District 3	District 4	District 5	Total
12 pounds and less	283	2,242	60,743	1,146	671	65,085
Over 12 pounds including 14 pounds	648	6,218	16,196	912	49	24,023
Over 14 pounds including 18 pounds	--	4,913	8,437	788	181	14,319
Over 18 pounds including 22 pounds	10	161	515	56	1,747	2,489
Over 22 pounds including 26 pounds	--	1,620	13,423	9	1,567	16,619
Over 26 pounds	1	4,658	25,516	803	6,219	37,197
Total	942	19,812	124,830	3,714	10,434	159,732

Table 7.—Comparison of 1970 and 1971 natural gas liquids production and value

	Thousand barrels		Percent change	Thousand dollars		Percent change	Dollars per barrel		Percent change
	1971	1970		1971	1970		1971	1970	
LP gases and ethane	417,634	399,611	+4.5	769,397	672,088	+14.5	1.84	1.68	+9.5
Natural gasoline and isopentane	165,297	165,139	+.1	496,676	468,602	+6.0	3.00	2.84	+5.6
Plant condensate	25,754	31,972	−19.5	86,870	101,723	−14.6	3.37	3.18	+6.0
Finished gasoline and naphthas	5,352	5,731	−6.6	23,210	23,234	−.1	4.34	4.05	+7.2
Other products	3,778	3,463	+9.1	9,901	9,465	+4.6	2.62	2.73	−4.0
Total	617,815	605,916	+2.0	1,386,054	1,275,112	+8.7	2.24	2.10	+6.7

Table 8.—Estimated proved recoverable reserves of natural gas liquids[1] in the United States

(Thousand barrels)

State	Reserves	Changes in reserves in 1971		Reserves December 31, 1971			
	Dec. 31, 1970	Extensions and revisions	Discoveries new fields and reservoirs	Non-associated	Associated dissolved	Total	Change from Dec. 31, 1970
Alabama	21,460	+541	2,440	23,243	954	24,197	+2,737
Alaska	335	+196	--	--	454	454	+119
Arkansas	12,272	−242	--	6,400	3,219	9,619	−2,653
California [2]	170,184	−2,344	--	4,490	146,601	151,091	−19,093
Colorado	18,796	+9,382	105	10,873	15,358	26,231	+7,435
Illinois	1,135	−9	--	3	939	942	−193
Indiana	34	−2	--	8	19	27	−7
Kansas	294,073	+2,075	166	270,052	6,541	276,593	−17,480
Kentucky	48,008	+2,295	47	47,118	--	47,118	−890
Louisiana [2]	2,566,980	+59,958	90,328	2,086,390	381,490	2,467,880	−99,100
Michigan	9,903	+788	3,002	4,616	7,968	12,584	+2,681
Mississippi	22,651	−5,985	380	7,057	7,876	14,933	−7,718
Montana	8,619	+2,058	--	1,142	7,939	9,081	+462
Nebraska	1,864	+55	--	850	569	1,419	−445
New Mexico	558,576	+42,267	97	339,149	210,877	550,026	−8,550
North Dakota	49,257	--	--	--	47,128	47,128	−2,129
Oklahoma	358,603	+14,011	3,108	212,223	126,130	338,353	−20,250
Pennsylvania	896	--	--	817	--	817	−79
Texas [2]	3,330,159	+87,090	18,911	1,727,756	1,372,861	3,100,617	−229,542
Utah	36,290	−229	--	1,081	32,866	33,947	−2,343
West Virginia	81,507	+6,879	--	82,263	--	82,263	+756
Wyoming	111,339	−1,043	83	41,539	56,103	97,642	−13,697
Miscellaneous [3]	--	+11,312	--	--	11,265	11,265	+11,265
Total	7,702,941	+229,053	118,667	4,867,070	2,437,157	7,304,227	−398,714

[1] Natural gasoline, liquefied petroleum gases, and condensate.
[2] Includes offshore. Remaining proved natural gas liquids reserves in Gulf of Mexico estimated to be 942,599,000 barrels.
[3] Includes Florida only.

Source: American Gas Association, Inc.

Table 9.—Estimated productive capacity of natural gas liquids in the United States, December 31, 1971

(Thousand barrels per day)

State	Productive capacity: Non-associated	Productive capacity: Associated—dissolved	Productive capacity: Total
Alabama	6	2	8
Alaska	--	--	--
Arkansas	4	1	5
California [1]	1	55	56
Colorado	4	4	8
Illinois	--	1	1
Kansas	162	6	168
Kentucky	9	--	9
Louisiana [1]	803	107	910
Michigan	3	3	6
Mississippi	2	4	6
Montana	1	5	6
Nebraska	1	1	2
New Mexico	88	97	185
North Dakota	--	6	6
Oklahoma	118	64	182
Texas [1]	826	571	1,397
Utah	1	6	7
West Virginia	19	--	19
Wyoming	17	23	40
Miscellaneous [2]	--	1	1
Total	2,065	957	3,022

[1] Includes offshore.
[2] Includes Arizona, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, 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	Iso-butane	Total
Production:						
At gas-processing plants	80,524	212,143	88,544	4,173	32,250	417,634
At refineries:						
For fuel use	--	71,934	13,765	2,949	--	88,648
For chemical use	9,266	21,512	5,886	3,029	1,877	41,570
Total	89,790	305,589	108,195	10,151	34,127	547,852
Net change in stocks:						
Liquefied petroleum gases:						
At gas processing plants	2,046	17,988	−826	82	3,774	23,064
At refineries	--	685	1,200	3	1,011	2,899
Liquefied refinery gases:						
For fuel use	--	749	536	274	--	1,559
For chemical use	--	117	−24	3	52	148
Exports	--	4,666	4,725	--	--	9,391
Imports	--	11,606	14,049	--	--	25,655
Used at refineries	--	3,273	46,061	2,896	27,465	79,695
Domestic demand:						
At gas processing plants	78,478	197,137	51,433	1,192	--	328,240
At refineries:						
For fuel use	--	71,185	13,229	2,675	--	87,089
For chemical use	9,266	21,395	5,910	3,026	1,825	41,422
Total	87,744	289,717	70,572	6,893	1,825	456,751
Stocks:						
Liquefied petroleum gases:						
At gas processing plants	3,365	56,779	13,571	815	9,129	83,659
At refineries	--	769	1,614	38	1,272	3,693
Liquefied refinery gases:						
For fuel use	--	5,050	1,448	494	--	6,992
For chemical use	--	263	11	3	92	369
Total	3,365	62,861	16,644	1,350	10,493	94,713

Table 11.—Natural gas liquids [1] used as refinery input in the United States, 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	569	382	333	245	185	312	301	227	470	155	188	284	3,651
Appalachian	2	1	3	5	4	208	168	154	142	43	5	2	737
Indiana, Illinois, Kentucky, etc	1,998	1,779	1,565	1,412	1,255	1,509	1,669	1,757	1,709	2,163	2,371	2,670	21,857
Minnesota, Wisconsin, North Dakota, South Dakota	628	537	575	416	488	576	565	589	691	796	747	759	7,367
Oklahoma, Kansas, Missouri	1,972	1,739	1,728	1,582	1,524	1,584	1,557	1,577	1,790	2,119	2,298	2,260	21,730
Texas:													
Inland	1,854	1,714	1,931	1,805	1,985	1,949	2,094	2,110	2,058	2,160	2,179	2,127	23,966
Gulf Coast	11,624	10,048	10,569	10,054	10,275	10,155	9,815	10,093	9,700	10,249	9,673	10,960	123,215
Total	13,478	11,762	12,500	11,859	12,260	12,104	11,909	12,203	11,758	12,409	11,852	13,087	147,181
Louisiana-Arkansas:													
Louisiana Gulf Coast	3,765	3,833	3,738	3,173	3,458	3,324	3,491	3,506	3,458	3,782	4,080	3,994	43,602
Arkansas and Louisiana Inland	375	362	365	340	315	210	351	343	333	313	309	355	3,971
Total	4,140	4,195	4,103	3,513	3,773	3,534	3,842	3,849	3,791	4,095	4,389	4,349	47,573
New Mexico	99	94	97	72	84	89	105	103	94	103	98	98	1,136
Other Rocky Mountain	498	480	414	338	389	839	1,072	984	1,150	1,145	889	1,445	9,643
West Coast	1,846	1,738	2,129	1,717	2,162	2,143	1,964	1,867	1,982	2,024	2,065	2,425	24,062
Total United States	25,230	22,707	23,447	21,159	22,124	22,898	23,152	23,310	23,577	25,052	24,902	27,379	284,937

[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 1971

(Thousand barrels)

States and PAD districts	Ethane	Propane	Butane	Butane-propane mixture	Total
District 1:					
New Jersey	217	5,374	15	--	5,606
Pennsylvania	--	7,366	109	--	7,475
Other States [1]	--	3,408	1,606	--	5,014
Total	217	16,148	1,730	--	18,095
District 2:					
Illinois	--	7,858	430	--	8,288
Indiana	--	948	436	--	1,384
Kansas	612	4,028	262	1	4,903
Kentucky	--	1,165	127	--	1,292
Michigan	--	1,497	45	--	1,542
Ohio	--	4,405	--	--	4,405
Oklahoma	--	3,190	360	281	3,831
Other States [2]	--	1,741	127	206	2,074
Total	612	24,832	1,787	488	27,719
District 3:					
Alabama and Mississippi	--	1,369	3	35	1,407
Arkansas	--	671	100	--	771
Louisiana:					
Gulf	3,334	14,644	2,064	2,512	22,554
Inland	--	84	174	43	301
Total	3,334	14,728	2,238	2,555	22,855
New Mexico	--	177	9	334	520
Texas:					
Gulf	4,395	21,813	9,142	863	36,213
West	--	1,167	581	5	1,753
East	--	236	--	--	236
Panhandle	97	1,005	453	--	1,555
Other	--	114	42	--	156
Total	4,492	24,335	10,218	868	39,913
Total	7,826	41,280	12,568	3,792	65,466
District 4:					
Colorado	--	162	309	--	471
Montana	--	538	37	3	578
Utah	--	489	8	--	497
Wyoming	--	246	502	79	827
Total	--	1,435	856	82	2,373
District 5	611	9,751	4,587	1,616	16,565
Total United States	9,266	93,446	[3] 21,528	5,978	130,218

[1] Includes Delaware, New York, Virginia, and West Virginia.
[2] Includes Minnesota, Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin.
[3] Includes 1,877,000 barrels of isobutane used for petrochemical feedstock.

Table 13.—Refinery input of LPG by product and PAD district

(Thousand barrels)

Item	PAD District 1	2	3	4	5	United States
1969						
Propane	9	2	681	15	925	1,632
Butane [1]	2,378	13,501	18,316	2,526	3,622	40,343
Isobutane	71	5,694	18,988	504	2,519	27,776
Butane-propane mix	--	1,996	237	494	286	3,013
Total LPG	2,458	21,193	38,222	3,539	7,352	72,764
1970						
Propane	--	50	580	9	867	1,506
Normal butane	690	8,668	16,479	1,023	437	27,297
Other butanes	1,200	6,234	2,895	1,230	3,138	14,697
Isobutane	277	9,244	20,686	911	1,181	32,299
Butane-propane mix	--	1,548	2,296	389	275	4,508
Total LPG	2,167	25,744	42,936	3,562	5,898	80,307
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

[1] "Normal butane" and "Other butanes" reported separately for 1970 and 1971.

Table 14.—Stocks of products of natural gas processing plants 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:									
1967	58,685	555	2,669	2,077	1,615	141	62,969	2,773	65,742
1968	71,140	647	2,628	1,860	1,528	137	75,296	2,644	77,940
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:									
Jan. 31	48,574	977	4,193	1,663	1,229	360	53,996	3,000	56,996
Feb. 28	41,858	1,506	3,895	1,705	1,132	510	46,885	3,721	50,606
Mar. 31	43,043	2,895	3,455	1,802	1,163	465	47,661	5,162	52,823
Apr. 30	51,318	3,345	3,711	2,034	1,118	473	56,147	5,852	61,999
May 31	62,623	3,409	3,696	1,858	1,363	520	67,682	5,787	73,469
June 30	72,428	3,782	3,604	1,746	1,154	564	77,186	6,092	83,278
July 31	83,082	4,195	3,762	1,753	1,326	420	88,170	6,368	94,538
Aug. 31	90,684	4,658	3,833	1,567	1,310	475	95,827	6,700	102,527
Sept. 30	94,309	4,669	3,623	1,736	1,317	387	99,249	6,792	106,041
Oct. 31	96,186	4,251	3,726	1,714	1,172	349	101,084	6,314	107,398
Nov. 30	91,318	4,039	3,774	1,519	1,167	386	96,259	5,944	102,203
Dec. 31	83,659	3,693	3,678	1,485	1,084	419	88,421	5,597	[1] 94,018

[1] Includes 72,004,000 barrels in underground storage.

Table 15.—Average monthly prices, liquefied petroleum gas (propane) in the United States[1]

(Cents per gallon)

	Jan.	Feb.	Mar.	Apr.	May	June	July
New York harbor and Philadelphia:							
1970	7.90	8.00	8.00	8.00	8.00	8.02	8.50
1971	9.00	9.00	9.00	8.58	8.50	8.50	8.50
Oklahoma:							
1970	4.95	5.22	5.25	5.25	5.25	5.25	5.25
1971	6.25	6.25	6.13	5.75	5.75	5.75	5.75
Baton Rouge, La.:							
1970	5.45	5.72	5.75	5.75	5.75	5.75	5.75
1971	6.73	6.73	6.23	5.73	5.73	5.73	5.73

	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
New York harbor and Philadelphia:						
1970	8.56	8.98	9.00	9.00	9.00	8.41
1971	8.50	8.50	8.50	8.50	8.50	8.63
Oklahoma:						
1970	5.59	6.22	6.25	6.25	6.25	5.58
1971	5.75	5.75	5.67	5.25	5.25	5.78
Baton Rouge, La.:						
1970	5.96	6.70	6.73	6.73	6.73	6.06
1971	5.73	5.73	6.14	5.73	5.73	5.97

[1] Producers' net contract prices (after some discounts and summer-fill allowances) for propane, tank cars/transport trucks.

Source: Platt's Oil Price Handbook and Oilmanac.

Table 16.—LP gases[1] exported from the United States, by country

(Thousand barrels and thousand dollars)

Country	1970				1971			
	Butane	Propane	Butane-propane mixtures	Total	Butane	Propane	Butane-propane mixtures	Total
Argentina	59	60	(2)	119	(2)	(2)	(2)	(2)
Bahamas	2	76	1	79	(2)	67	(2)	67
Belgium-Luxembourg	(2)	--	31	31	--	--	--	--
Brazil	(2)	--	--	(2)	56	--	1	57
Canada	159	16	125	300	12	9	76	97
France	(2)	31	(2)	31	--	--	--	--
Guatemala	2	4	26	32	--	--	19	19
Japan	2	508	2	512	10	3	1	14
Mexico	1,419	1,150	5,939	8,508	831	2,008	6,236	9,075
United Kingdom	(2)	293	(2)	293	(2)	29	1	30
Other	6	11	10	27	7	8	5	20
Total	1,649	2,149	6,134	9,932	916	2,124	6,339	9,379
Total value	4,858	7,770	19,046	31,674	2,984	6,834	19,417	29,235

[1] Data include LR gases.
[2] Less than ½ unit.

Source: Bureau of the Census.

Nickel

By Horace T. Reno [1]

Nickel production in the United States and other parts of the world in 1971 was little changed from that of 1970, but there was an apparent surplus of approximately 150 million pounds of nickel in world markets. The surplus was caused by an exceptionally low level of industrial activity in the United States, in European countries, and in Japan. It dampened some plant expansion work and postponed a few nickel plant construction projects. Canadian producers closed some higher cost underground nickel mines. Nevertheless the effect of the surplus on the whole of the nickel industry was measurably less than the proportionate imbalance between supply and demand.

At the beginning of the year, domestic merchant and scrap nickel prices were compatible with sales prices quoted by primary nickel producers. In the last half of the year, however, scrap and merchant nickel prices trended downward as the surplus weighed on the market.

Domestic nickel consumption was about 17 percent less than in 1970. Most of the decrease was in the use of nickel in superalloys, but less nickel in stainless and alloy steels and in the nickel alloys was also responsible. Consumption decreased to 128,816 tons in 1971, compared with the 155,719 tons consumed in the U.S. markets in 1970.

There was no significant change in the pattern of nickel markets in 1971 compared with the 1970 pattern. As in the past, by far the largest part of the nickel consumed in the United States was used in stainless steels. Producers of consumer and institutional metal products, producers of machinery and transportation equipment, and the automotive industry accounted for more than 40 percent of the nickel end-use categories.

International Nickel Company of Canada Ltd. (INCO) estimated free-world nickel consumption in 1971 at 825 million pounds, compared with the 975 million pounds used in 1970. Consumption of nickel in the Communist countries apparently was at about the same level as in 1970.

Legislation and Government Programs.—According to the July–December 1971 Statistical Supplement, Stockpile Report to the Congress prepared by the General Services Administration, 49,410 short tons of nickel plus cobalt was in the defense materials inventory as of December 31, 1971. Of this quantity, 38,857 tons was in the national stockpile; 9,404 short tons was held for the U.S. Mint; and 1,149 tons was in the Defense Production Act (DPA) stocks. The U.S. Department of Commerce progressively reduced the requirements for nickel to be set aside for defense purposes from 20 percent of the average monthly shipments during the last 6 months of 1968 to 15 percent of the average monthly shipments in that period. The nickel strategic stockpile objective was reduced from 55,000 short tons to zero in February; however, the Congress did not enact the laws necessary to dispose of the excess nickel.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient nickel statistics

(Short tons)

	1967	1968	1969	1970	1971
United States:					
Mine production	15,287	17,294	17,056	15,933	17,036
Plant production:					
Primary	14,615	15,241	15,810	15,558	15,654
Secondary	20,731	14,061	18,775	23,159	29,657
Exports	31,537	33,681	34,758	31,456	26,143
Imports for consumption	143,000	147,950	129,332	156,252	142,183
Consumption	173,798	159,306	141,737	155,719	128,816
Stocks Dec. 31: Consumer	31,007	27,466	16,574	24,708	16,105
Price cents per pound	85¼–94	94–103	103–128	128–133	133
World: Production	494,835	547,960	536,608	694,129	706,069

DOMESTIC PRODUCTION

The Hanna Mining Co. at Riddle, Oreg., was the sole producer of primary nickel in the United States. Byproduct nickel salts were produced at copper and other metal refineries. Part of the byproduct nickel originated from scrap. Exploration for nickel in the continental United States was little changed from that of the last three years. However, there was marked increase in nickel exploration in Southeastern Alaska, as Newmont Exploration Ltd. and others continued investigating copper-nickel sulfide deposits under the Brady Glacier in the Glacier Bay National Monument, west of Juneau.

Table 2.—Primary nickel produced in the United States

(Short tons, nickel content)

	1967	1968	1969	1970	1971
Byproduct of metal refining	1,579	r 2,117	r 2,714	r 2,909	2,581
Domestic ore	13,036	13,124	13,096	12,649	13,073

r Revised.

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	1970	1971	Form of recovery	1970	1971
New scrap:					
Nickel-base	1,634	1,129	As metal	982	854
Copper-base	4,742	6,296	In nickel-base alloys	2,105	1,974
Aluminum-base	585	465	In copper-base alloys	7,342	8,272
			In aluminum-base alloys	905	774
Total	6,961	7,890	In ferrous and high-temperature alloys [1]	11,612	17,586
Old scrap:			In chemical compounds	213	197
Nickel-base	15,385	20,832			
Copper-base	511	577	Total	23,159	29,657
Aluminum-base	302	358			
Total	16,198	21,767			
Grand total	23,159	29,657			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

CONSUMPTION AND USES

The pattern of nickel consumption in 1971 was changed little from that of 1970. Twenty six percent of the total consumed was used to make stainless steels; 14 percent was used in alloy steels; 16 percent was used in nickel plating; 28 percent was used to make high-nickel and super alloys; and 3 percent went into iron and steel castings. According to INCO the principal end-use markets in 1971 were as follows: [2] Consumer and industrial products, 17 percent of the total; machinery and transportation, 13 percent; automotive, 11 percent; petroleum, 9 percent; electronic, 8 percent; chemical, 8 percent; process and aircraft, 7 percent each; energy conversion, 5 percent; and marine, building construction, coinage, and all others, the remaining 15 percent.

Differing interpretation of the term "superalloy" among consumers has caused inaccurate data on the use of nickel in superalloys in the past. However, most consumers reporting their use of nickel in superalloys to the Bureau of Mines in the last three quarters of 1971 have been using a definition developed by a committee of experts from the principal consumers for use in the American Iron and Steel Institute reporting instructions for high-temperature metals. The definition is as follows: High-temperature metals are those having the following compositions to provide high strength at high temperature; more than 8 percent chromium with high

[2] The International Nickel Company of Canada Ltd. 1971 Annual Report, p. 15.

nickel or cobalt contents with other elements such as molybdenum, tungsten, columbium, titanium, aluminum, zirconium and boron; and because of such total element content have less than 50 percent iron. Highly corrosion-resistant alloys with compositions similar to the high-temperature alloys should be included in this category, including nickel-and cobalt-base alloys with a very low iron content. The Institute lists the following 21 proprietary alloys to be included in this category or to be used as examples of those with analysis identical or similar to these grades:

Hastelloys B, C, X	625
901	Inconel 600
D–979	Incoloy 800
718	N–155
Waspaloy	Nimonic Alloys
Astroloy	Udiment 500
IN–100	Udiment 600
713C	L–605
X=750	Rene Alloys
	Inconel X–751

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1971

(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:						
Unalloyed nickel	384	972	640	217	857	499
Monel metal	1,068	1,736	370	1,436	1,806	998
Nickel silver [1]	598	3,577	736	2,998	3,734	441
Cupronickel [1]	33	697	--	652	652	78
Miscellaneous nickel alloys	--	4,285	50	4,232	4,282	3
Nickel residues	5,702	458	67	277	344	5,816
Total	7,154	7,451	1,127	6,162	7,289	7,316
Foundries and plants of other manufacturers:						
Unalloyed nickel	19,502	13,622	2	18,450	18,452	14,672
Monel metal	25	71	13	64	77	19
Nickel silver [1]	1,429	12,169	11,201	--	11,201	2,397
Cupronickel [1]	1,508	12,444	12,599	100	12,699	1,253
Nickel residues	118	732	412	254	666	184
Total	19,645	14,425	427	18,768	19,195	14,875
Grand total:						
Unalloyed nickel	19,886	14,594	642	18,667	19,309	15,171
Monel metal	1,093	1,807	383	1,500	1,883	1,017
Nickel silver [1]	2,027	15,746	11,937	2,998	14,935	2,838
Cupronickel [1]	1,541	13,141	12,599	752	13,351	1,331
Miscellaneous nickel alloys	--	4,285	50	4,232	4,282	3
Nickel residues	5,820	1,190	479	531	1,010	6,000
Total	26,799	21,876	1,554	24,930	26,484	22,191

[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

(Short tons)

Form	1967 [1]	1968 [1]	1969 [1]	1970 [1]	1971 [1]
Metal	124,639	115,839	99,096	112,825	95,639
Ferronickel	25,228	15,170	17,804	15,230	11,332
Oxide powder and oxide sinter	19,349	24,362	19,133	21,369	16,751
Salts	4,582	3,935	2,647	3,792	2,376
Other	--	--	3,057	2,503	2,718
Total	173,798	159,306	141,737	155,719	128,816

[1] Metallic nickel salts consumed by plating industry are estimated.

Table 6.—U.S. consumption of nickel (exclusive of scrap), by use and form, 1971

(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	16,572	6,694	9,786	--	146	33,198
Alloys (excludes stainless)	7,408	4,182	5,504	--	313	17,407
Superalloys	7,896	130	12	--	81	8,119
Nickel-copper and copper-nickel alloys	7,552	--	14	--	300	7,866
Permanent magnet alloys	2,979	11	23	--	--	3,013
Other nickel and nickel alloys	27,265	120	651	4	80	28,120
Cast irons	2,542	193	407	--	978	4,120
Electroplating [1]	18,566	1	26	2,037	98	20,728
Chemicals and chemical uses	915	--	35	194	15	1,159
Other uses [2]	3,944	1	293	141	707	5,086
Total reported by companies canvassed and estimated	95,639	11,332	16,751	2,376	2,718	128,816

[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	1969	1970 [r]	1971
Metal	12,528	17,944	11,505
Ferronickel	1,868	2,249	2,385
Oxide powder and oxide sinter	1,018	3,304	1,189
Salts	539	498	358
Other	621	713	668
Total	16,574	24,708	16,105

[r] Revised.

PRICES

The producers' price for electrolytic nickel was $1.33 per pound, unchanged during the year. Quoted prices for merchant nickel and for nickel in scrap was little different from that quoted by the primary producers in the first half, but both merchant and scrap nickel prices trended downward in the last half.

FOREIGN TRADE

U.S. foreign trade in nickel in 1971 was down slightly from that of 1970. However, the trade pattern was changed somewhat. More than 5,000 tons of nickel ore was imported from New Caledonia for use in pilot plant research operations in the United States. Canada continued as the principal nickel supplier with 82 percent of the total imported for consumption. Norway and the French Pacific Islands supplied a large part of the remainder, but that from Norway originated in Canadian mines. Nickel imports from Canada were 13 percent less than in 1970, and from Australia were 10 percent less. Ferronickel imports from New Caledonia in 1971 were almost double those of 1970, but the U.S.S.R. supplied only 45,000 pounds of nickel to the United States in 1971, compared with 1,700,000 pounds in 1970.

U.S. exports of nickel and nickel alloys were 15 percent less than in 1970, but exports of nickel compounds and catalysts were up almost 50 percent.

Table 8.—U.S. exports of nickel and nickel alloy products, by class

Class	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Unwrought	1,851	$5,631	6,103	$13,450	4,287	$8,614
Bars, rods, angles, shapes and sections	5,052	12,405	5,311	16,047	4,904	16,828
Plates, sheets, and strip	4,218	16,582	4,653	21,893	3,351	14,675
Anodes	91	347	160	600	334	1,147
Wire	746	3,630	870	5,642	643	3,269
Powder and flakes	398	2,517	281	2,405	696	2,754
Foil	14	83	18	76	7	41
Catalysts	3,592	7,531	2,524	6,451	3,740	10,018
Tubes, pipes, blanks, and fittings therefore, and hollow bars	768	3,887	1,756	6,520	2,134	9,985
Waste and scrap	18,028	29,455	9,780	12,840	6,047	7,239
Total	34,758	82,068	31,456	85,924	26,143	74,570

Table 9.—U.S. imports for consumption of nickel products, by class

Class	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)	1971 Short tons	1971 Value (thousands)
Ore	--	--	21	$251	13,173	$297
Unwrought	99,656	$209,476	r 117,334	r 302,578	110,531	259,931
Oxide and oxide sinter	4,013	6,524	6,423	12,611	5,769	11,604
Slurry [1]	23,714	54,784	35,114	82,643	32,944	73,656
Bars, plates, sheets, and anodes	113	628	177	773	79	302
Rods and wire	540	2,171	544	2,630	768	3,642
Shapes, sections, and angles	5	30	2	12	(2)	1
Pipes, tubes, and fittings	10	45	22	97	10	47
Powder	2,708	6,452	r 3,050	r 10,416	r 2,708	8,234
Flakes	65	136	76	207	1	3
Waste and scrap	3,184	8,077	2,149	4,485	1,336	1,896
Ferronickel	15,696	9,507	r 14,251	r 9,834	26,233	16,986
Total (gross weight)	149,704	297,830	r 179,163	r 426,537	183,552	376,599
Nickel content (estimated)	129,332	XX	156,252	XX	142,183	XX

r Revised. 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 10.—U.S. imports for consumption of new nickel products,[1] by country

(Short tons)

Country	Metal 1970 (Gross weight)	Metal 1971 (Gross weight)	Oxide and oxide sinter 1970 (Gross weight)	Oxide and oxide sinter 1971 (Gross weight)	Slurry and other [2] 1970 r Gross weight	Slurry and other [2] 1970 r Nickel content	Slurry and other [2] 1971 Gross weight	Slurry and other [2] 1971 Nickel content
Australia	849	457	--	--	126	32	442	336
Canada	104,248	87,040	6,412	5,728	31,492	25,207	30,446	25,122
Finland	4	21	--	--	3	3	--	--
France	--	181	--	28	--	--	45	45
Germany, West	122	50	11	--	--	--	52	18
Israel	r 13	2	--	--	--	--	--	--
Netherlands	21	408	--	--	22	22	--	--
Norway	10,789	11,067	--	--	36	36	43	43
South Africa, Republic of	98	929	--	13	4,922	2,288	3,099	1,521
Sweden	2	25	--	--	--	--	--	--
U.S.S.R.	863	22	--	--	--	--	--	--
United Kingdom	302	329	(3)	(3)	1,639	1,639	1,525	1,502
Other countries	23	--	--	(3)	--	--	1	1
Total	r 117,334	100,531	6,423	5,769	38,240	29,227	35,653	28,588

r Revised.
[1] Ore: 1970, 21 short tons from Republic of South Africa; 1971, 13,173 short tons, Australia 2,196, French Pacific Islands 5,566, Colombia 4,314, Philippines 1,097, Canada less than 1 short ton.
[2] Nickel-containing material in powder, 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

There was an apparent surplus of approximately 150 million pounds of nickel in world markets in 1971. This surplus dampened some planned expansion plans and postponed a few planned nickel plant construction projects, but its effect on the whole of the nickel industry was measurably less than the proportionate imbalance with demand. Practically all the planned projects affected would not have been producing nickel before 1974. The surplus had minimal effect on 1971 production.

Australia.—Australia's nickel production increased more than 7 percent compared with that of 1970. Western Mining Corp. Ltd.'s Silver Lake shaft at Kambalda again accounted for most of the output, and the company continued to lead the Western Australian nickel boom of the last 4 years. The corporation increased its reserves by approximately 5 million tons containing more than 3 percent nickel, and began construction of a smelter that will have a capacity of 20,000 tons of nickel per year with built-in provisions for expansion to 40,000 tons per year.

Australian nickel reserves were reported several times during the year. Those who compiled the reserves in the first part of the year reported approximately 2½ million tons of nickel metal in ore averaging 1.73 percent nickel.[3] A later compilation reported almost 200 million tons of ore containing more than 3 million tons of nickel in ore averaging 1.6 percent nickel.[4]

The reported reserves of nickel in Western Australia lie in sulfide ore bodies in the Western Australian Gold Belt, a mineralized area that extends in an arc from Norsman north to Wiluna. The potential of this area is believed to be many times the reserve figures reported to date.

Poseidon N. L. reported its drilling program of the last year had sufficiently detailed the potential ore zone of its property to plan mine development for the first 7 or 8 years of operation. The company entered an agreement with the Western Australian Government to bring the Mt. Windara nickel mine into production at a cost of over $62 million. Under the terms of the agreement the company is committed to investigate construction of a nickel smelter within 10 years and to build and operate a smelter if the investigation proves it technically and economically feasible. The Mt. Windara mine is scheduled to start producing ore in mid-1973.

Freeport, Queensland Nickel, Inc., and Metals Exploration Queensland Ltd. announced at yearend that they will proceed with development of the Greenvale-Queensland nickeliferous laterite deposits. The Export-Import Bank of the United States authorized a loan of $9 million for the project and guaranteed a loan of equal amount from the Chase Manhattan Bank. According to the terms of the loan, Freeport-Queensland and Metals Exploration will make cash payments of $2 million, which, with the loan and guarantee, will provide $20 million for purchase of U.S. goods and services required for the Greenvale project.

Poseidon, Union Oil Co., Homestake Mining Co., and Hanna Mining Co. entered an agreement to combine their nickel properties in Western Australia and share development costs equally. The agreement is subject to approval of the Western Australian Government. If approved, Poseidon would operate the project and own a 50-percent interest. Union Oil Development Corp., a subsidiary of Union Oil Co., would own 25 percent while the operating subsidiaries of Homestake and Hanna would have a 12 ½-percent interest each.

Botswana.—Development of the Pikwe-Selebi copper-nickel deposit was delayed as the costs being incurred exceeded estimates and as Metallgesellschaft AG of West Germany announced that it was not prepared immediately to underwrite a loan which would provide funds to proceed with the project. Apparently the delay was caused mainly by the worldwide surplus of nickel, as Metallgesellshaft had been expected to market most of the nickel from the project in the Federal Republic of Germany.

Brazil.—Brazil produced 3,500 tons of nickel in ferronickel with an average metal content of about 23 percent. Morro do Niquel, S.A. made a feasibility study of a $45

[3] Fletcher, Kenneth. Dramatic Results of Nickel Exploration in Australia. Min. Cong. J., v. 57, No. 1, January 1971, pp. 17–19.

[4] American Metal Market. Australia May Furnish 20% of Nickel Used in Free World in Four Years. V. 78, No. 88, May 7, 1971, p. 14.

million plant which would produce 10,000 tons of nickel in ferronickel per year.[5]

Canada.—Canadian mines produced 294,000 tons of nickel in 1971, just 3½ percent less than the record output of 1970. The high level of production was obtained despite closing of the Murray and Soab mines in the middle of the year by INCO and the dampening influence of the imbalance between supply and demand.

Reported nickel exploration projects by the principal producers and independent mining companies indicated no slackening in the search for nickel deposits in Canada.

The Canadian nickel industries' planned expansion proceeded about on schedule. INCO's new Clarabelle concentrator, which has a capacity to treat 35,000 tons of ore per day, became operational in November. Construction of INCO's 2,500-ton-per-day Shebandowan concentrator was on schedule; however, construction of the Company's 125-million-pound-per-year nickel refinery was running behind schedule by 6 months to a year.

Falconbridge Nickel Mines Ltd. completed construction of the surface plant at its new Manibridge mine. The mine began producing ore in July. The Falconbridge nickel-iron refinery completed in 1970 operated throughout the year, but the plant continued to have startup problems and did not achieve regular, continuous production of specification products.

INCO announced that it had suspended planned expansion of its iron-ore recovery plant and cancelled plans to construct a 700,000-ton-per-year sulfuric acid plant. These actions will not materially affect INCO's overal expansion plans.

Falconbridge Nickel Mines announced that it would build a nickel-copper refinery and sulfur recovery plant at Becancourt, Quebec. The new plant will have capacity to produce 30 million pounds of nickel, 22 million pounds of copper, 7,000 tons of sulfur, and over 500,000 pounds of cobalt annually. It is expected to be completed by 1974.[6]

Giant Mascot Mines reported proved reserves of 1,688,034 tons of ore containing 0.80 percent nickel and 0.40 percent copper. This is a 22-percent increase compared with the measured reserve at the end of 1970. Giant Mascot's Hope mine was closed from August 1970 through May 1971 for rebuilding of surface facilities destroyed last year by fire.[7]

Canadian nickel producers and their 1971 production or delivery to customers as given in their annual reports to stockholders were as follows:

Company	Type of operation	Pounds
The International Nickel Co. of Canada Ltd	Delivery	342,450,000
Falconbridge Nickel Mines Ltd	Delivery	85,864,000
Sherritt Gordon Ltd	Sales	14,587,000
Consolidated Canadian Faraday Ltd	Production	1,147,606
Giant Mascot Mines Ltd	Recovery	1,861,492

Dominican Republic.—Falconbridge Dominicana C. por A. substantially completed construction of its ferronickel plant just 24 months after the first foundations were poured. First metal was tapped from the No. 1 furnace on October 9, 1971, and from the No. 2 furnace on December, 1971. The company exported 190 tons of nickel in ferronickel on December 29, 1971.

The Dominican Republic exercised its option to purchase 47,664 shares of Falconbridge Dominicana C. por A., thus reducing Falconbridge Nickel Mines Ltd. share from 68.9 percent to 65.7 percent. Ore reserves at the property were increased to 72,300,000 short dry tons containing 1.58 percent nickel by definition drilling of the ore bodies during the 2-year plant construction period.[8]

Greece.—Intercontinental Mining and Abrasives, Inc. (ICON), headquartered in New York, announced that Intercontinental had concluded an agreement with Southland Mining Ltd. of Australia to construct a refinery in Greece to produce between 8,000 and 10,000 tons of ferronickel annually. In the announcement Intercontinental emphasized that it would probably build another refinery with capacity of about 6,000 tons without outside help.[9]

[5] U.S. Bureau of Mines. Nickel: Brazil, Mineral Trade Notes, v. 68, No. 8, August 1971, pp. 34–35.

[6] Cooper, Marshall A. Address to annual meeting of Falconbridge Nickel Mines Ltd. Toronto, Canada. Apr. 14, 1971, p. 22.

[7] Northern Miner. Ore Reserves Up Sharply at Giant Mascot Nickel Mine. V. 57, No. 41, Dec. 30, 1971, p. 3.

[8] Falconbridge Nickel Mines Ltd. Annual Report 1971, p. 38.

[9] American Metal Market. Intercontinental Mining Plans 2 Nickel Refineries in Greece. V. 78, No. 117, June 18, 1971, pp. 1, 3.

According to unofficial reports from Greece, Intercontinental Mining of the United States and Southland Mining of Australia applied to the Ministry of Coordination of Greece for approval of a $30 to $50 million investment in nickel mining and manufacturing in that country.[10]

Larco, the only concern that produced nickel in Greece in 1971, encountered marketing difficulties. However, it increased its output to an estimated 12,000 tons, compared with the record 8,642 tons produced in 1970.

Colombia.—Colombian Nickel Co. (CONICOL) and the Industrial Development Institute of Colombia (IFI) began construction of the infrastructure for a nickel project at Cerro Matoso, in the Department of Córdoba. CONICOL was formed by the Chevron Petroleum Co. and Hanna Mining Co. of the United States to exploit Colombian nickel deposits.[11]

According to the terms of an agreement with the Colombian Government, CONICOL will operate the property during the first 15 years, but overall control is to be the responsibility of a 9-man Directive Council composed of three representatives each from IFI and the two companies, Chevron and Hanna. After the 15 years are up, IFI must hold at least 50 percent of the operating company.

Guatemala.—Plans of Exploraciones y Explotaciones Mineras Izabal, S.A. (EXMIBAL) to develop a lateritic ore body in the Lake Izabal area were again delayed as the company continued efforts to find a viable basis for financing the development.[12] EXMIBAL is owned 80 percent by International Nickel Co. of Canada Ltd. and 20 percent by Hanna Mining Co. of the United States. Apparently uncertainties in the world nickel market made it advisable to reevaluate the proposed 60-million-pound-per-year project.

Indonesia.—President Suharto, in an Independence Day speech August 16, 1971 cited increased nickel output of 12 percent as one of the spectacular gains in the metal extractive industries that contributed to the expanding Indonesian economy.

P.T. International Nickel, Indonesia, a wholly owned subsidiary of International Nickel Co. of Canada Ltd., confirmed location of a significant lateritic deposit in the Soroako area of the island of Sulawesi.[13] The company is conducting a feasibility study with related planning and financing activities on the project.

P.T. Pacific Nikkel, Indonesia, owned 43 percent by United States Steel Corp., 22 percent by Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V., 15 percent by Newmont Mining Corp., and 10 percent each by W. H. Muller & Co. and Sherritt Gordon Mines Ltd., arranged to ship 12,000 tons of laterite nickel ore to the Sherritt Gordon Mines Ltd. demonstration plant at Fort Saskatchewan, Canada.[14] An independent engineering concern will make a feasibility study to determine the capital and operating cost of a plant to produce 60 million to 100 million pounds of nickel a year from the deposits Pacific Nikkel has proved in the Waigeo area of Irian Barat.

New Caledonia.—New Caledonia produced about the same quantity of nickel in 1971 as in 1970. Its production of nickel in ferronickel increased 7 percent and its production of nickel in matte increased 2 percent, an increase of 5 percent in the nickel content of processed products. However, its production of nickel in ore measured by the quantity exported decreased 6 percent compared with 1970. Overall, crude nickel ore production in 1971 was 8 percent more than in 1970. The high rate of production was achieved despite a 2-month labor strike from July 1 to August 30, 1971, at Société Le Nickel's operations.

Société Le Nickel, S.A. continued to consolidate its position as the premier nickel producer of New Caledonia. In a joint venture with Kaiser Nickel Co. through New Caledonian Nickel Co., a 50–50 partnership, another 33,000-kilowatt electric furnace was added to the plant at Doniambo.

A proposed 50,000-ton nickel pellet project of the Compagnie Française Industrielle et Minière du Pacifique (COFIMPAC) was cancelled because the French concerns were not prepared to move ahead with such a large-scale project.

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[10] U.S. Bureau of Mines. Nickel: Greece. Mineral Trade Notes, v. 68, No. 11, November 1971, p. 33.

[11] U.S. Bureau of Mines. Nickel: Colombia. Mineral Trade Notes, v. 68, No. 10, October 1971, p. 8.

[12] International Nickel Co. of Canada Ltd. 1971 Annual Report, p. 11.

[13] Work cited in footnote 12.

[14] Skillings' Mining Review. Sherritt to Test Laterite Ore for P. T. Pacific Nikkel. V. 60, No. 44, Oct. 30, 1971, p. 6.

At yearend, the International Nickel Co. of Canada Ltd., the principal factor in COF-IMPAC, was negotiating with the French Government for alternative nickel resource developments on a much smaller scale and with a broader financial base.[15]

Philippines.—Marinduque Mining and Industrial Corp. (MMIC) encountered numerous delays in obtaining the capital needed to construct its proposed laterite mining plant on the Surigao mineral reservation. However, at yearend essentially all the obstàcles had been overcome. The company issued a Prospectus in August offering 200,000 shares of capital stock for sale in the United States and the Philippines, the price to be negotiated between representatives of the underwriters and the company. The company cancelled the proposed public offering of the stock when the negotiated price proved so low that it would have been necessary to issue a higher number of shares to acquire the necessary funds. Nevertheless, Marinduque was assured of adequate funding when the Development Bank of the Philippines agreed to purchase 1,608,750 shares of MMIC capital stock at a price of approximately $12.41 per share. Thus the project became viable and Marinduque was in a position to sell stock to the public at times of its own choosing.

A. Soriano y Cia. and Universal-Rio Tuba developed sufficient ore in Palawan and Devao Oriental to justify construction of a mining plant to exploit it.

Rhodesia.—Geologists of the Johannesburg Consolidated Investment Co. (JCI) proved nickel-copper mineralization at Damba, 60 kilometers north of Bulawayo, and according to press reports, JCI confirmed that it would open a nickel mine and smelter at Shangani, 96 miles north of Bulawayo.[16] JCI has announced that both the quantity and grade of the ore so far delineated are sufficient to justify production at the rate of 720,000 tons of ore per year.

Rio Tinto Rhodesia Ltd. announced that plans are under way to develop a copper-nickel mine near Chakari. Ore reserves are reported to be about 1 million tons.[17]

[15] Work cited in footnote 12.
[16] U.S. Bureau of Mines. Nickel: Rhodesia. Mineral Trade Notes, v. 68, No. 12, December 1971, p. 29.
[17] Mining Journal (London). New Rhodesian Copper-Nickel Mine. V. 276, No. 7070, Feb. 19, 1971, p. 126.

Table 11.—Nickel: World production by country [1]

(Short tons)

Country [2]	1969	1970	1971 p
Australia (content of concentrates)	12,324	31,862	e 34,000
Brazil (content of ore) e	1,900	3,200	3,500
Burma (content of speiss)	33	23	e 20
Canada [3]	213,611	305,881	293,947
Cuba:			
Content of oxide e	20,400	20,400	40,000
Content of sulfide e	18,400	18,400	
Finland:			
Content of concentrates	3,996	5,634	4,968
Content of nickel sulfate	211	165	e 165
Greece (recoverable content of ore)	9,115	p 9,500	e 11,600
Indonesia (content of ore) [4]	8,404	19,842	29,762
Mexico (content of ore)	39	49	e 55
Morocco (content of nickel ore and cobalt ore)	311	152	e 220
New Caledonia (recoverable) [5]	99,731	116,164	112,751
Norway (content of concentrate)	273	e 360	e 360
Poland (content of ore) e	1,650	2,200	2,000
Rhodesia, Southern (content of concentrate) e	4,400	r 12,000	13,000
South Africa, Republic of (electrolytic)	e 11,000	12,739	14,067
U.S.S.R. (content of ore) e	r 115,000	r 120,000	130,000
United States:			
Byproduct of metal refining	r 2,714	r 2,909	2,581
Nickel recovered from domestic ore	13,096	12,649	13,073
Total	r 536,608	694,129	706,069

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 are used in lieu of actual reported mine output as a measure of mine output. Countries such as Czechoslovakia, Japan, and North Korea, which produce smelter nickel from imported raw materials, have been excluded to avoid double counting.
[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 content of oxides and salts produced, plus recoverable nickel in matte and concentrates exported.
[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.

TECHNOLOGY

Judging by the number of domestic and foreign patents granted and the number of articles published in the technical press on extracting nickel from its ores, the pattern of nickel research in 1971 was little different from that of 1969 and 1970. Research in nickel applications probably was intensified in view of the large supply surplus, but the published literature did not reflect the change. Studies to recover secondary nickel were as numerous as in 1970. The Committee on Biologic Effects of Atmospheric Pollutants, Division of Medical Sciences of the National Research Council, formed an ad hoc, interdisciplinary panel of experts to study nickel as a possibly hazardous pollutant and toxic material.

Bureau of Mines researchers studied the variables involved in the recovery of nickel and associated metals from sulfide and silicates by acid-bake and salt-roast processes. At yearend, the work had not progressed enough to give conclusive results, but in small-scale laboratory tests most of the nickel and copper in nickel ores were extracted in water-soluble sulfates. Cadmium and nickel were recovered from scrap batteries in Bureau of Mines laboratories. An ammonium nitrate solution was used to leach cadmium selectively from the battery plates leaving a high-nickel-low-iron alloy residue. The process is described in Bureau of Mines Report of Investigation 7566.[18]

Scientists of the U.S. Geological Survey developed a neutron bombardment device which can be used to detect nickel in the earth's crust.[19] The device uses the recently discovered, man-made element californium-252 as a source of neutrons. In laboratory tests the device detected nickel concentration as low as 0.1 percent.

Researchers at the University of Minnesota developed a thermodynamic interpretation of the segregation process for copper and nickel ores.[20]

Nickel ore from New Caledonia was imported into the United States for testing at the American Metal Climax, Inc. research station in Golden, Colorado. Reportedly, metallurgists of the French company Société Minière et Métallurgique de Peñarroya S.A. worked with those of American Metal Climax, Inc. to develop a process to recover both nickel and cobalt from the New Caledonian ore.[21] These reports on extractive metallurgical studies in 1971 did not indicate an impending breakthrough to new or greatly improved processes.

A number of new nickel-base alloys were developed during the year, but no one stood out over the others as having unusual or noteworthy practical application. On the other hand, there seemed to be definite progress in the technology of improving nickel-base and other superalloys by reinforcing them with other materials. Scientists of the National Aeronautics and Space Administration described fabrication techniques for thoria dispersed (TD) nickel.[22] Proprietary spin-forming techniques developed by Tri-Metals Co., combined with welding techniques developed by Bell Aerospace Co., were used successfully to fabricate the combustion chamber and nozzle of rocket motors. Refractory monocarbides of titanium, zirconium, hafnium, vanadium, niobium, and tantalum, metals from groups IVb and Vb of the periodic table were investigated as reinforcing agents in the nickel-and cobalt-base superalloys.[23] The researchers demonstrated significant reinforcement of a nickel or cobalt matrix with aligned monocarbide whiskers. They theorized that research in more complex systems might prove fruitful.

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[18] Wilson, D. A., and B. J. Wiegard, Jr. Recovery of Cadmium and Nickel from Scrap Batteries. BuMines Rept. of Inv. 7566, 1971, 15 pp.

[19] Senftle, F. E., P. F. Wiggins, D. Duffey, and P. Philbin. Nickel Exploration by Neutron Capture Gamma Rays. Econ. Geol., v. 66, 1971, pp. 583–590.

[20] Iwasaki, I. A Thermodynamic Interpretation of the Segregation Process. Pres. at Met. Soc. AIME 100th Annual Meeting, New York 1971. To be published in the Transactions of the Met. Soc. of AIME.

[21] World Mining. French Metallurgists Operate Colorado Nickel Pilot Plant. V. 7, No. 11, October 1971, p. 57.

[22] Lewis Research Center Contract LEW 11240. Investigation of Advanced Thrust Chamber Design. Reference: NASA–CR–72742 (N71–14135). Available from National Technical Information Service, Springfield, Va. 22151.

[23] Lembey, F. D. and E. R. Tompsoon. Nickel and Cobalt Eutectic Alloys Reinforced by Refractory Metal Carbides. Met. Trans. AIME, v. 2. No. 6, June 1971, pp. 1537–1544.

Nitrogen

By Ted C. Briggs [1]

Domestic production of fixed nitrogen increased by 1 percent, and production of elemental nitrogen increased by 8.8 percent. Anhydrous ammonia plants, the major source of fixed nitrogen, operated at about 81 percent of capacity. The most serious problem facing the domestic producers of ammonia is the diminishing availability of low-cost natural gas.

Nitrogen fertilizer consumption increased by 9 percent for the fiscal year ending June 30, 1971, and about 73 percent of the fixed nitrogen produced in the United States is consumed as fertilizers. The States that consumed the most nitrogenous fertilizers were Illinois, Iowa, Texas, and Kansas, in that order. Some environmentalists and ecologists have advocated State or national controls on fertilizer usage; however, a recent U.S. Department of Agriculture appraisal found no indication of widespread upward trends of nitrate concentrations in foods, feeds, and surface or ground water.

Exports of major nitrogen compounds dropped again in 1971, and imports remained roughly the same. There was a worldwide oversupply of nitrogen fertilizers during the year, consequently fierce competition developed for markets.

[1] Chemist, Division of Nonmetallic Minerals.

Table 1.—Salient nitrogen statistics

(Thousand short tons of contained nitrogen)

	1967	1968	1969	1970	1971 p
United States:					
Production as ammonia	10,205	10,130	10,664	11,307	11,417
Production as nitrogen gas	3,766	4,302	4,807	5,477	5,957
Exports of nitrogen compounds	828	1,428	1,645	1,400	1,017
Imports for consumption of nitrogen compounds	691	669	738	942	919
Consumption [1]	9,216	9,682	9,939	10,667	11,207
World: Production [1]	31,627	35,427	39,556	42,747	45,357

p Preliminary.
[1] Estimated, excludes nitrogen gas.

Table 2.—Nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1967	1968	1969	1970	1971 p
Anhydrous ammonia: Synthetic plants [1]	10,029	9,968	r 10,502	r 11,160	11,283
Ammonia compounds, coking plants:					
Ammonia liquor	12	14	12	12	12
Ammonium sulfate	156	142	143	r 126	122
Ammonium phosphates	8	6	7	r 9	(2)
Total	10,205	10,130	r 10,664	r 11,307	11,417
Nitrogen gas [1]	3,766	4,302	r 4,807	r 5,477	5,957

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	1970	1971 p
Ammonium nitrate	r 6,475	6,584
Ammonium sulfate [1]	r 2,531	2,363
Ammonium phosphate	5,212	5,891
Nitric acid	r 6,685	6,671
Urea	r 3,119	3,071

p Preliminary. r Revised.
[1] Includes ammonium sulfate from coking plants.
Sources: Bureau of the Census and Tariff Commission.

DOMESTIC PRODUCTION

The most serious problem facing domestic producers of anhydrous ammonia is the diminishing availability of low-cost natural gas used to obtain the hydrogen required to produce ammonia and to provide plant energy requirements. Alternate feedstocks for ammonia plants can, of course, be used; but production costs would increase, thus making domestic ammonia less competitive than ammonia produced in countries that have large reserves of low-cost natural gas.

Production capacity in 1971 for synthetic ammonia was about 14 million tons of contained nitrogen, although actual production in 1971 was about 81 percent of capacity. Production of fixed nitrogen increased by 1 percent, and production of elemental nitrogen increased by 8.8 percent.

Theoretically, operators of new ammonia plants would like to hold plant downtime to 15 days per year; however, this goal has yet to be achieved. Onstream time has improved during the past several years, but a survey covering the operating period January 1969 to May 1971 indicated that the average ammonia plant had nine shutdowns per year and was out of production for an average of 49 days per year. Another factor to be considered, however, was that another study showed some new plants operated at 107 percent of design capacity, thus moving total yearly production close to the plant specifications.[2]

[2] Chemical Week. More Time to Make Ammonia. V. 109, No. 15, Oct. 13, 1971, pp 77–78.

Table 4.—Domestic producers of anhydrous ammonia

(Thousand short tons per year)

Company	Location	Capacity
Air Products and Chemicals Inc	New Orleans, La	210
Do	Pace Junction, Fla	100
Allied Chemical Corp	Geismar, La	340
Do	Hopewell, Va	340
Do	La Platte, Nebr	202
Do	South Point, Ohio	80
American Cyanamid Co	Fortier, La	340
American Oil Co	Texas City, Tex	720
Apache Powder Co	Benson, Ariz	15
Apple River Chemical Co	East Dubuque, Ill	230
Arco Chemical	Fort Madison, Iowa	340
Arkla Chemical Corp	Helena, Ark	210
Atlas Chemical Industries Inc	Joplin, Mo	136
Borden Chemical Div	Geismar, La	240
CF Industries, Inc	Fremont, Nebr	48
Do	Donaldsonville, La	680
Central Nitrogen, Inc	Terre Haute, Ind	135
Cherokee Nitrogen, Inc	Pryor, Okla	55
Chevron Chemical Co	Richmond, Calif	130
Do	Fort Madison, Iowa	105
Do	Pascagoula, Miss	510
Cities Service Co	Tampa, Fla	120
Collier Carbon & Chemical Corp	Kenai, Alaska	510
Do	Brea, Calif	260
Columbia Nitrogen Corp	Augusta, Ga	122
Commercial Solvents Corp	Sterlington, La	340
Continental Oil Co	Blytheville, Ark	340
Cooperative Farm Chemical Assn	Lawrence, Kan	340
Diamond-Shamrock Corp	Dumas, Tex	160
Dow Chemical Co	Freeport, Tex	115

See footnotes at end of table.

Table 4.—Domestic producers of anhydrous ammonia—Continued

(Thousand short tons per year)

Company	Location	Capacity
E. I. DuPont de Nemours Co	Beaumont, Tex	340
Do	Belle, W. Va	340
Do	Victoria, Tex	100
El Paso Products Co	Odessa, Tex	137
Farmers Chemical Co	Tunis, N. C	210
Do	Tyner, Tenn	170
Farmland Industries Inc	Dodge City, Kans	210
Do	Fort Dodge, Iowa	210
Do	Hastings, Nebr	140
Felmont Oil Corp	Olean, N.Y	85
FMC Corp	South Charleston, W. Va	24
Goodpasture, Inc	Dimmitt, Tex	30
W. R. Grace & Co	Woodstock, Tenn	275
Do	Big Spring, Tex	100
Green Valley Chemical Co	Creston, Iowa	35
Hawkeye Chemical Co	Clinton, Iowa	138
Hercules, Inc	Hercules, Calif	70
Do	Louisiana, Mo	70
Hill Chemicals, Inc	Borger, Tex	340
Hooker Chemical Co	Tacoma, Wash	23
Kaiser Agricultural Chemicals	Savannah, Ga	150
Miscoa	Yazoo City, Miss	340
Mobil Chemical Co	Beaumont, Tex	260
Monsanto Co	Muscatine, Iowa	100
Do	Luling, La	450
New Jersey Zinc Co	Palmerton, Pa	35
Nipak, Inc	Pryor, Okla	105
Do	Kerens, Tex	125
Occidental Agricultural Chemical Co	Lathrop, Calif	96
Do	Plainview, Tex	52
Olin Corp	Lake Charles, La	490
Pennsalt Chemicals Co	Wyandotte, Mich	34
Do	Portland, Oreg	8
Phillips Pacific Chemical Co	Kennewick, Wash	155
Phillips Petroleum Co	Beatrice, Nebr	210
Do	Etter, Tex	210
Do	Pasadena, Tex	230
PPG Industries	Natrium, W. Va	50
Shell Chemical Co	St. Helens, Oreg	90
Do	Ventura, Calif	165
J. R. Simplot Co	Pocatello, Idaho	54
Southwestern Nitrochemical Corp	Chandler, Ariz	40
Sun Oil Co	Marcus Hook, Pa	133
Tenneco Chemicals Inc	Houston, Tex	210
Tennessee Valley Authority	Muscle Shoals, Ala	74
Terra Chemicals International	Port Neal, Iowa	210
Triad Chemical Co	Donaldsonville, La	340
USS Agri-Chemicals, Inc	Cherokee, Ala	177
Do	Clairton, Pa	400
Do	Geneva, Utah	70
Valley Nitrogen Producers, Inc	El Centro, Calif	210
Do	Helm, Calif	176
Vistron Corp	Lima, Ohio	510
Vulcan Materials Co	Wichita, Kan	23
Willchemco, Inc	Donaldsonville, La	340
Wycon Chemical Co	Cheyenne, Wyo	167
Total		17,009

Source: Tennessee Valley Authority.

CONSUMPTION AND USES

The major use of fixed nitrogen continued to be for fertilizers. Chemically combined nitrogen is irreplaceable and essential for plant growth; however, some environmentalists and ecologists have advocated State or national controls on fertilizer usage. The U.S. Department of Agriculture (USDA) recently published a comprehensive report on the accumulation of nitrate in soil, water, and plants. The USDA appraisal found no indication of widespread upward trends of nitrate concentrations in foods, feeds, and surface or ground water.[3]

The USDA reported that 8,140,247 tons of nitrogen contained in fertilizers were consumed during the fiscal year ending June 30, 1971, which was an increase of 9 percent over the fiscal year ending June

[3] Viets, Frank G., Jr., and Richard H. Hageman. Factors Affecting the Accumulation of Nitrate in Soil, Water, and Plants. Agriculture Handbook No. 413, U. S. Department of Agriculture, November 1971, 63 pp.

30, 1970.[4] Fertilizer nitrogen consumption was equal to 72.9 percent of the total fixed nitrogen production during the 12 month period ending June 30, 1971. Of the synthetic anhydrous ammonia produced, 29.5 percent was consumed in direct application as ammonia to the soil for fertilizer. An additional 18.5 percent of the fixed nitrogen production was consumed in mixed fertilizers that contain other plant nutrients.

Most of the remaining fixed nitrogen was consumed as explosives, plastics, synthetic fibers, and in other industrial chemicals.

The most promising area for growth in elemental nitrogen consumption was as a refrigerant. Liquid nitrogen was used, in increasing amounts, for fast freezing of foods and for cooling during transport.[5]

A potential large market for sodium nitrilotriacetate (NTA) vanished with the Government's decision that it should not be used in detergents. The chemical had been under consideration as a replacement for phosphates in synthetic detergents, but unresolved questions arose concerning the long-term effects of NTA on health and the environment.

PRICES

The list price of ammonium sulfate dropped precipitously from the 1970 list price. The new list price, however, more accurately reflects the actual selling price, as ammonium sulfate was heavily discounted last year. At least three factors have combined to lower the price of ammonium sulfate. First, ammonium sulfate is a byproduct from the production of some plastics and from coke-oven gas; second, the Agency for International Development is no longer funding large exports of ammonium sulfate to developing countries; and, third, domestic farmers now prefer fertilizers that have a higher nitrogen content.

The price of agricultural-grade urea was weak during 1971, with the list price about 12 percent below last year's price. The worldwide surplus of urea probably acted as a ceiling on the domestic price.

The price of imported sodium nitrate jumped 13 percent. The domestic market for sodium nitrate is relatively small and localized, and the reasons for the price increase are, in general, obscure. The price of a pound of nitrogen in sodium nitrate is about 16 cents, compared with a pound of nitrogen in urea at about 6 cents.

Otherwise, prices were essentially constant.

[4] Statistical Reporting Service, U.S. Department of Agriculture. Commercial Fertilizers—Consumption in the United States—Fiscal Year Ended June 30, 1971. May 1972, 26 pp.
[5] Chemical & Engineering News. Future Looks Favorable for Industrial Gases. V. 49, No. 43, Oct. 18, 1971, pp. 23, 25.

Table 5.—Price quotations for major nitrogen compounds

(Per short ton)

Compound	Jan. 3	Dec. 27
Ammonium nitrate, fertilizer-grade, 33.5 percent nitrogen, bulk, 5-ton min., works	$40–46.50	$40–46.50
80 pound bags, same basis	47–54	47–54
Ammonium sulfate, standard-grade, commercial, bulk, f.o.b. works	12–22	12–22
Bags, carlots, works	20.50	20.50
Anhydrous ammonia, fertilizer, wholesale, tank, delivered east of Rockies	55–57	55–57
Aqueous ammonia, 29.4 percent, NH_3	65–70	65–70
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-lb. bags, carlot, same basis	55.50	55.50
Urea:		
Industrial 46 percent nitrogen, bulk, 50-ton carlots, delivered East	64–76	64–76
Agricultural 46 percent nitrogen, bulk, same basis	55–60	55–60
Agricultural 45 percent nitrogen, bulk, 50-ton carlots, delivered East	53–58	53–58
Diammonium phosphate, fertilizer-grade, 18–46–0, bulk, carlots, f.o.b. Fla. works	55–62	55–62

Source: Chemical Marketing Reporter, formerly Oil, Paint and Drug Reporter.

FOREIGN TRADE

Exports of major nitrogen compounds declined again in 1971. Exports of chemical-grade ammonia fell by 77 percent, fertilizer ammonia by 40 percent, and urea by 19 percent, calculated on a contained nitrogen basis. Exports of ammonium phosphates increased by 33 percent, partially offsetting the effects of the declines. Because of the increased exports of ammonium phosphates, the total value of exports dropped by only $9 million, or 6 percent from last year. The total nitrogen content exported, however, dropped by 27 percent. Thirty percent of the urea exports went to South Vietnam and 23 percent went to Singapore; 20 percent of the fertilizer ammonia went to Belgium, 15 percent to Denmark, and 14 percent to Mexico.

There is, at present, no foreseeable reason to expect a dramatic increase in exports. There will, in fact, be increasing competition for all world nitrogen markets.

Total imports of contained nitrogen declined by a modest 2 percent, but the value of imports only decreased by about $1 million, or 1 percent. Virtually all of the imported ammonium nitrate and ammonium phosphates came from Canada, as did 78 percent of the imported ammonium sulfate, 30 percent of the ammonia, and 50 percent of the urea. Ninety-four percent of the imported calcium nitrate came from Norway, and almost all of the imported natural sodium nitrate came from Chile.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds

(Thousand short tons and thousand dollars)

Compound	1970			1971		
	Gross weight	Nitrogen content e	Value	Gross weight	Nitrogen content e	Value
EXPORTS						
Industrial chemicals: Anhydrous ammonia and chemical-grade aqua (ammonia content)	243	199	$6,877	56	46	$2,391
Fertilizer materials:						
Ammonium nitrate	67	22	3,393	39	13	2,236
Ammonium phosphates	1,022	184	54,643	1,357	244	72,384
Ammonium sulfate	522	110	8,061	516	108	7,255
Anhydrous ammonia and aqua (ammonia content)	r 734	r 602	r 23,092	440	361	13,888
Nitrogenous chemical materials, n.e.c	19	6	1,376	90	27	8,656
Sodium nitrate	2	(1)	93	1	(1)	76
Urea	465	223	32,439	392	180	19,180
Mixed chemical fertilizers	340	54	20,541	235	38	15,315
Total	r 3,414	r 1,400	r 150,515	3,126	1,017	141,381
IMPORTS						
Industrial chemicals: Ammonium nitrate	1	(1)	82	3	(1)	212
Fertilizer materials:						
Ammonium nitrate	326	109	15,125	374	125	16,106
Ammonium nitrate-limestone mixtures	(1)	(1)	8	(1)	(1)	2
Ammonium phosphates	457	87	28,086	457	87	28,018
Ammonium sulfate	218	46	6,501	229	48	5,060
Calcium cyanamide or lime nitrogen	8	2	762	5	1	523
Calcium nitrate	52	8	1,138	40	6	982
Nitrogen solutions	124	37	5,200	168	50	5,523
Anhydrous ammonia	485	398	20,678	462	379	20,426
Potassium nitrate or saltpeter, crude	15	2	812	22	3	1,421
Potassium nitrate, sodium nitrate mixtures	56	8	2,231	61	9	2,651
Sodium nitrate	129	21	4,142	203	32	6,917
Urea	434	200	22,373	328	151	16,114
Nitrogenous fertilizers, n.s.p.f	14	3	870	21	4	1,227
Mixed chemical fertilizers	176	21	11,168	200	24	13,099
Total	2,495	942	119,176	2,573	919	118,281

e Estimate. r Revised.

1 Less than ½ unit.

WORLD REVIEW

The worldwide oversupply of nitrogen fertilizers continued during 1971, and there was fierce competition for markets.

Afghanistan.—A urea plant with a production capacity of 115,000 short tons per year was more than half completed at midyear. Production, on a trial basis, was scheduled to start in spring 1973, with full production targeted for summer 1976. The plant, located 10 miles from Mazar in a rugged and semiarid region, was being financed by the U.S.S.R.[6]

Australia.—The continuing poor performance of the nitrogenous fertilizer industry in Australia resulted in significant company operating losses. Eastern Nitrogen Ltd. reported a loss of $5.67 million. Prospects for the next few years were considered unfavorable. The revenue losses were due, in part, to a depressed rural economy and an uncertain future for primary farm production. Also, local demand for nitrogenous fertilizers was overestimated and plant expansions resulted in serious overcapacity.[7]

Austria.—The Austrian Government's nitrogen fertilizer monopoly, Österreichische Stickstoffwerke, was planning to build a large ammonia plant at its Linz complex in western Austria. The new plant will have a capacity of about 280,000 tons per year, and the planned startup date was late 1973 or early 1974. The plant will replace older units that now use coke-oven gas feedstock from the Vereinigte Österreichische Eisen und Stahlwerke A.G. steel works; total ammonia capacity will only increase marginally from the current 365,000 tons per year. When the new plant is operational, all of the ammonia will be based upon either natural gas from Österreichische Ferngas A.G. or naphtha supplied by Österreichische Mineralölverwaltung.[8]

Chile.—The Government of Chile decided to nationalize the entire nitrates industry. Chile is the world's leading producer of natural nitrates, an industry that has operated as a single group for nearly 2 years since the merger in 1969 of the Anglo-Lautaro Nitrate Co. and the Corporación de Fomento de la Producción (CORFO). Three plants were in operation, but the plants had worked at only 50 percent capacity because of slack demand.

CORFO is the Chilean Government-controlled development agency, and purchase of Anglo-Lautaro's assets will be through this agency. Under the terms of the agreement, Anglo-Lautaro will receive $6 million for its 49 percent interest. Half of the money was to be paid immediately and the balance was to be paid by March 31, 1972.[9]

Chile and the Peoples Republic of China signed a commercial trade agreement under which Chile would supply China with 25,000 tons per year of natural nitrates. The amount of nitrates to be supplied to China could increase to 40,000 tons per year between 1972 and 1976.[10]

Colombia.—A caprolactam plant, reputedly the first in Latin America, went on stream in Barranquilla. The plant has a yearly production capacity of 16,500 tons of caprolactam. Operating the $48 million installation is a three-way venture involving the Governments of Colombia, 45 percent; Venezuela, 45 percent; and Dutch State Mines of Holland, 10 percent.

Complex fertilizers will also be produced at the new facilities. Fertilizer capacity totals 145,000 tons per year of mixed fertilizer containing 26 percent nitrogen and 297,000 tons per year of fertilizer containing 14 percent nitrogen.[11]

France.—Official statistics released for France for the first half of 1971 show that ammonia production rose 13.3 percent by comparison with the same period last year, and first-half production was 868,000 tons of contained nitrogen. Nitrogenous fertilizers gained by 12.2 percent to 744,000 tons of contained nitrogen.[12]

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[6] Bureau of Mines. Nitrogen Compounds. Mineral Trade Notes, v. 68, No. 9, September 1971, p. 22.

[7] Chemical Age. Australian Fertiliser Rationalization Nears Completion. V. 103, No. 2712, July 9, 1971, p. 6.

European Chemical News. Eastern Nitrogen Returns Increases Losses. V. 19, No. 464, Jan. 22, 1971, p. 42.

[8] European Chemical News. OSW Adds New Ammonia Capacity at Linz. V. 20, No. 489, July 16, 1971, p. 20.

[9] Industrial Minerals. Nitrates Industry Comes Under Complete State Control. No. 46, July 1971, p. 31.

[10] U.S. Embassy Santiago, Chile. State Department Telegram. No. 571, April 1971, 2 pp.

[11] European Chemical News. Caprolactam, NPK and PVC Start-Ups in the Americas. V. 20, No. 506, Nov. 12, 1971, p. 6.

Oil, Paint and Drug Reporter. Caprolactam Facility On Stream in Colombia. V. 200, No. 22, Nov. 29, 1971, p. 5.

[12] European Chemical News. French Trade Balance Declines Sharply. V. 20, No. 498, Sept. 17, 1971, p. 6.

French sales of domestic ammonia dropped during the year. The roots of the trouble lie not in the booming agricultural market itself, but in imports of nitrogenous fertilizers from the Middle East, North Africa and East Europe.

Large sums were invested in ammonia plants a few years ago in France, which enabled substantial reductions in the production cost due to the modern technology. In 1971, with too many 1,000-ton-per-day plants, there was price cutting to compete for sales outlets. Having large domestic requirements to meet, East European countries also built large capacities based on modern technology. As a result, they were turning out large quantities of ammonium nitrate, causing French producers great concern because East European countries were exporting fertilizer nitrogen in bulk in exchange for imports of French capital equipment. In addition, it was reported that African markets, which were expected to absorb about one-third of French production, were captured by East European producers.

To compound the problems of the French nitrogen industry, there was the prospect of mounting imports of ammonia from Algeria, with the Algerian ammonia production being based on cheap natural gas.[13]

Germany, West.—The depression in the nitrogen fertilizer industry in West Germany was blamed on five major factors, which were increased production and distribution cost, decreased export earnings, uncertainties about the international monetary system, imports from East European countries, and a continued drop in production.

Falling production made it impossible to reduce costs and led German nitrogen producers to believe a drastic rationalization of distribution systems was their last hope for cost reduction. Producers were considering a radical change in distribution policy whereby they would supply farmers and trade organizations in close proximity to production facilities, instead of transporting large tonnages of fertilizers throughout Germany. Such a plan may, however, be illegal, according to the strict German cartel laws. Development of bulk fertilizer distribution facilities was also raised as a possible measure to reduce cost because, in 1971, 80 percent of the fertilizers were being transported in bagged form.

One of the major factors that opened up markets in West Germany for imports of nitrogenous fertilizers was the high prices that German farmers had to pay for domestically produced fertilizers compared with other European Economic Community countries.[14]

India.—Fertiliser Corporation of India expected to be able to supply half of India's fertilizer needs by 1975 as a result of an expansion program in progress. Included in the program are five new plants. The plant at Durgapur went on stream, the plants at Barauni and Nampur were due on stream by the end of 1972, and construction was expected to start on the Ramgumdam plant in Andhra Pradesh and the Tolcher plant in Orissa after the monsoon season.

India's imports of fertilizers decreased by more than 50 percent in crop year 1970/71 as a result of lower demand combined with increased domestic production.[15]

Iraq.—Commissioning trials were begun at the 60,000-ton-per-year urea and 150,000-ton-per-year ammonium sulfate plant of the Ministry of Industry at Abu Floos. Both units use the Chemical Construction Co. processes. The Mitsubishi Group acted as the overall contractor. A 2,000-ton-per-day ammonia plant was under construction and will also operate with the Chemical Construction Co. process using natural gas from the Kirkuk area.[16]

Japan.—The M. W. Kellogg Co. of Houston, Tex., announced that the world's largest ammonia plant of its design had gone on steam in Chiba, Japan. The plant has a design capacity in excess of 1,700 short tons per day. Energy requirements for the plant are lower than 32 million British thermal units per short ton. The plant incorporates a new converter design that provides a greater flow area and minimizes pressure drop. Design changes were included that permit increased inlet air temperatures to the secondary reformer, extending the life of the primary reformer catalyst and permitting

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[13] Chemical Age. Opinion: French Fertiliser Problems. V. 103, No. 2727, Oct. 22, 1971, p. 24.
[14] European Chemical News. German N Producers Seek New Distribution Deal. V. 20, No. 507, Nov. 19, 1971, p. 8.
[15] Feed & Farm Supplies. India's Expansion Programme. V. 68, No. 10, October 1971, p. 25.
[16] Nitrogen (London). New Plants and Projects. No. 70, March–April 1971, p. 12.

greater design flexibility both upstream and downstream.[17]

Japan's Ministry of International Trade and Industry (MITI) requested firms producing ammonium sulfate, as a byproduct or recovered product of their principal industrial activity, to reduce such production in order to combat sharply falling prices and an accumulation of stocks expected to exceed the June level, which was the equivalent of a 3.5-month supply. MITI was reportedly concerned that, without restriction of production, the price of ammonium sulfate would decrease further than the 28-percent drop since 1967. Estimated production of ammonium sulfate for the fertilizer year ending June 1971 was 1.4 million short tons from caprolactam production, 0.3 million tons from titanium oxide production, 0.6 million tons from coke-oven gas, and 0.5 million tons from other sources, for a total of 2.8 million short tons with a nitrogen content of about 0.6 million tons.[18]

Kuwait.—With the completion, at Shuaiba, of the Kuwait Petrochemical Industries Co. ammonia and urea complex, Kuwait will become the largest ammonia and urea producer in the area. Total installed ammonia production capacity will be 2,400 tons per day, and total installed urea capacity will be 2,200 tons per day.

The Kuwait complex will be centered on two 900-ton-per-day ammonia plants and two 770-ton-per-day urea plants. Ammonia will be stored in two 25,000-ton tanks. The plant also includes urea storage and bagging facilities, and about 50 million standard cubic feet per day of natural gas will be used.[19]

Netherlands.—Dutch State Mines (DSM) and Verenigde Kunstmestfabrieken Mekog-Albatros NV (VKF) expected that the merger of DSM's fertilizer sector and the VKF works would be completed by year-end and the merger would be retroactive to January 1, 1971. The new company will operate under the name Unie van Kunstmestfabrieken BV (UKF); its total ammonia capacity will amount to 1.3 million tons per year. Compound fertilizers, urea, calcium ammonium nitrate, ammonium phosphates, and ammonium sulfate are among the products, 70 percent of which are exported, from the merged activities. Dutch State Mines will have a 60-percent share in UKF, with Shell, Akzo, and Hoogovens having 16, 16, and 8 percent, respectively.

Nederlandse Stickstof Mattschappij NV (NSM) brought on stream a new 1,000-ton-per-day ammonia plant at Sluiskil in the Netherlands, thus doubling NSM's ammonia capacity.[20]

Pakistan.—The largest single train ammonia plant in Pakistan was placed on stream. Plant capacity is 625 tons per day. The plant was designed by the M. W. Kellogg Co. for Dawood Hercules, and is located at Chichoki Mallian, near Lahore, Pakistan.[21]

Romania.—The Romanian trading organization, Romchim, awarded the M. W. Kellogg Co. contracts for two more 1,000-ton-per-day ammonia plants. The plants will be located at Turnu Magurele and Arad.

Turnu Magurele is already the site of two 1,000-ton-per-day ammonia plants. The plant at Arad, in the extreme west of the country, will be located on a completely new site as far as fertilizers are concerned. Most of the existing fertilizer plants are concentrated in the south and east of Romania, near the country's Black Sea ports.[22]

Spain.—Empresa Nacional Siderúrgica commissioned its new fertilizer plant at Avilés. The plant will produce 420,000 tons per year of calcium ammonium nitrate and complex fertilizers. Coke-oven gases from steel production are used as a feedstock.[23]

Swaziland.—The Swaziland Government announced plans to set up its own fertilizer manufacturing plant. Planned capacity is 125,000 tons of compound fertilizers per year, with capacity eventually rising to 250,000 tons. Preliminary work started at the plant site, and arrangements were com-

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[17] Chemical Engineering Progress. World's Largest Ammonia Plant. V. 67, No. 10, October 1971, p. 115.

[18] U.S. Embassy Tokyo, Japan. State Department Airgram. No. A-136, Apr. 20, 1971, 2 pp.

[19] Nitrogen (London). The KPIC Complex at Shuaiba. No. 74, November-December 1971, pp. 36–37.

[20] European Chemical News. DSM and UKF Announce Terms of Fertilizer Merger. V. 20, No. 508, Nov. 26, 1971, p. 8.

[21] Chemistry and Industry. Pakistan's Largest Ammonia Plant Goes Onstream. No. 49, Dec. 4, 1971, p. 1393.

[22] European Chemical News. Ammonia Orders Herald Romanian Fertilizers Boost. V. 19, No. 480, May 14, 1971, p. 14.

[23] European Chemical News. ENSIDESA Commissions CAN Plant. V. 20, No. 498, Sept. 17, 1971, p. 8.

pleted to purchase plant and equipment. Also, agreement was reached with Iran, which has large supplies of surplus ammonia, to supply raw materials and technical assistance.

To produce fertilizers, the plant will import ammonia, phosphoric acid, and potash. Both ammonia and phosphoric acid are available in the Republic of South Africa, but ammonia can be obtained from Iran more cheaply.[24]

U.S.S.R.—U.S. Government licenses were granted to the M. W. Kellogg Co. to permit the export of basic technology for three 1,500-ton-per-day ammonia plants to be built in Novgorod, Novomoskovsk, and Severodonetsk.

Kellogg will provide the basic process design and engineering technology to Toyo Engineering Corp. of Tokyo, as immediate consignee of the license. Construction of the plants will be handled within the U.S.S.R. by Russian groups.[25]

United Kingdom.—Leading compound fertilizer producers of the United Kingdom made application with the Department of Trade and Industry for antidumping duties to be imposed on compound fertilizer imports from the Netherlands, France, West Germany, and Ireland.[26]

Air Products will supply the United Kingdom Gas Council with 146,000 short tons per year of nitrogen gas with 99.5 percent or better purity under a new 6-year contract. The nitrogen gas will be used to purge gas lines and storage tanks. The bulk of the nitrogen comes from the company's newly expanded air separation plant at Carrington, Lancashire.[27]

The British Oxygen Co. (BOC) received an order from the British Steel Corp. (BSC) for the bulk supply of nitrogen to BSC Anchor Development Scheme under construction at Scunthorpe, Lincolnshire. The bulk order of about 25,000 tons per year of gaseous nitrogen will be supplied by pipeline from the new 250,000-ton-per-year BOC installation now under construction at Scunthorpe. Nitrogen gas is used by BSC primarily for the purging of basic oxygen steel converters.[28]

Two rail distribution terminals were opened by BOC. The terminals situated at Sheffield and Wolverhampton constitute part of a rail-based distribution system for liquid nitrogen. Expansion of new bulk distribution facilities was nearing completion at the new 1,400-ton-per-day production plant opened in July. BOC will be running the first company-owned trains in which liquefied nitrogen will be carried at cryogenic temperatures down to −196° C. Under the new system, the Sheffield terminus receives four 10-car trains from the Widnes plant each week, and the Wolverhampton terminus, one 10-car train. Each rail tank car has a 100-ton capacity.

At the terminals the rail tank cars are emptied into stainless steel lined storage tanks with capacities of about 2,000 tons of liquid nitrogen. The nitrogen is then redistributed by road tanker directly to the customer or alternatively to other BOC sites for compression into cylinders and further redistribution.[29]

Uruguay.—A new fertilizer plant is being built for Fosfato Thomas of Montevideo, Uruguay. The plant will have a production capacity of 60,000 tons per year of mixed fertilizers.[30]

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[24] Feed & Farm Supplies. Fertilizers Made in Swaziland. V. 68, No. 12, December 1971, p. 30.
[25] Chemistry & Industry. Kellogg's Contract for Ammonia Plants in the U.S.S.R. No. 1, Jan. 2, 1971, p. 5.
[26] Industrial Minerals. Fertilizers: Dumping Charges, Reaction, and Cooperation. No. 51, December 1971, pp. 35–36.
[27] Chemical & Engineering News. Gas Council's Nitrogen. V. 49, No. 51, Dec. 13, 1971, p. 17.
[28] European Chemical News. British Oxygen Concludes Nitrogen Contract. V. 20, No. 500, Oct. 1, 1971, p. 4.
[29] European Chemical News. BOC Opens Two Major Rail Distribution Terminals. V. 20, No. 500, Oct. 1, 1971, p. 10.
[30] Feed & Farm Supplies. Fisons' "Granpack" Unit for Uruguay. V. 68, No. 12, December 1971, p. 31.

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		
	1968–69	1969–70	1970–71	1968–69	1969–70	1970–71
North America:						
Canada	611	740	[e] 777	278	298	[e] 316
Costa Rica	[e] 21	[e] 18	[e] 18	[1] 32	[e,1] 31	[e,1] 33
Cuba	[e] 3	--	5	[e] 193	[1] 197	[1] 175
Dominican Republic	--	--	--	[e] 14	[e] 22	[e] 25
El Salvador [e]	7	9	9	37	39	55
Guatemala	--	--	--	[1] 26	15	32
Mexico	284	399	364	417	432	483
Netherlands Antilles [e]	37	39	42	--	--	--
Nicaragua [e]	--	1	7	17	15	22
Trinidad and Tobago [2]	434	387	[e] 387	[e] 6	[e] 6	[e] 7
United States (includes Puerto Rico)	7,869	8,413	8,932	6,959	7,362	7,925
South America:						
Argentina	27	22	38	34	39	45
Brazil [1]	10	7	22	159	181	304
Chile [1]	129	[e] 118	[e] 137	27	[e] 45	[e] 47
Colombia	[1] 46	[1] 55	[e,1] 64	[e,1] 58	[1] 60	[e] 71
Ecuador	[e] 2	3	[e] 2	40	21	17
Peru	34	36	[e] 36	64	75	[e] 111
Venezuela	[1] 19	[1] 15	[e] 11	[1] 31	[1] 24	[e] 31
Europe:						
Albania [e,1]	19	22	31	17	18	30
Austria	281	273	241	124	133	139
Belgium	546	[e] 542	536	180	[e] 201	[e] 184
Bulgaria [1]	563	646	[e] 664	402	443	[e] 474
Czechoslovakia	[1] 324	[1] 371	[1] 388	392	441	[e] 472
Denmark [3]	75	78	81	273	298	319
Finland	111	166	213	127	176	187
France	1,508	1,447	[e] 1,489	1,370	[e] 1,368	[e] 1,569
Germany, East [1]	387	431	417	563	537	564
Germany, West	1,761	1,735	1,659	1,028	1,196	1,250
Greece	140	161	195	201	210	221
Hungary [1]	270	331	386	336	376	420
Iceland [1]	9	9	8	13	13	13
Ireland	[e] 61	[e] 66	[e] 73	71	79	96
Italy	1,200	1,059	1,065	566	607	655
Luxembourg	[e] 2	[e] 2	[e] 2	10	11	12
Netherlands	1,052	984	1,025	374	427	448
Norway	412	409	408	76	85	86
Poland	[1] 837	[1] 1,034	[1] 1,135	773	865	907
Portugal	151	129	[e] 126	112	122	[e] 121
Romania [1]	464	544	713	364	[e] 386	404
Spain	545	607	639	626	653	595
Sweden [4]	159	159	180	210	226	249
Switzerland	40	32	30	36	38	39
U.S.S.R. [1]	4,604	4,970	5,978	3,807	4,187	5,076
United Kingdom	[4] 927	[4] 783	824	[4,5] 943	[4,5] 761	[4,5] 882
Yugoslavia [1]	132	202	254	298	313	324
Africa:						
Algeria	--	[e] 17	[e] 22	15	33	44
Arab Republic of Egypt	[1] 154	[1] 130	[e,1] 120	[6] 332	[6] 342	[e,6] 331
Ivory Coast	--	--	[e] 2	[1] 4	[1] 5	[e,1] 9
Kenya [e]	--	--	--	11	18	24
Morocco [1]	1	5	[e] 13	41	38	[e] 42
Mozambique [e]	1	1	1	5	9	9
Senegal	3	2	8	4	[3] 3	3
South Africa, Republic of [e,1]	160	225	220	159	165	199
Southern Rhodesia [e]	--	[e] 25	[e] 47	46	43	53
Sudan	--	--	--	[e] 46	43	[e] 73
Tunisia	[1] 1	[1] 1	[e,1] 1	10	15	[e] 17
Zambia	--	--	4	[e] 13	10	13
Asia:						
Burma [e]	--	--	--	25	29	17
Ceylon	--	--	--	[1] 62	[e] 54	[e] 64
China, People's Republic of [e,1]	1,036	1,146	1,323	2,459	2,754	3,293
India [e]	621	804	917	1,247	1,499	1,639
Indonesia [e]	47	47	50	138	149	202
Iran [e]	25	29	31	54	61	64
Israel	30	33	30	30	33	35
Japan	2,313	2,349	2,320	999	969	954
Korea, North [e,1]	129	173	226	129	173	226
Korea, South	[1] 348	[1] 392	[1] 425	[1] 315	[1] 353	392
Kuwait	76	81	94	--	--	--
Lebanon	[1] 12	[e] 14	[e] 15	[1] 15	[e,1] 18	[1] 21
Malaysia, West [e]	20	34	29	46	60	65

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		
	1968–69	1969–70	1970–71	1968–69	1969–70	1970–71
Asia—Continued						
Pakistan e	128	191	195	287	394	388
Philippines	50	59	53	70	112	131
Saudi Arabia e	--	--	25	1	1	1
Syrian Arab Republic	--	--	--	24	22	29
Taiwan	211	215	174	188	182	170
Thailand e	[1] 9	[1] 9	[1] 11	56	54	47
Turkey [1]	38	58	e 90	206	255	e 268
Vietnam, North e [1]	--	--	--	24	40	42
Vietnam, South e [1]	--	--	--	68	109	77
Oceania:						
Australia e	105	176	176	192	190	165
Other:						
North America and Central America e [7]	--	--	--	54	59	66
South America e [8]	--	--	--	24	23	27
Europe [9]	--	--	--	4	4	4
Africa e [10]	--	--	--	87	99	122
Asia e [11]	--	--	--	62	65	70
Oceania [12]	--	--	--	14	16	14
World total	31,631	33,670	36,233	29,250	31,533	34,845

e Estimate.
[1] Calendar year referring to the first part of the split year.
[2] Calendar year referring to the last part of the split year; data represent nitrogen content of anhydrous ammonia produced. Source: Department of State Airgrams.
[3] Fertilizer year: August-July.
[4] Fertilizer year: June-May.
[5] Deliveries by manufacturers or importers to first buyers.
[6] Fertilizer year: November-October.
[7] Includes Barbados, British Honduras, Guadeloupe, Haiti, Honduras, Jamaica, Martinique, Panama, St. Kitts, Nevis and Anguilla, St. Lucia, and St. Vincent.
[8] Includes Bolivia, Guyana, Paraguay, Surinam, and Uruguay.
[9] Includes Channel Islands (Jersey only) and Isle of Man.
[10] Includes Angola, Botswana, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Dahomey, Equatorial Guinea, Ethiopia, Ghana, Guinea, Liberia, Libya, Malagasy Republic, Malawi, Mali, Mauritius, Mozambique, Nigeria, Reunion, Sierra Leone, Somalia, Swaziland, Tanzania, Uganda, and Zaire.
[11] Includes Afghanistan, Cyprus, Iraq, Jordan, Laos, Nepal, Republic Khmer, Ryukyu Island, and Singapore.
[12] Includes Fiji Islands and New Zealand.

Source: Statistical Office of the United Nations, Statistical Yearbook, 1971. New York, 1972, pp. 263–264, 523–524, unless otherwise specified.

TECHNOLOGY

Three designs for 3,000-ton-per-day ammonia plants were disclosed at the 70th national meeting of the American Institute of Chemical Engineers. The M. W. Kellogg Co. design uses a horizontal converter. Haldor Topsoe of Denmark proposed a radial flow design with the synthesis gas flowing radially outward through one catalyst bed and inward through another, thus making possible the use of smaller size catalyst. In the design presented by Imperial Chemical Industries of the United Kingdom, quench gas is introduced through distributors or lozenges at several points down the length of a single annular catalyst bed surrounding a heat exchanger.

The horizontal converter was adopted by Kellogg to gain design and operating flexibility. Extending conventional vertical designs above 1,500 tons per day would have exceeded diameter limitations imposed by fabricating facilities and shipping clearances. The converter contains a basket with three catalyst beds and a heat exchanger located externally to the basket. Reactants flow to the interchanger between basket and pressure shell to cool the shell. Gas then flows downward through each catalyst bed in turn, mixing with quench gas. The Kellogg design gains economic benefits through the large catalyst bed cross section, which makes possible the use of smaller size catalyst.[31]

Fertilizer chemicals were being used to fight forest fires. An ammonium sulfate and attapulgite clay combination, and a diammonium phosphate and sodium carboxymethylcellulose combination are among the fire suppressant chemicals used. The chem-

[31] Chemical & Engineering News. Ammonia Plants: Ready for 3000 Tons a Day. V. 49, No. 37, Sept. 6, 1971, pp. 7–8.

icals are applied in a water mixture from different types of aircraft.[32]

Allied Chemical disclosed details of its technology for making high-analysis liquid fertilizers that have a long storage life. The long storage life of liquid ammonium polyphosphate fertilizers results from a method to prevent precipitation of sediment. Much of the sediment comes from precipitation of magnesium ammonium pyrophosphate, which forms during storage if the magnesium oxide concentration in the liquid fertilizer is high; therefore, in the Allied process, magnesium is removed by forming an insoluble magnesium aluminum fluophosphate that is separated before the phosphoric acid is reacted with ammonia.[33]

Norsk Hydro A/S of Oslo, Norway, started production of a new type of forest fertilizer. The fertilizer is a coarse-grained ammonium nitrate suitable for aerial fertilizing. The grains are heavy and not easily blown away by the wind. Also, the new fertilizer grains are not so easily caught in treetops.[34]

Sumitomo Chemical Co. of Japan announced a new process for manufacturing 98 percent concentrated nitric acid. Concentrated nitric acid is produced directly from ammonia and air in the new process. It is also possible to produce dilute nitric acid simultaneously at any desired ratio. Another advantage claimed for the new process was that it does not produce any dilute sulfuric acid byproduct.[35]

A research team at the DuPont experimental station near Wilmington, Del., was attempting to develop a supersoybean by improving its ability to take nitrogen from the air and combine it with other elements to produce amino acids and protein. The researchers were confident that their work will help unlock the secret of how some plants fix nitrogen.

The study of nitrogen fixation in plants could reveal new routes to the production of ammonia and many other nitrogen compounds. In legumes, the nitrogen fixation process takes place within nodules on the roots of the plants. Certain bacteria present in the plant convert atmospheric nitrogen into ammonia and then into nitrogen compounds essential to the plant. DuPont was centering its work on soybeans and the U.S. Department of Agriculture was also looking for new bacterial strains that may increase the nitrogen fixing ability of soybeans. Similar projects were underway at the University of Wisconsin, the University of Minnesota, and the University of North Carolina.

A few years ago the present research goals would have seemed beyond reach; however, since then, laboratory processes have produced minute amounts of ammonia under mild conditions similar to those under which plants carry out the process.[36]

A stripping unit developed by M. W. Kellogg removes ammonia and carbon dioxide from steam condensate formed during ammonia production. The unit was designed primarily for Kellogg's own 1,000-ton-per-day ammonia plants, but is adaptable to other plants. The condensate stripper will remove almost all of the carbon dioxide and will reduce ammonia from 1,000 parts per million to less than 50 parts per million.[37]

Joslyn Manufacturing and Supply believed it was on the threshold of a breakthrough in the refining of stainless steels. The use of nitrogen in the refining process makes it easier and more reliable to manufacture a small, but growing, segment of stainless steels that specify nitrogen as an alloy component. Depending on the steel product and its intended application, a significant portion of the argon now required in the process can be replaced by nitrogen gas. It is possible to achieve nitrogen contents up to saturation levels for the various stainless steel grades in a closely controlled manner. The greatest potential would appear to be in the area of alloy modification or development.[38]

Mitsui Toatsu Chemicals Inc. of Tokyo announced the development of a new process for a urea-based compound fertilizer. The process is based on the dispersion of the viscous hot melt of urea, phosphate

[32] Chemical & Engineering News. Forest Fires: Fighting With Chemicals. V. 49, No. 35, Aug. 30, 1971, p. 4.

[33] Chemical & Engineering News. Liquid Fertilizers Have Long Storage Life. V. 49, No. 44, Oct. 25, 1971, p. 37.

[34] Oil, Paint and Drug Reporter. Aluminum, Fertilizers: Norsk Hydro Expands. V. 200, No. 14, Oct. 4, 1971, p. 5.

[35] Oil, Paint and Drug Reporter. Nitric Acid Produced Directly from Air, NH_3. V. 200, No. 17, Oct. 25, 1971, p. 7.

[36] Chemical Week. Science Seeks a Super Soybean. V. 108, No. 17, Apr. 28, 1971, pp. 49–50.

[37] Chemical & Engineering News. Condensate Stripper. V. 49, No. 29, July 19, 1971, p. 44.

[38] 33 Magazine. Nitrogen Use Expands Stainless Refining Process. V. 9, No. 8, August 1971, p. 35.

and potash salt suspension into homogeneously sized droplets. The droplets are then cooled in an appropriate cooling oil to produce solidified granules.

A special feature claimed for the process was the use of an oil-prilling tank for cooling and prilling. The tank eliminates the large and costly rotary dryer and cooler that are used with conventional processes. The company claimed plant investment costs are reduced by 20 to 30 percent. Utility and labor costs also were said to be cut.

Raw materials used in the new process are urea, ammonia and phosphoric acid, or monoammonium phosphate and potash salt. No binder is required for granulation. Products are spherical and free-flowing with high hardness and low-water content.[39]

Additional research on sulfur-coated urea was conducted by the Tennessee Valley Authority (TVA). Greenhouse and laboratory studies measured the factors controlling the release of nitrogen from sulfur-coated urea. Results of two greenhouse pot experiments with common bermudagrass and a third with uncropped soil in controlled environments showed that the rate of dissolution of sulfur-coated urea increased greatly with higher temperatures. Dissolution rates of sulfur-coated urea granules were decreased by heavier coating with sulfur, by inclusion of 0.5 percent coal-tar oil microbicide in the coating and by surface application compared with mixing with the soil. Satisfactorily coated urea or split applications of uncoated ammonium nitrate or urea both resulted in a more uniform distribution of forage production and nitrogen uptake than did a single application at time of seeding. Greater yields of forage were obtained from single applications of some sulfur-coated urea products than from urea or ammonium nitrate. Apparent volatilization losses of surface-applied urea were severe, particularly at higher growth or incubation temperatures. Losses of nitrogen were reduced but not entirely eliminated by sulfur coating.[40]

TVA developed a modified process for producing ammonium phosphate fertilizer on a pilot-plant scale. Calcium is removed by precipitating it with ammonium sulfate. Sulfate requirements are minimized because the precipitated gypsum is converted to ammonium sulfate, which is recycled. Raw materials used are phosphate rock, nitric acid, ammonia, carbon dioxide, and a little sulfuric acid, ammonium sulfate, or gypsum for makeup. Most of the development work was directed toward precipitation and filtration of gypsum from the extraction slurry, and conversion of gypsum to ammonium sulfate liquor and the subsequent separating of this liquor from the byproduct calcium carbonate by filtration. The TVA studies identified suitable equipment design and operating limits for the primary variables.[41]

Small amounts of potassium azide added to anhydrous ammonia fertilizer was found to delay the conversion of ammonia into nitrite and nitrate and could help to insure against nitrate pollution of groundwater in certain cases. Maintaining fertilizer nitrogen in the ammonia form with nitrification inhibitors would restrict loss of nitrate to soil water through leaching and runoff, would keep a greater amount of the applied nitrogen available to plants for a longer time, and would permit fall application of ammonium fertilizers in regions where such practice is not presently feasible because of rapid nitrification and leaching.

In tests, researchers applied, to fallow soil, 200 pounds per acre of anhydrous ammonia in formulations which contained 0, 2, and 6 percent potassium azide. Two months after application, 64 percent of the nitrogen applied with 6 percent potassium azide remained in the retention zone, 52 percent of the nitrogen remained when applied with 2 percent potassium azide, and only 33 percent of the nitrogen remained where ammonia was applied without potassium azide.

Potassium azide is also used as a herbicide and has been tested as a soil fumigant to control weed seeds and plant diseases. Potassium azide has a relatively

[39] European Chemical News (London). Mitsui Toatsu Develops NPK Fertilizer Process. V. 19, No. 482, May 28, 1971, p. 30.

[40] Allen, S. E., C. M. Hunt, and G. L. Terman. Nitrogen Release From Sulfur-Coated Urea, As Affected by Coating Weight, Placement and Temperature. Agronomy Journal, v. 63, July–August 1971, pp. 529–33.

[41] Meline, Robert S., Henry L. Faucett, Charles H. Davis, and Arthur R. Shirley, Jr. Pilot-Plant Development of the Sulfate Recycle Nitric Phosphate Process. Ind. Eng. Chem. Process Design & Development, v. 10, No. 2, April 1971, p. 257–64.

short soil life and decomposes into potassium and nitrogen.[42]

A research group at the Institute of Chemical Physics of the U.S.S.R. revealed results from a project to produce hydrazine under mild conditions. The group believed the new process was close to the biological fixation of nitrogen.

In the process, molecular nitrogen is reduced in aqueous and alcoholic media with titanium, vanadium, or chromium salts as reducing agents and molybdenum compounds as catalysts. Nitrogen fixation occurs at room temperature and atmospheric pressure, although higher temperatures and pressures enhance the yield of hydrazine. Initial results indicate that fixation of nitrogen occurs only in an alkaline media, and at room conditions the reaction is complete in a few minutes to a half hour, depending on the catalyst used. Further development of the process will be directed at making it economical for the production of hydrazine. Currently, there are two leading processes used in the United States to make hydrazine. One, Olin process, uses ammonia and sodium hypochlorite as starting materials, and the other uses urea, which is degraded by sodium hypochlorite.[43]

Kaiser Aluminum & Chemical Corp. started up facilities for making building panels filled with urethane foam. The new plant is at Dalton, Ill., about 20 miles south of Chicago. The foam-filled panels can be turned out at 35 linear feet per minute and can measure 9 feet across.

A sizeable market for the urethane foamed panels could develop because of such inherent characteristics as light weight, structural strength and rigidity, and excellent insulating properties.[44]

Oak Pulp & Paper Co. of Poteau, Okla., was planning to build a small pilot plant to investigate the profitability of the Nitracell pulping process developed by Alscope Consolidated Ltd., Vancouver. The process involves the digestion of wood chips with nitric acid.

A particular characteristic of the process is the use of special additives to promote delignification and improve pulping efficiency. Kilborn Engineering of Toronto, which carried out much of the development work, claimed that profits could be raised by $13 per ton of pulp by using the technique. Pulp yields of the order of 55 percent or more are envisaged, which is a considerable improvement over the Kraft and other processes, and, in addition, the new system has fewer pollution drawbacks.

Conversion of sulfite mills to the Nitracell technique is apparently quite simple as ammonia oxidation replaces sulfur burning and extra ammonia is utilized to neutralize spent liquor. In this way, both ammonium nitrate and liquid nitrates are produced as byproducts for possible fertilizer applications. Ammonia consumption in the process was said to be around 400 pounds per ton of paper.[45]

Thirty-four phosphorus-nitrogen compounds were prepared in a TVA laboratory and compared in a greenhouse as high-analysis sources of fertilizer nitrogen and phosphorus for corn. The compounds included phosphonitrilic derivatives, metaphosphimates, metaphosphates, sulfur-containing compounds, and amido and imidophosphates. The metaphosphates, amidophosphates, thioamidophosphates, and phosphoryl thiamide were excellent sources of both nitrogen and phosphorus, but metaphosphimates were poor sources. Several of the sulfur compounds were toxic in early growth stages, but thereafter were effective sources of plant nutrients. Of the phosphonitrilic derivatives, only phosphonitrilic hexaamine was an effective source of both nitrogen and phosphorus.[46]

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[42] Agricultural Chemicals Inhibitor Prevents Nitrate Pollution. V. 26, No. 8, August 1971, p. 24.
Chemical Week. Potassium Azide May Become an Important Agricultural Chemical. V. 109, No. 16, Oct. 20, 1971, p. 69.

[43] Chemical & Engineering News. Processes: Soviet Hydrazine Route. V. 49, No. 49, Nov. 29, 1971, pp. 10–11.

[44] Chemical & Engineering News. Construction: Urethane Foam Sandwiches. V. 49, No. 27, July 5, 1971, pp. 9–10.

[45] Nitrogen (London). Nitracell Pulping Process Tested. No. 70, March–April 1971, p. 34.

[46] Wakefield, Zachary T., Seward E. Allen, John F. McCullough, Richard C. Sheridan, and John J. Kohler. Evaluation of Phosphorus Nitrogen Compounds as Fertilizers. Agricultural and Food Chemistry. V. 19, No. 1, January–February 1971, pp. 99–103.

Peat

By Eugene T. Sheridan [1]

Peat production in the United States increased 17 percent in 1971, reversing a trend in which production had declined each year since 1968. Most of the increase was the result of larger output from operations in Florida, Illinois, Indiana, Iowa, and Michigan.

Commercial sales of peat were 14 percent higher than in 1970, but the total value of peat, f.o.b. plant, rose 17 percent to $7.0 million. An increase of $0.30 per ton in the average value of all peat sold in the United States was attributed principally to sales from Michigan, which increased about $1.00 per ton in average value.

Imports increased 5 percent and the quantity of peat imported in 1971 was about one-half the quantity produced domestically. Ninety-six percent of the peat imported was shipped from Canada.

World production was estimated at 215 million short tons. The U.S.S.R. was the largest producer with an output estimated at 206 million tons, 96 percent of the world total.

DOMESTIC PRODUCTION

The 89-thousand-ton increase in production resulted mainly from a larger output of both moss and reed-sedge peat. Of the reported total production, about one-half was reed-sedge peat, while the remainder was about equally divided between moss peat and humus.

Twenty-four States produced peat in 1971. Michigan remained the largest producer, with about one-third of the Nation's output. Illinois, Florida, Indiana, New Jersey, and Pennsylvania followed in output in the order named. These States, with Michigan. had nearly four-fifths of the total production.

Active operations decreased from 122 to 120, but average output per plant increased 19 percent to 5,045 tons. Three-fourths of the operations, however, had outputs smaller than the average. Only 30 plants had production in excess of 5,000 tons and only six 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.

[1] Mineral specialist, Division of Fossil Fuels.

Table 1.—Salient peat statistics

	1968	1969	1970	1971
United States:				
Number of operations	135	128	122	120
Production short tons	618,995	572,122	516,825	605,382
Commercial sales do	619,161	565,760	525,603	599,548
Value of sales thousands	$7,230	$7,055	$5,986	$7,011
Average per ton	$11.68	$12.47	$11.39	$11.69
Imports short tons	287,600	299,997	283,211	296,283
Available for consumption [1] do	906,761	865,757	808,814	895,831
World: Production thousand short tons	206,686	202,731	215,550	215,412

[1] Commercial sales plus imports.

Table 2.—Peat produced in the United States in 1971, by kinds

(Short tons)

Kind	Unprepared	Processed: Shredded	Processed: Kiln-dried only	Processed: Shredded and kiln-dried	Total
Moss	62,726	83,827	--	3,732	150,285
Reed-sedge	88,189	221,410	--	--	309,599
Humus	40,666	102,214	2,018	600	145,498
Total	191,581	407,451	2,018	4,332	605,382

Table 3.—Production and commercial sales of peat in the United States in 1971, by State

State	Active plants	Production (short tons)	Commercial sales: Short tons	Value: Total (thousands)	Value: Average per ton
California	3	11,618	11,618	W	W
Colorado	11	28,283	28,283	$156	$5.51
Florida	10	56,667	56,667	412	7.28
Georgia	3	1,150	1,150	13	10.87
Idaho	1	W	W	W	W
Illinois	7	72,823	71,823	W	W
Indiana	9	47,693	49,748	W	W
Iowa	2	W	W	W	W
Maine	3	2,902	2,234	W	W
Maryland	2	3,446	3,404	39	11.31
Massachusetts	1	2,000	2,000	32	16.00
Michigan	19	209,835	202,189	2,497	12.35
Minnesota	6	W	W	W	W
Montana	1	W	W	W	W
New Jersey	4	44,826	46,081	526	11.42
New Mexico	1	1,297	1,297	W	W
New York	5	15,763	14,968	196	13.11
North Dakota	1	W	W	W	W
Ohio	10	6,330	6,230	84	13.47
Pennsylvania	10	38,850	38,186	461	12.08
South Carolina	1	8,000	8,000	W	W
Vermont	1	W	W	W	W
Washington	8	17,756	17,256	72	4.20
Wisconsin	1	1,575	1,575	153	97.42
Total	120	605,382	599,548	7,011	11.69

W Withheld to avoid disclosing individual company confidential data; included in total.

Table 4.—Relative size of peat operations in the United States

Size	1970 Active plants: Number	1970 Active plants: Percent of total	1970 Production: Short tons	1970 Production: Percent of total	1971 Active plants: Number	1971 Active plants: Percent of total	1971 Production: Short tons	1971 Production: Percent of total
Under 500 tons	32	26.2	6,872	1.3	29	24.1	5,868	1.0
500 to 999 tons	16	13.1	10,724	2.1	17	14.2	11,649	1.9
1,000 to 4,999 tons	46	37.7	101,048	19.6	44	36.7	93,949	15.5
5,000 to 14,999 tons	18	14.8	141,174	27.3	20	16.7	182,622	30.2
15,000 to 24,999 tons	6	4.9	100,511	19.4	4	3.3	67,388	11.1
Over 25,000 tons	4	3.3	156,496	30.3	6	5.0	243,906	40.3
Total	122	100.0	516,825	100.0	120	100.0	605,382	100.0

CONSUMPTION AND USES

Commercial sales and imports both increased in 1971 and the amount of peat available for consumption was 11 percent greater than in 1970.

Peat was used for a variety of purposes, but 84 percent of the total sold was used for general soil improvement. Among the principal markets for this peat were nurseries and greenhouses, which used peat as a mulch and as a medium for growing plants and shrubs; landscape gardeners and contractors, who used peat for building lawns and 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. The remaining peat was sold principally for use in potting soils and for packing flowers and shrubs, but small quantities were used in mushroom beds and in mixed fertilizers, and for earthworm culture and seed inoculant.

Fifty-four percent of the peat was sold in packages. Package sizes vary greatly, but a large part of packaged peat probably was sold in 50- and 100-pound bags. Of the packaged material, about two-thirds was reed-sedge peat; nearly one quarter was moss peat; and the remainder was humus. Ninety-six percent of the packaged material was reported sold for general soil improvement. A large part of this peat was ultimately sold to homeowners for use on lawns and gardens and for mulching.

Of the bulk peat, 71 percent was reported sold for general soil improvement. The other major uses for bulk peat are for shipping flowers and shrubs (packing material) and for use in mixed fertilizers.

Table 5.—Commercial sales of peat in the United States in 1971, by kind and use

Use	Moss		Reed-sedge		Humus	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Bulk:						
Soil improvement	57,070	$513	83,442	$715	52,806	$321
Other uses	15,364	84	10,958	114	53,329	406
Total	72,434	597	94,400	[1] 828	106,135	727
Packaged:						
Soil improvement	71,568	1,239	206,569	2,582	35,038	452
Other uses	3,593	84	5,068	297	4,743	205
Total	75,161	1,323	211,637	2,879	39,781	657
Total:						
Soil improvement	128,638	1,752	290,011	3,297	87,844	772
Other uses	18,957	168	16,026	410	58,072	612
Grand total	147,595	1,920	306,037	3,707	145,916	1,384

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

Table 6.—Commercial sales of peat in the United States in 1971, by uses

Use	In bulk		In packages		Total [1]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Soil improvement	193,318	$1,549	313,175	$4,272	506,493	$5,821
Potting soils	19,324	166	8,455	341	27,779	507
Packing flowers, shrubs, etc	42,747	320	2,616	45	45,363	366
Seed inoculant	60	1	2,234	198	2,294	199
Mushroom beds	3,844	36	--	--	3,844	36
Earthworm culture	1,489	14	99	2	1,588	16
Mixed fertilizers	12,187	66	--	--	12,187	66
Total [1]	272,969	2,152	326,579	4,859	599,548	7,011

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

PRICES AND SPECIFICATIONS

Prices of peat at individual operations varied greatly in 1971, with 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 peat sold in 1971 was $11.69. This was a $0.30 per ton increase in average value over that of 1970, and the increase was attributed mainly to substantially larger sales of packaged peat in Michigan.

Bulk prices averaged $7.88 per ton, a decrease of $0.25 per ton from the price of 1970. Packaged prices, however, increased an average of $0.37 per ton to $14.88 per ton. The increase in the average value of peat sold in packages was attributed principally to a 9-percent increase in the average value of packaged peat sold in Michigan.

Imported peat had a total value of $15.1 million. The total value of imported peat was 12 percent greater than in 1970, partially because there was 13,000 tons more peat imported, but also because the average value per ton increased from $47.67 to $51.11.

Although the average value of imported peat was more than 4 times that of domestically produced packaged peat, the two values are not comparable because they are assigned at different marketing levels. Also, imported peat has different physical properties than most of the peat sold domestically and is therefore usually 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 produce peat with properties similar to those of the imported kind.

Peat is broadly classified in the United States as moss peat, reed-sedge peat, or humus. Moss peat has been formed principally from sphagnum, hypnum, and/or other mosses; reed-sedge peat originated mainly from reeds, sedges, and other swamp plants; and humus is peat too decomposed for identification of its biological origin.

The Federal Trade Commission regulates the labeling and marketing of all peat sold in the United States. Peat sold to the Federal Government is subject to specifications developed by the Federal Supply Service, General Services Administration (GSA).

The American Society for Testing and Materials has issued a standard classification for peat, moss, humus, and related products, effective as of April 25, 1969.[2]

FOREIGN TRADE

The quantity of peat imported into the United States in 1971 was 5 percent greater than imports in 1970, mainly because of increased shipments from Canada. Canada provided the bulk of the imports, supplying 96 percent of the 296,000 tons of peat imported in 1971. Virtually all of the remaining peat imported was supplied by Europe.

European shipments to the United States decreased 6 percent, mainly because of the smaller quantities shipped from Ireland and West Germany. West Germany supplied about three-fourths 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, 99 percent was duty-free fertilizer-grade peat. A duty of $0.25 per long ton was levied on poultry-and-stable-grade peat.

Foreign peat entered the United States through 26 customs districts in 1971, but 82 percent of the total imported was shipped through the Ogdensburg and Buffalo, N.Y.; Detroit, Mich.; St. Albans, Vt.; and Seattle, Wash., customs districts. The largest quantity, 69,895 tons, was shipped through the Ogdensburg district.

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[2] American Society for Testing and Materials. Standard Classification of Peat, Mosses, Humus, and Related Products. ASTM Designation: D 2607–69, Philadelphia, Pa., Apr. 25, 1969.

Table 7.—U.S. imports for consumption of peat moss, by grade and country

Country	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1970						
Belgium-Luxembourg	--	--	22	(1)	22	(1)
Canada	1,679	$94	267,944	$12,792	269,623	$12,886
Finland	7	(1)	--	--	7	(1)
Germany, West	86	3	9,919	429	10,005	432
Ireland	4	3	960	46	964	49
Japan	--	--	30	2	30	2
Mexico	--	--	24	1	24	1
Norway	6	4	7	4	13	8
Poland	--	--	1,950	88	1,950	88
Spain	--	--	7	5	7	5
Sweden	--	--	449	22	449	22
United Kingdom	--	--	117	9	117	9
Total	1,782	104	281,429	13,398	283,211	13,502
1971						
Canada	1,941	129	281,519	14,403	283,460	14,532
Denmark	--	--	19	1	19	1
Germany, West	513	21	9,327	423	9,840	444
Ireland	6	3	172	10	178	13
Mexico	--	--	93	4	93	4
Netherlands	13	1	--	--	13	1
Poland	--	--	2,308	121	2,308	121
Sweden	--	--	319	22	319	22
United Kingdom	--	--	53	4	53	4
Total	2,473	154	293,810	14,988	296,283	15,142

[1] Less than ½ unit.

Table 8.—U.S. imports for consumption of peat moss in 1971, by grades and customs district

Customs district	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Baltimore Md	--	--	1,778	$69	1,778	$69
Boston, Mass	6	$3	210	11	216	14
Buffalo, N.Y	22	2	30,854	1,536	30,876	1,538
Charleston, S.C	--	--	145	6	145	6
Detroit, Mich	135	14	41,066	2,239	41,201	2,253
Duluth, Minn	--	--	5,674	513	5,674	513
Great Falls, Mont	--	--	8,088	434	8,088	434
Honolulu, Hawaii	44	5	--	--	44	5
Houston, Tex	--	--	620	33	620	33
Los Angeles, Calif	--	--	873	40	873	40
Miami, Fla	463	19	1,071	64	1,534	83
Mobile, Ala	--	--	1,839	81	1,839	81
New Orleans, La	--	--	1,157	53	1,157	53
New York, N.Y	13	1	1,394	82	1,407	83
Norfolk, Va	50	2	774	23	824	25
Ogdensburg, N.Y	10	1	69,885	3,187	69,895	3,188
Pembina, N. Dak	1,570	99	18,204	918	19,774	1,017
Philadelphia, Pa	--	--	395	16	395	16
Portland, Me	--	--	6,500	345	6,500	345
Portland, Ore	--	--	42	1	42	1
St. Albans, Vt	160	8	48,052	2,194	48,212	2,202
San Francisco, Calif	--	--	103	13	103	13
San Juan, P.R	--	--	358	22	358	22
Savannah, Ga	--	--	631	30	631	30
Seattle, Wash	--	--	53,307	3,045	53,307	3,045
Tampa, Fla	--	--	790	33	790	33
Total	2,473	154	293,810	14,988	296,283	15,142

Table 9.—Peat moss imported for consumption from Canada and West Germany in 1971, by grades and customs district

Customs district	Canada				West Germany			
	Poultry and stable grade		Fertilizer grade		Poultry and stable grade		Fertilizer grade	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Baltimore, Md	--	--	--	--	--	--	1,685	$62
Boston, Mass	--	--	13	$(1)	--	--	42	2
Buffalo, N.Y	22	$2	30,854	1,536	--	--	--	--
Charleston, S.C	--	--	--	--	--	--	134	6
Detroit, Mich	135	14	41,066	2,239	--	--	--	--
Duluth, Minn	--	--	5,674	513	--	--	--	--
Great Falls, Mont	--	--	8,088	434	--	--	--	--
Honolulu, Hawaii	44	5	--	--	--	--	--	--
Houston, Tex	--	--	--	--	--	--	283	12
Los Angeles, Calif	--	--	--	--	--	--	823	37
Miami, Fla	--	--	--	--	463	$19	532	28
Mobile, Ala	--	--	--	--	--	--	1,839	81
New Orleans, La	--	--	--	--	--	--	253	10
New York, N.Y	--	--	--	--	--	--	1,063	61
Norfolk, Va	--	--	--	--	50	2	464	15
Ogdensburg, N.Y	10	1	69,846	3,186	--	--	--	--
Pembina, N. Dak	1,570	99	18,150	915	--	--	--	--
Philadelphia, Pa	--	--	--	--	--	--	320	12
Portland, Me	--	--	6,500	345	--	--	--	--
Portland, Ore	--	--	--	--	--	--	42	1
St. Albans, Vt	160	8	48,052	2,194	--	--	--	--
San Francisco, Calif	--	--	--	--	--	--	103	13
San Juan, P.R	--	--	--	--	--	--	358	22
Savannah, Ga	--	--	--	--	--	--	565	24
Seattle, Wash	--	--	53,276	3,041	--	--	31	4
Tampa, Fla	--	--	--	--	--	--	790	33
Total	1,941	129	281,519	14,403	513	21	9,327	423

(1) Less than ½ unit.

WORLD REVIEW

World production of peat in 1971 was estimated at 215 million short tons, virtually the same output reported for 1970.

The U.S.S.R. remained the largest producer with an estimated output of 206 million tons, 96 percent of the world total. It is estimated that about one-third of the Soviet production was used for fuel and that two-thirds was used for agricultural purposes, including general soil improvement and the manufacture of fertilizers. Most of the fuel peat was used for generating electric power, but substantial quantities were converted into briquets, which were used for both domestic and industrial heating.

Ireland ranked second in peat production with an estimated 1971 output of 5.5 million short tons. Although production was small in comparison with that of the U.S.S.R., peat provided a substantial part of Ireland's energy requirements for electric power generation and household heating. Ireland produced only a small quantity of peat for agricultural use.

West Germany ranked third in world peat output with an estimated production of 1.8 million short tons. An estimated one-fourth of the West German production was used for fuel. Peat fuel accounts for only a very minor part of the primary energy needs of this country.

Other producers, ranking in output in order named, were the United States, the Netherlands, Canada, and Finland. The combined output of these countries however, was only 0.7 percent of the world total. Although fourth in world production, output of the United States was only 0.3 percent of the world total.

Table 10.—Peat: World production by country
(Thousand short tons)

Country [1]	1969	1970	1971 [p]
Argentina, agricultural use	[r] 2	3	[e] 3
Canada, agricultural use	330	317	[e] 310
Denmark, fuel [e]	6	6	6
Finland:			
Agricultural use [e]	138	158	[e] 160
Fuel	120	97	[e] 100
France, agricultural use [e]	80	80	80
Germany, West:			
Agricultural use	1,260	1,276	[e] 1,430
Fuel	397	357	352
Hungary, agricultural use [e]	72	72	72
Ireland:			
Agricultural use	60	57	[e] 55
Fuel	[r] 6,268	5,411	[e] 5,400
Israel, agricultural use [e]	22	22	22
Japan [e]	80	80	80
Korea, Republic of, agricultural use	10	9	[e] 10
Netherlands [e]	440	440	440
Norway:			
Agricultural use	12	[e] 13	[e] 13
Fuel [e]	4	4	4
Poland, fuel	24	55	[e] 55
Sweden:			
Agricultural use	123	86	[e] 90
Fuel [e]	28	28	25
U.S.S.R.:			
Agricultural use [e]	143,300	143,300	143,300
Fuel	49,383	63,162	[e] 62,800
United States, agricultural use	572	517	605
Total	[r] 202,731	215,550	215,412
Fuel peat (included in total)	[r] 56,230	69,120	68,742

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Austria, Canada, Iceland, Italy, and Spain produce a negligible quantity of fuel peat. No data are available for East Germany, a major producer.

TECHNOLOGY

A method for the preparation of phosphoric acid fertilizers from peat was described in a Japanese patent.[3] In the method, phosphorite powders and peat powders are charged in a high-pressure boiler, mixed with 60 percent water (by weight) and treated at 120°–184° C and 1–4 kg/cm^2 steam pressure to further the decomposition reaction, $Ca_3(PO_4)_2 + (CO_2H)_2 + 2\ H_2O \rightarrow 2\ CaHPO_4 + Ca(CO_2)_2 + 2H_2O$. For example, 102 kg of peat (45 percent water and 60 percent organic substances), 42.25 kg of phosphorite (30.8 percent phosphorus pentoxide and 3 percent water), and 112 kg of water are steam treated for 2 hours at 120°–184° and 2–4 kg/cm^2 to give 129 kg of fertilizer.

Radioactive iodine, strontium, and yttrium have been removed from rain and synthetic waters by percolation through peat filters, according to a report on peat research published in Switzerland.[4] With the use of such filters, breakthrough capacity was influenced by the type of peat, degree of drying, and freezing. When retention of available radioactive iodine was observed at concentrations of less than 10^{-9} moles of Na ^{131}I per liter, retention increased exponentially with increasing dilution.

Extensive tests in Finland[5] show that air-dried milled moss peat can be used to absorb oil spillages both on land and at sea. The State Fuel Central Board of Finland has begun producing oil-absorbent compressed peat in 170-liter plastic packs for sale to oil companies and port authorities.

[3] TAKATA, KIKIYI. Preparation of Phosphoric Acid Fertilizers from Peat. Japanese Pat. 7,020,526 (cl.4 F21), July 13, 1970: Chem. Abs., v. 74, Mar. 29, 1971.
[4] Bezzegh-Galantai, Maria. Decontamination of Radioactively Contaminated Water with Peat Filters. SCHWEIZ Z. HYDROL. 1970, 32 (1), 226–70: Chem. Abs., v. 74, Feb. 22, 1971.
[5] Ekman, E., and others. The Use of Peat in Combatting Oil Pollution. Internat. Peat Soc. Bull. No. 2, 1971, pp. 19–23: Peat Abs., Spring 1971

Perlite

By Arthur C. Meisinger [1]

The domestic perlite industry in 1971 experienced an overall decline both in the quantity of crude perlite mined, sold, and used, and in the quantity of expanded perlite produced and sold or used. The quantity of crude perlite mined (495,000 tons) was the lowest in 6 years, and the quantity sold and used (432,000 tons) declined for the second year. Value of crude perlite sold or used, however, was approximately $37,000 more than in 1970. Expanded perlite production was 7 percent lower than in 1970.

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
1967	638	190	$1,802	223	$2,171	413	351	350	$15,115
1968	558	202	1,975	226	2,246	428	339	336	15,265
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

DOMESTIC PRODUCTION

Crude perlite was produced by 11 companies at 12 mines in six States in 1971. The quantity of crude perlite mined was 495,000 tons, and was the smallest output since 1965 when mining operations yielded 502,000 tons. New Mexico, with 90 percent of the U.S. crude perlite mined, continued to be the principal producing State. Other producing States, in descending order, were Arizona, California, Nevada, Colorado, and Idaho. No crude perlite was produced in Utah in 1971. Producers sold or used 432,000 tons of crude perlite valued at $4,941,000 compared with 456,000 tons valued at $4,904,000 in 1970.

Crude perlite was expanded at 87 plants in 33 States during 1971. The quantities of expanded perlite produced and sold or used both declined 7 percent from the record totals of 1970. The quantity of expanded perlite produced was 389,000 tons compared with 420,000 tons in 1970, and the quantity sold or used was 385,000 tons compared with 416,000 tons in 1970. The value of expanded perlite sold or used was about $2 million less than in 1970. Illinois continued to be the leader in production of expanded perlite and in the quantity sold or used. Other States with significant production of expanded perlite in 1971 were California, Colorado, Florida, Kentucky, Mississippi, New Jersey, and Pennsylvania.

[1] Industry economist, Division of Nonmetallic Minerals.

Table 2.—Expanded perlite produced and sold by producers in the United States

State	1970				1971			
	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	24,190	23,980	$1,912	$79.73	23,512	23,250	$1,778	$76.45
Florida	15,490	14,390	855	59.42	17,547	16,741	909	54.32
Georgia	(1)	(1)	20	(1)	(1)	(1)	(1)	(1)
Illinois	(1)	(1)	3,175	(1)	(1)	(1)	(1)	(1)
Indiana	5,200	5,200	380	73.08	7,253	7,253	462	63.70
Kansas	790	790	62	78.48	716	716	(2)	(2)
Maryland	5,700	5,410	391	72.27	(1)	(1)	(1)	(1)
Massachusetts	1,250	1,250	147	117.60	1,294	1,210	159	131.41
Missouri	(2)	(2)	(2)	(2)	3,278	3,278	(2)	(2)
New York	3,830	3,770	(1)	(1)	3,569	3,515	284	80.72
Ohio	7,790	7,790	455	58.41	7,709	7,709	(1)	(1)
Oregon	360	360	36	100.00	(2)	(2)	(2)	(2)
Pennsylvania	18,070	18,220	1,020	55.98	23,161	22,664	1,254	55.32
Texas	46,030	46,030	3,634	78.95	13,720	13,717	1,309	95.39
Other Eastern States [3]	225,340	223,190	9,245	[4] 55.74	232,405	230,560	13,856	[5] 58.15
Other Western States [6]	65,760	65,850	3,639	55.26	54,858	54,870	3,146	[7] 53.45
Total [8]	419,790	416,220	24,972	60.00	389,022	385,483	23,156	60.07

[1] Included with "Other Eastern States."
[2] Included with "Other Western States."
[3] Includes Georgia (1970 quantity only), Illinois (1970 quantity only), Kentucky, Louisiana (1971), Maine, Maryland (1971), Michigan, Mississippi, New Hampshire, New Jersey, New York (1970 value only), North Carolina, Ohio (1971 value only), Tennessee, and Wisconsin.
[4] Based on quantity of 223,190 tons and value of $12,440,000 ($9,245,000 "Other Eastern States" plus $20,000 for Georgia and $3,175,000 for Illinois).
[5] Based on quantity of 238,269 tons and value of $13,856,000 (230,560 tons "Other Eastern States" plus 7,709 tons for Ohio).
[6] Includes Arizona, Colorado, Idaho, Iowa, Kansas (1971 value only), Louisiana (1970), Minnesota, Missouri (1971 value only), Nebraska, Nevada, Oregon (1971), Utah, and Washington.
[7] Quantity of 58,862 tons and value of $3,146,000 (54,870 tons "Other Western States" plus 716 tons for Kansas and 3,278 tons for Missouri).
[8] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Filter aids, plaster aggregate, concrete aggregate, and insulation board continued to be the major domestic uses of expanded perlite. The percent disposition of expanded perlite by end use is shown in table 3. Compared with that in 1970, consumption of expanded perlite in filter aids decreased significantly from 23 percent to 14 percent, but use in plaster aggregate increased from 8 percent to 10 percent. Use in both concrete aggregate and horticultural aggregates dropped off slightly in 1971. "Other uses" comprised 60 percent of U.S. consumption of expanded perlite in 1971 compared with 47 percent in 1970, and included primarily insulation board, fillers, formed products, and smaller amounts of paint additives, texturing, refractories, charcoal base, and oil absorbent.

Table 3.—End use of expanded perlite
(Percent)

Use	1970	1971
Filter aid	23	14
Plaster aggregate	8	10
Concrete aggregate	11	10
Horticultural aggregates	4	3
Low-temperature insulation	2	2
Masonry and cavity fill insulation	1	1
Fillers	1	(1)
Formed products	3	(1)
Other [2]	47	60

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes insulation board.

PRICES

Producers sold crushed, cleaned, and sized crude perlite to expanding plants at an average price of $11.78 per short ton in 1971, and the portion used by producers in their own expanding plants was valued at an average of $11.20 per ton. The weighted average of both categories was $11.44 per ton in 1971 compared with $10.75 per ton in 1970.

According to expanders, expanded perlite sold or used had an average value of $60.07 ton compared with $60.00 per ton in 1970. However, average values by States in 1971 ranged from $26 to $167 per ton.

WORLD REVIEW

Algeria.—A small quantity (86 short tons) of crude perlite was produced in Algeria in 1971.[2]

New Zealand.—New Zealand Forest Products, Ltd., and Consolidated Brick and Pipe Investments, Ltd., a joint venture, announced plans for the development of several perlite deposits in the Atiamuri area, southern Waikato region, North Island. A development study is to be conducted by New Zealand Perlite, Ltd., which has established a pilot plant in the deposit area.

Expanded perlite is used in New Zealand primarily for home insulation.

Philippines.—Crude perlite from the Trinity Lodge deposit was processed in a plant at San Pedro, Laguna. The plant went on stream in mid-1971.

The Philippine Bureau of Mines conducted geologic mapping investigations in areas of known perlite occurrences in the Philippines.

Turkey.—The quantity of perlite produced in Turkey in 1971 amounted to 10,119 tons, but value of production was not available.[3]

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[2] USINT Algiers. State Dept. Airgram A–70, Mar. 15, 1972, p. 2.

[3] U.S. Embassy, Ankara, Turkey. State Dept. Airgram A–148, June 14, 1972, p. 4.

Crude Petroleum and Petroleum Products

By James G. Kirby [1] and Betty M. Moore [2]

The total demand [3] for petroleum products averaged 15,429,000 barrels daily in 1971, an increase for the year of 3.3 percent.

The increase of 3.5 percent reported for domestic product demand in 1971 was the lowest gain reported since 1964. The small increase was attributed to the low level of general economic activity and adverse weather conditions. The fuel oil market continued to benefit in some areas where air quality standards were too restrictive for some coals, and where supplies of natural gas were not available to take over additional markets.

The pipeline from the Middle East to the Mediterranean was reopened at the end of January 1971, and settlements for higher royalties were agreed on by the oil companies and the producing countries, thus eliminating the supply problems and the long tanker hauls around Africa that had existed since May 1970. The resulting surplus of tankers caused a sharp decline in tanker rates, and from April throughout the balance of the year, crude oil imports were at record high levels.

Leasing of areas in the Outer Continental Shelf by the Department of the Interior, as well as the Alaskan pipeline project, were delayed by court order pending solutions to environmental concerns. Permits for placing drilling platforms in the Santa Barbara Channel off the coast of California were denied. Plans for a new refinery and offshore deepwater terminal in Delaware were canceled when the State government passed an ordinance prohibiting the projects.

The data presented in this chapter are essentially limited to the United States to permit a breakdown and balancing of supply and demand of operations by States and districts. The composition of the districts used by the Bureau of Mines is explained in a following section.

The increasing volume of natural gas liquids recovered from natural gas has made it desirable to present data on these liquids with the crude oil data, as these liquids are blended with refinery products and are similar to materials recovered from refinery gases. These natural gas liquids are recovered at natural gas processing plants, separate from the oil refineries.

The Bureau of Mines uses crude-oil production data (including field condensate) compiled by State agencies for those States that compile the information. Where such data are not available, monthly questionnaires are sent to all pipeline companies operating within the State. Annual canvasses and State agencies also provide supplemental information on the value of crude petroleum at wells, and the number of producing wells.

Individual refineries reported monthly receipts, input, stocks, refinery production, and deliveries. Data on both product stocks at refineries and pipeline and bulk terminal stocks are collected. These data are also published monthly. Annually, sales

[1] Industry economist, Division of Fossil Fuels.
[2] Statistical assistant, Division of Fossil Fuels.
[3] 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 consumer's 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.

of fuel oils, asphalt and road oils by uses, and refinery capacity are canvassed.

Demand By Product.—*Gasoline.*—Domestic demand for motor gasoline in 1971 was 2,195,279,000 barrels, an increase of 83,930,000 barrels or 4 percent for the year. Motor gasoline represents almost 40 percent of the demand for petroleum products. The demand for aviation gasoline continued the decline of the past 13 years. Commercial use of aviation gasoline increased 4 percent to 10,305,000 barrels in 1971, but military use declined 24 percent to 7,589,000 barrels.

Distillate Fuel Oil.—The 4.8-percent increase in domestic demand for distillate fuel oil in 1971 was the largest gain reported since 1968. Demand for the year was 971,320,000 barrels. During the year stronger emission control regulations became effective in some cities which placed additional limitations on the use of coal and residual fuel in the heating, commercial, and light industrial markets. Distillate fuel oil, in most cases, will make inroads into these markets since supplies of natural gas are not available to assume this additional demand.

Residual Fuel Oil.—A 17.2-percent increase in the use of residual fuel oil for the generation of electricity in 1971 more than offset losses in the other use categories so that the domestic demand for residual fuel oil increased 4.2 percent to 837,869,000 barrels. Imported residual fuel oil supplied 67.9 percent of the demand requirements in 1971 compared with 67.7 percent in 1970.

Sales of residual fuel for the generation of electric power in 1971 by PAD districts were as follows: PAD district I, 295,151,000 barrels; PAD district II, 17,819,000 barrels; PAD district III, 4,728,000 barrels; PAD district IV, 2,231,000 barrels; and PAD district V, 42,093,000 barrels.

Kerosine.—Warmer than normal weather in addition to the usual loss of heating markets to liquefied gases resulted in a 5.3-percent decline in the demand for kerosine in 1971. The domestic demand for kerosine in uses other than jet fuel was 90,917,000 barrels for the year.

Jet Fuels.—The demand for jet fuel showed some recovery from the low demand reported for 1970, with an increase for the year of 3.7 percent. Domestic demand in 1971 was 366,626,000 barrels (94,733,000 for naphtha-type jet and 271,893,000 for kerosine-type jet). The military used 112,968,000 barrels of jet fuel in 1971, mostly of the naphtha-type JP4 and JP5, compared with 110,087,000 barrels in 1970.

Liquefied Gases and Ethane.—Until the fourth quarter of 1971, domestic demand for liquefied gases was below the 1970 level but rallied enough to show a 1.6-percent gain for the year. Domestic demand for the year was 369,007,000 barrels. Ethane demand increased 4.8 percent in 1971 to 87,744,000 barrels. More detail on liquefied gases and ethane can be found in the "Natural Gas Liquids" chapter.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States
(Thousand 42-gallon barrels unless otherwise indicated)

	1967	1968	1969	1970	1971 p
Crude petroleum:					
Domestic production (including lease condensate)	3,215,742	3,329,042	3,371,751	3,517,450	3,453,914
World production	12,889,252	14,093,150	15,214,885	16,689,617	17,653,214
U.S. proportion ____ percent	25	24	22	21	20
Exports [1]	26,541	1,802	1,436	4,991	503
Imports [2]	411,649	472,323	514,114	483,293	613,417
Stocks, end of year	248,970	272,193	265,227	276,367	259,648
Runs to stills	3,582,594	3,774,360	3,879,605	3,967,503	4,087,809
Value of domestic product at wells:					
Total ____ thousands	$9,375,727	$9,794,826	$10,426,680	$11,173,726	$11,692,998
Average per barrel	$2.92	$2.94	$3.09	$3.18	$3.39
Total producing oil wells Dec. 31	565,289	553,920	542,227	530,990	517,318
Total oil wells completed during year (successful wells)	15,329	14,342	14,368	13,020	11,858
Refined products:					
Exports [1]	85,519	82,742	83,449	89,467	81,182
Imports [3]	514,342	567,046	641,437	764,769	817,204
Stocks, end of year [4]	629,399	647,439	656,344	675,502	695,878
Completed refineries, end of year	291	284	281	279	282
Daily crude-oil capacity	11,533	11,740	12,074	13,020	13,437
Natural gas liquids:					
Production	514,456	550,311	580,241	605,916	617,815
Stocks, end of year	65,742	77,940	58,552	65,992	88,421
All oils:					
Total product and crude oil demand	4,699,862	4,990,467	5,249,056	5,463,259	5,636,594
Exports	112,060	84,544	84,885	94,458	81,685
Domestic product and crude oil demand	4,587,802	4,905,923	5,164,171	5,368,801	5,554,909

p Preliminary (except for crude production and value).
[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.
[4] Stocks of refined products also include stocks of unfinished oils, natural gasoline, plant condensate, and isopentane.

Other Products.—This category includes refinery gas (still gas) used for fuel, asphalt, petrochemical feedstocks, petroleum coke, lubricating oils, special naphthas, miscellaneous products, road oil, and wax. Refiners used 156,967,000 barrels of still gas for fuel in 1971 and 16,158,000 barrels for petrochemical feedstocks. The domestic demand for asphalt increased 3.3 percent to 158,528,000 barrels (28,823,000 short tons). The demand for petrochemical feedstocks was strong in both the domestic and export market. Domestic demand for the year increased 9.2 percent to 110,521,000 barrels and exports increased 39.5 percent to 5,269,000 barrels. Sales of marketable coke were down 0.7 percent in 1971 because of a decline in exports of 713,000 short tons. Domestic demand for petroleum coke, including 9,365,000 short tons of catalyst coke, was 15,995,000 short tons in 1971, an increase of 3.6 percent. The demand for lubricating oils declined slightly in both the domestic and export market. In 1971, domestic demand was 49,378,000 barrels and exports, 15,768,000 barrels. The demand for special naphthas declined 5.3 percent in 1971 to 31,231,000 barrels. Domestic demand was 29,781,000 barrels, 1,609,000 less than in 1970. Miscellaneous oils include various specialty oils, medicinal oils, spray oils, and petrochemicals. The demand for these oils in 1971 was 15,943,000 barrels, up slightly from 1970. The demand for road oil in 1971 was 8,487,000 barrels, 12.0 percent less than in 1970. Although exports declined 8.5 percent, the demand for petroleum wax increased 7.7 percent in 1971. Domestic demand increased 14.0 percent to 5,254,000 barrels.

Shipments to U.S. Territories and Possessions.—Domestic demand, as defined in this chapter, refers to demand in all States of the United States. Shipments from the United States to territories and possessions are included with exports. Any foreign receipts into these territories and possessions are not included in the total imports shown.

Shipments from territories and possessions to foreign countries are excluded from exports. Shipments to the United States are included in imports.

Districts.—The Bureau of Mines reports production of crude petroleum and natural gas liquids, and the number of wells drilled, by States. Data for Louisiana, New Mexico, and Texas are also reported by districts.

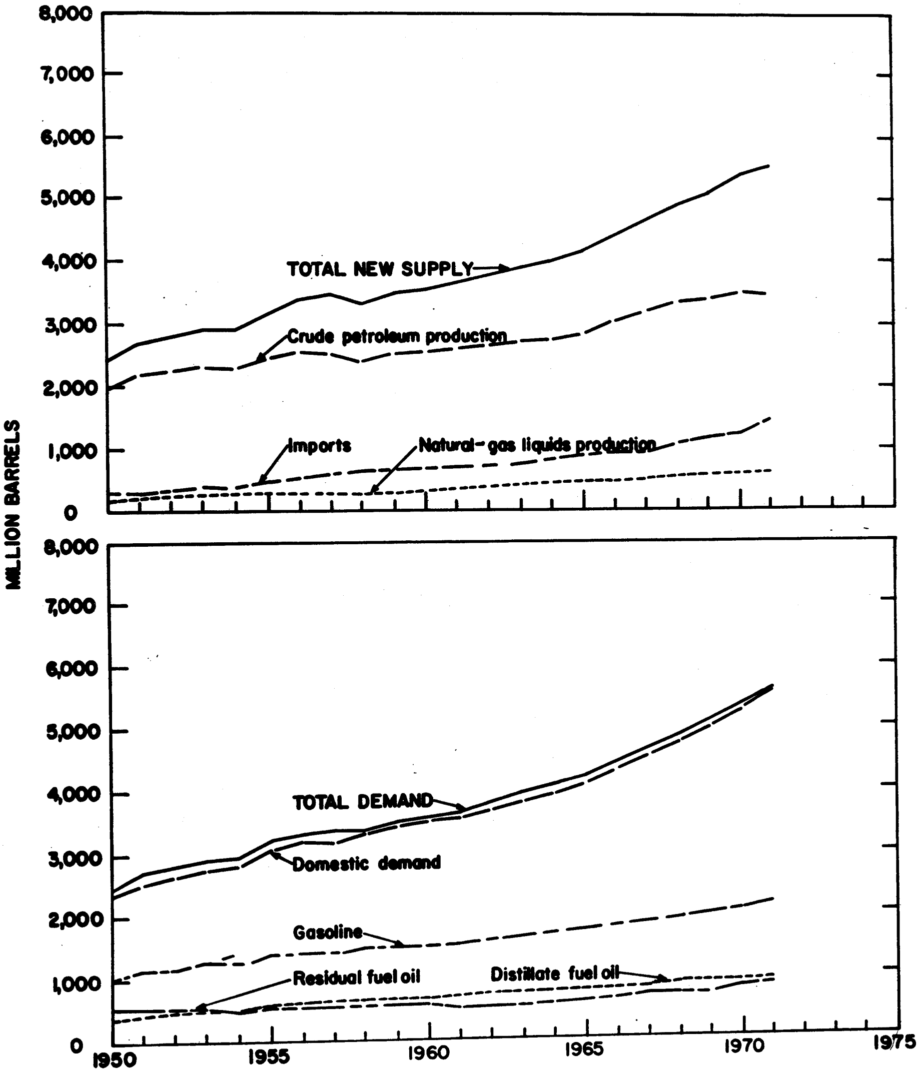

Figure 1.—Supply and demand of all oils in the United States.

New Mexico has two widely separated producing areas. The Southeastern district comprises mainly Lea, Eddy, Chaves, and Roosevelt Counties. The Northwestern district comprises mainly San Juan, Rio Arriba, Sandoval, and McKinley Counties.

The Bureau of Mines producing districts in Texas correspond, with one exception, to the Texas Railroad Commission districts, grouped as follows:

Bureau of Mines districts	*Railroad Commission districts*
Gulf Coast	Nos. 2 and 3
West Texas	Nos. 7C, 8 and 8a.
East Proper	Part of No. 6 (East Texas field in Cherokee, Smith, Upshur, Rush, and Gregg).
Panhandle	No. 10.
Rest of State:	
North	Nos. 7B and 9.
Central	No. 1
South	No. 4.
Other East Texas	Nos. 5 and 6 (exclusive of East Proper).

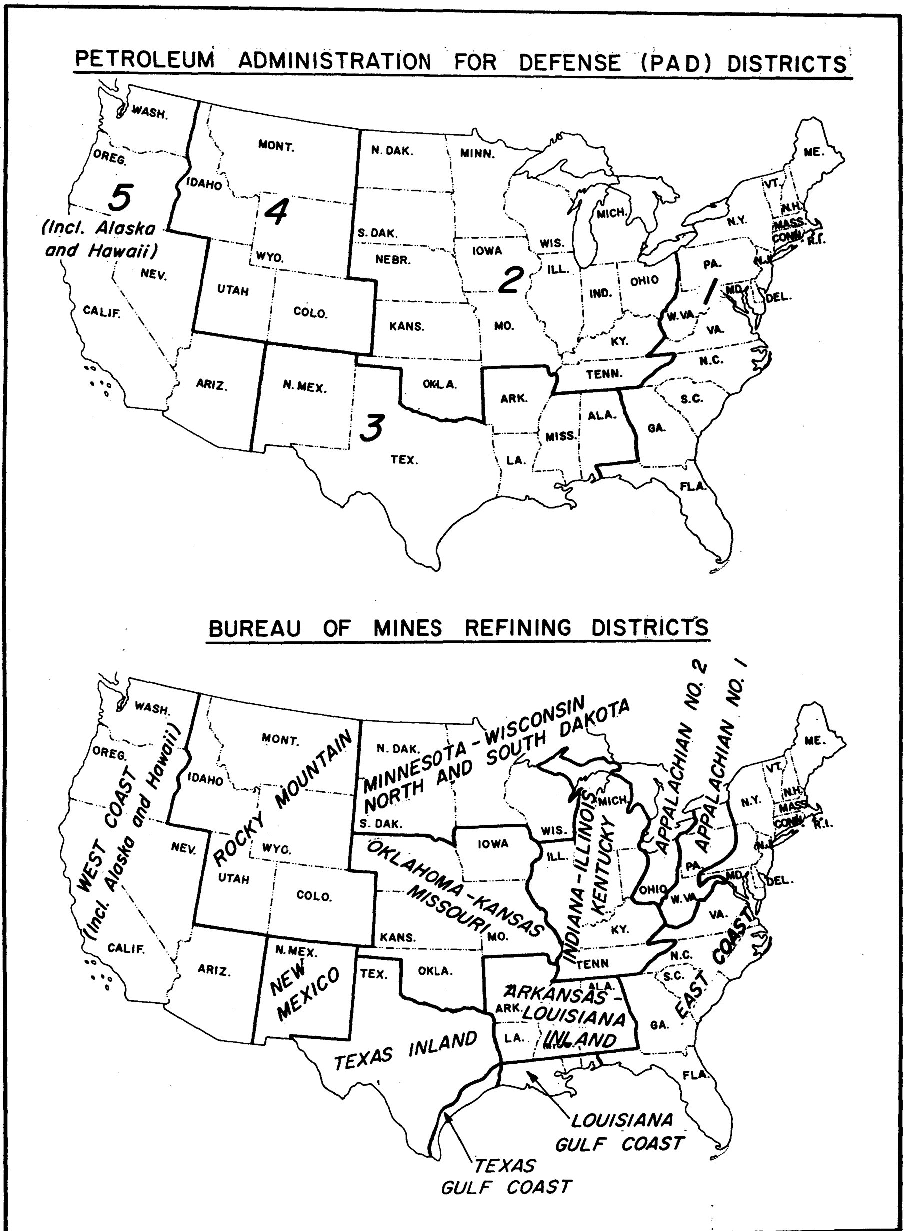

Figure 2.—Map of PAD Districts and Bureau of Mines Refining Districts.

Separate production data are shown for the Louisiana Gulf Coast, including the offshore area.

The Bureau of Mines groups refinery operations into another set of districts called refining districts. These refining districts correspond with the grouping originated by the Petroleum Administration for War during World War II and called PAW districts (later changed to PAD districts).

PAD district	*Refining districts*
I	*East Coast*—District of Columbia and Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida, and the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof, and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York, and all counties east thereof.
I	*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.
II	*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.
II	*Indiana-Illinois-Kentucky*—Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.
II	*Oklahoma-Kansas-Missouri*—Oklahoma, Kansas, Missouri, Nebraska, and Iowa.
II	*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.
III	*Texas Inland*—Texas, except Texas Gulf Coast district.
III	*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Harris, Galveston, Waller, Fort Bend, Brazoria, Wharton, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.
III	*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George, Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Ala.
III	*North Louisiana-Arkansas*—Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast district.
III	*New Mexico*—New Mexico.
IV	*Rocky Mountain*—Montana, Idaho, Wyoming, Utah, and Colorado.
V	*West Coast*—Washington, Oregon California, Nevada, Alaska, Arizona, and Hawaii.

CRUDE PETROLEUM

PRODUCTION

The production of crude oil (including lease condensate) in 1971 was 3,453,914,000 barrels, 63,536,000 barrels below the 1970 output. Production increased in nine States but declined in 20. Louisiana, with an increase of 28.3 million barrels, was the only State reporting a sizable gain. States reporting large declines for the year were Texas, 26.8 million barrels; California, 13.7 million barrels; Oklahoma, 10.3 million barrels; New Mexico, 9.8 million barrels; and Kansas, 6.3 million barrels. From January through July, new production records were established each month, and in April crude oil imports also began to reach record levels and crude supply exceeded demand. Beginning in August, crude oil production was cut back for the rest of the year to avoid an excessive stock buildup.

The dispute which closed the Trans-Arabian Pipeline from the Persian Gulf producing countries to the Mediterranean Sea in 1969 was settled at the end of January 1971. The 400,000 barrels daily of crude oil carried by this line was again available for markets in Europe without the necessity of the long tanker haul around Africa. A surplus tanker market soon developed, resulting in a substantial reduction in tanker rates. The price advantage of imported oil over domestic oil in the United States was restored, and from April through the balance of the year, imports were at record highs.

CONSUMPTION

The total demand for crude oil in the United States in 1971 averaged 11,189,000 barrels daily, of which 9,526,000 barrels daily was supplied from domestic sources and 1,663,000 barrels daily came from foreign sources. The demand for domestic crude oil declined 0.9 percent in 1971, while the demand for foreign crude oil increased 25.8 percent. This was the first year since 1958 that the demand for domestic crude oil did not increase.

Runs to Stills.—Crude oil was processed at refineries at the rate of 11,200,000 barrels daily in 1971 compared with 10,870,000 in 1970. Record high runs of 11,483,000 barrels daily were established in June. Based on the total capacity operable on January 1, 1971, 12,860,000 barrels daily, refineries operated at 87.1 percent of capacity in 1971.

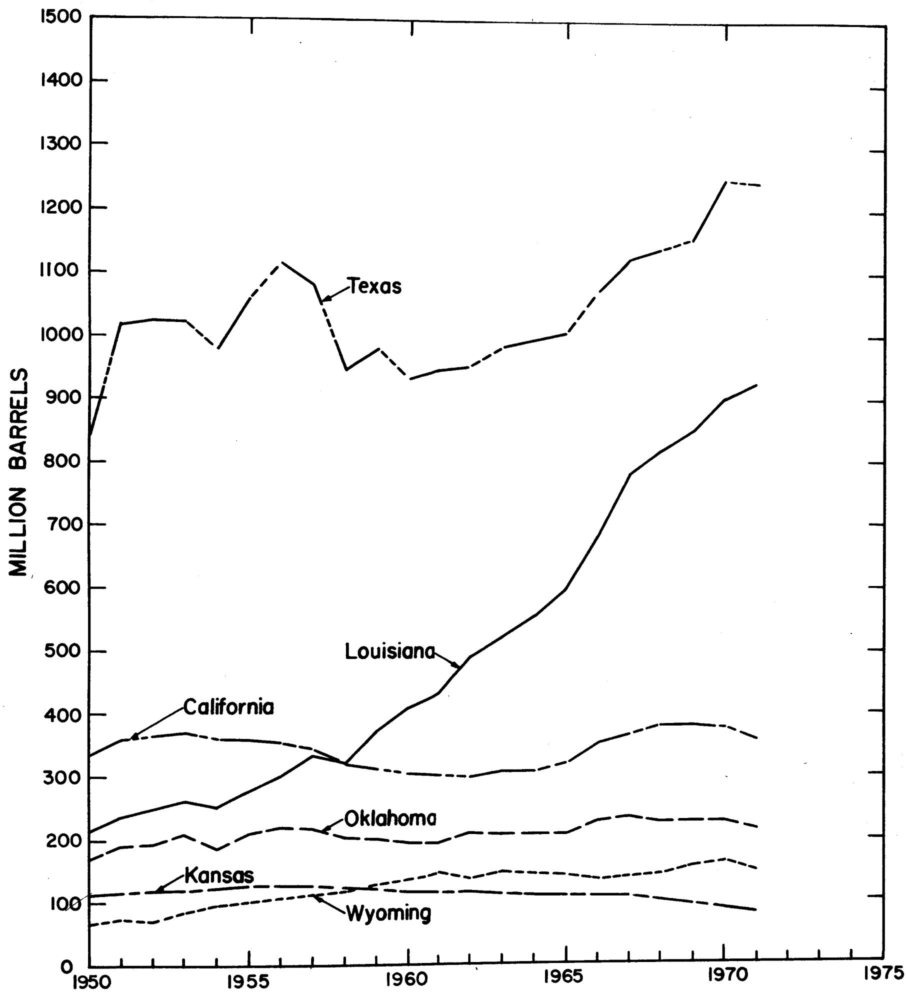

Figure 3.—Production of crude petroleum in the United States by principal producing States.

Demand by State of Origin.—Distribution of domestic crude oil can be analyzed from the individual refinery reports, which show origin of crude oil receipts, and from crude oil stock reports filed by refiners, pipeline companies, and terminal operators, which show stocks of crude oil by States of origin and location. When long-distance shipments are involved, various crude oil may be mixed in transit or storage, and identification by origin may be only approximate.

SUPPLY AND DISTRIBUTION

The total distribution of crude oil in 1971 was 4,098.9 million barrels, of which domestic crude oil accounted for 3,492.0 million barrels, and foreign crude oil for 606.9 million barrels. The total new supply of crude oil in 1971 was 4,067.3 million barrels including the production of crude oil and lease condensate of 3,453.9 million barrels and imports of 613.4 million barrels. Stocks of domestic crude oil were reduced 23.2 million barrels during the year, but stocks of foreign crude oil increased 6.5 million barrels. The difference, 14.9 million barrels, was classed as "unaccounted for" crude oil to avoid making arbitrary adjustments in the reported supply or consumption.

PRODUCTIVE CAPACITY

According to the American Petroleum Institute (API) the maximum crude oil production that could be attained in the United States as of January 1, 1972, was 10.6 million barrels daily, down 0.5 million barrels daily from January 1, 1971. This estimate is 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 significant production capacity is credited to the crude oil located at the North Slope of Alaska since there is as yet no way to transport that oil and companies have not completed the installation of production equipment.

WELLS

A further decline in drilling activity occurred in 1971 when 25,851 new wells were drilled, 2,269 fewer than in 1970. The drilling in 1971 resulted in 11,858 new oil wells, 3,830 new gas wells, and 10,163 dry holes. Average depth of the wells drilled was 4,806 feet, compared with 4,953 feet in 1970.

States which reported the largest dropoff in drilling for the year were Wyoming, 506 fewer wells; Texas, 451; Oklahoma, 430; and California, 279 fewer wells drilled. Court suits by environmental groups caused the Department of the Interior to cancel a lease sale of offshore acreage in the Gulf of Mexico and to postpone other planned sales.

When the discovery of an oil well at Sable Island off the coast of Nova Scotia was announced in 1971, geologists indicated that similar geographic structures underlie the coastal waters of several east coast States. The Secretary of the Interior, requested by several State and conservation groups not to lease any of this continental offshore area for the drilling of oil and gas wells, withheld leasing these lands in 1971.

There were 517,318 oil wells producing at the end of 1971, compared with 530,990 on December 31, 1970.

RESERVES

The API Committee on Petroleum Reserves estimated proved reserves of crude oil as of December 1, 1971, to be 38,063 million barrels, a decline of 938 million barrels for the year. Excluding Alaska, crude oil reserves of the lower 48 States were at the lowest level since 1951. Only four States—Florida, Michigan, Ohio, and Oklahoma—reported additions to reserves during the year, but other than Florida with an increase of 129 million barrels, the additions were minor. Reserves declined 311 million barrels in Louisiana and 278 million barrels in California.

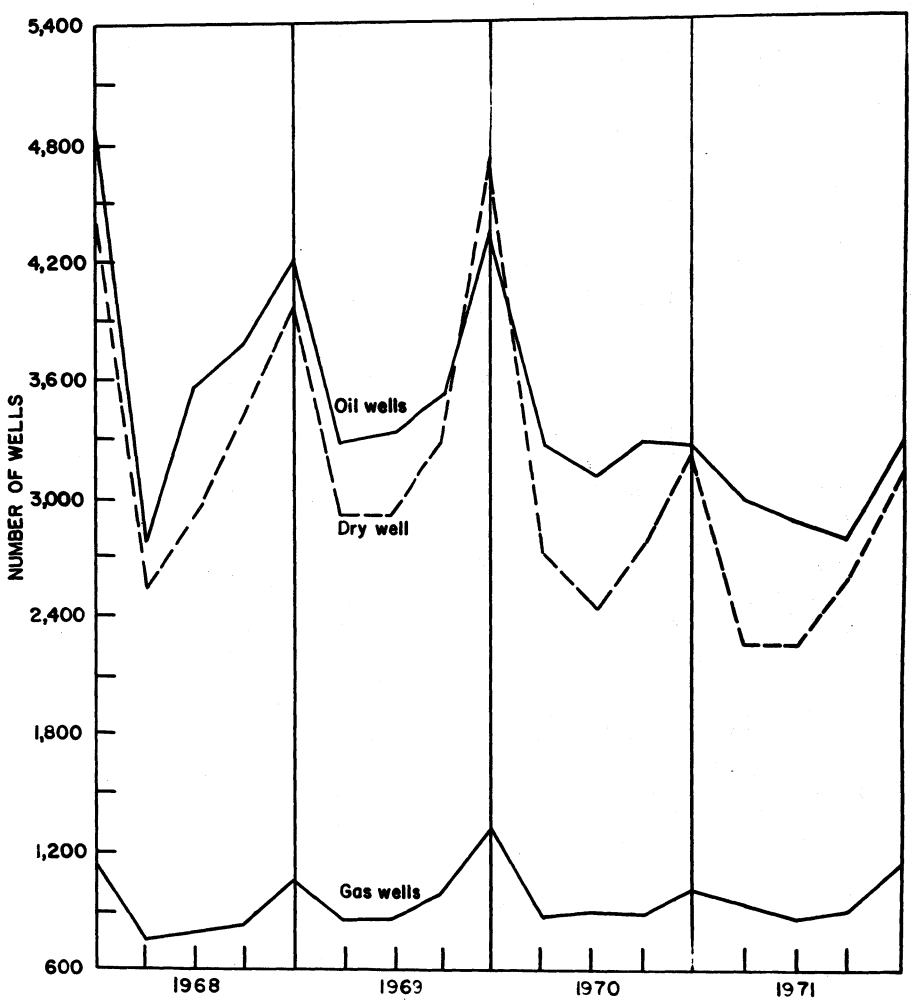

Figure 4.—Wells drilled for oil and gas in the United States, by quarters.

REFINED PRODUCTS

Because of limited supplies of natural gas and the inability of coal to meet air emission standards in some areas, petroleum products were required to supply an even greater share (45 percent) of the Nation's energy requirements in 1971 than in 1970 (44 percent). Petroleum supplies 95 percent of the fuel used for transportation, 46 percent of that used in household and commercial establishments, 25 percent for industrial installations, and 14 percent for the generation of electricity by utilities.

Gasoline is consumed principally in highway transport, aviation, mechanized farming and power boating. Kerosine (other than the straight-run kerosine used as fuel in commercial jet aircraft) is used primarily in space heaters, as range oil, or for farm equipment. Distillate fuel oils, which include the light diesel fuels, are used for space heating, locomotive fuel, industrial use, vessel use, and by the military. Residual fuel oil is used primarily by electric utilities and for heavy-fuel use. Residual fuel usually sells for less than crude oil at the refineries. As it is not normally moved by pipeline, its distribution depends on low-cost water transportation and limited tank car movement.

Liquefied gases, in competition with kerosine and light distillate fuel oil for domestic use, are used as fuel in internal-combustion engines and are becoming increasingly important as the initial raw material in the development of many petrochemicals.

The total demand for petroleum products averaged 15,429,000 barrels daily in 1971, including a domestic demand of 15,207,000 barrels daily and exports of 222,000 barrels daily. Compared with 1970, total demand increased 3.3 percent, domestic demand increased 3.5 percent, and exports declined 9.4 percent.

Total supply for the year averaged 15,442,000 barrels daily, and after allowing for crude oil losses and exports, there was an average addition to stocks of 72,000 barrels daily for the year.

GASOLINE

Domestic demand for motor gasoline increased only 4 percent in 1971 to an average of 6,014,000 barrels daily. This was below the 4.5-percent growth rate of the past 5 years and below industry forecasts. It has been anticipated that, despite the growth trend in smaller cars, the average annual growth rate for motor gasoline would remain at about 5 percent because of reduced engine efficiency in new cars that have been modified to meet Federal air emission standards and more cars with air conditioning units. Demand averaged only 3.5 percent above the 1970 level through the first 9 months of 1971 but rallied in the fourth quarter to 5.3 percent.

The new supply of motor gasoline in 1971 was 2,206 million barrels, of which 1,888 million barrels was produced from crude oil, 290 million was from natural gas liquids, 6 million was from other hydrocarbons and hydrogens, and 22 million was imported.

According to data compiled by the API based on tax data reported by the States, 2,236 million barrels of motor gasoline was consumed in the United States in 1971 compared with 2,129 million in 1970. This differs from the demand data compiled by the Bureau of Mines, which do not include changes in secondary storage.

KEROSINE

A further decline in the demand for kerosine continued in 1971. The domestic demand for the year averaged 249,000 barrels daily, a decrease of 14,000 barrels daily from 1970. The principal market for kerosine is for space heaters, but propane (bottle gas) is replacing kerosine because of its convenience.

Stocks of kerosine declined 3.4 million barrels to 24.4 million barrels at the close of 1971.

DISTILLATE FUEL OIL

Distillate fuel oil demand experienced a healthy 4.8 percent growth rate in 1971 despite mild weather and a slowdown of general industrial activity. The reason for this increase was the air quality restrictions in several areas limiting the use of fuels with a high sulfur content. Previously natural gas would have claimed a good share of this market, but because of short supply, the market is shifting primarily to distillate fuel oil. Domestic demand for the year averaged 2,661,000 barrels daily. Electric utility companies, using more gas turbine plants to meet peak load requirements, increased the use of distillate fuel oil from 68,000 barrels daily in 1970 to 94,000 barrels daily in 1971.

The new domestic supply of distillate fuel oil in 1971 averaged 2,503,000 barrels daily; imports averaged 153,000 barrels daily, and to meet the total demand requirements for the year, stocks were reduced at the rate of 13,000 barrels daily.

RESIDUAL FUEL OIL

After 2 hectic years for consumers and suppliers of residual fuel oil, the situation settled down in 1971. More normal weather for the year, both summer and winter, curbed demand requirements, as did the low level of industrial activity. Domestic demand increased only 4.2 percent in 1971 compared with 11.4 percent in 1970 and 8.3 percent in 1969. More refineries in the Caribbean are now able to supply a residual fuel oil that meets specific sulfur specifications required by consumers in east coast markets with various air quality regulations. Imports of residual fuel oil for consumption (excluding fuel

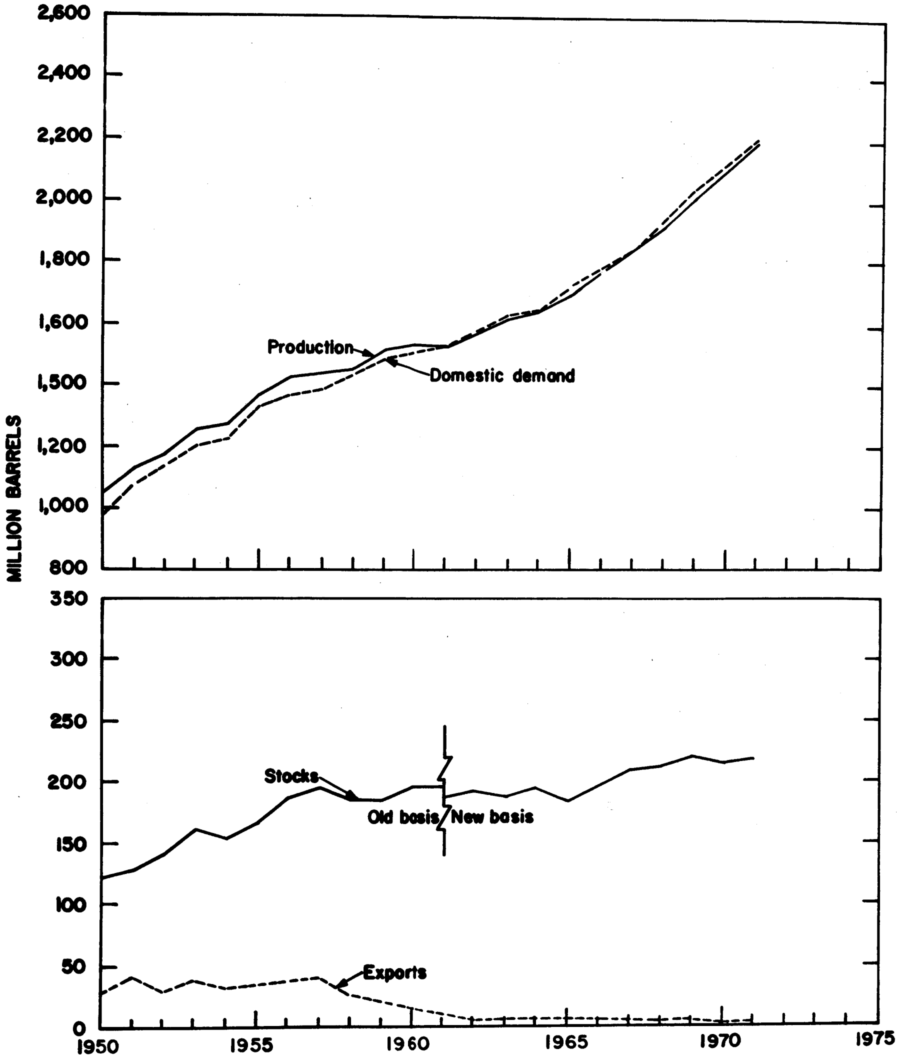

Figure 5.—Production, domestic demand, stocks and exports of gasoline in the United States.

for bunkering) into the United States in 1971 averaged 1,468,000 barrels daily. Of this total, an average of 300,000 barrels daily had a sulfur content of 0.5 percent or less; 456,000, a content of 0.51 to 1.0 percent; 212,000, a content of 1.01 to 2.00 percent; and the balance, 500,000 barrels daily, a content in excess of 2.0 percent. Imported oil accounted for almost 69 percent of the domestic demand for residual fuel in 1971.

Electric utilities used an average of 991,842 barrels daily for the generation of electric power in 1971 compared with 846,630 barrels daily in 1970, an increase of 17.2 percent.

Because of stricter air pollution regulations in some areas, residual fuel oil is taking over some electric utility fuel markets formerly favoring coal but is losing out in the heating market to distillate fuel oil for the same reason.

Total residual fuel oil stocks at the end of 1971 were 59.7 million barrels, an increase of 5.7 million barrels for the year.

JET FUELS

The demand for jet fuels increased 3.9 percent in 1971, a decided improvement over the slump shown in 1970 but well below the 13-percent annual growth rate of the 1960's. The airlines efforts to curtail some flights and establish a greater utilization of existing seating capacity could keep future demand growth closer to the 3.9-percent level of 1971. The demand for kerosine-type jet fuel increased 27,000 barrels daily during 1971 to 745,000 barrels, and demand for naphtha-type jet fuel, used primarily by the military, increased 11,000 barrels daily to 260,000 barrels.

Imports of jet fuels averaged 174,000 barrels daily in 1971, of which 146,000 barrels daily was imported in bond for use as fuel for aircraft engaged in flights with destinations outside the United States. There is no customs duty on these imports, and bonded imports of such fuels are not subject to import control regulations.

LUBRICANTS

A slight decline occurred in both the domestic and export market for lubricants in 1971. Total demand in 1971 was 65.1 million barrels, compared with 65.8 million barrels in 1970. The export market has been declining for several years as more facilities are installed abroad, but in previous years increases in the domestic market offset that decline. The Bureau of the Census conducts a biannual survey of domestic sales of lubricants. Over half of the sales are for industrial use. The slowdown of industrial activity that occurred in 1971 apparently was responsible for the decline in the domestic demand for the year.

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 produced from natural gas. The liquefied petroleum gases (LPG) are all saturated (propane, butane, etc). The liquefied refinery gases (LRG) may contain unsaturated compounds or olefins (propylene, butylene, etc.). The olefins are used as feedstocks for chemical plants. The saturated gases may be used as chemical raw materials or as fuel.

Separate data are collected on liquefied refinery gas used as fuel and that used as raw material for petrochemical feedstocks. Liquefied gases are also used in producing gasoline and are reported in this chapter as natural gas liquids at refineries or as gasoline.

The total demand for liquefied gases, excluding that blended into other products at refineries or terminals in 1971, was 378,398,000 barrels, compared with 373,014,000 barrels in 1970. Domestic demand for the year increased 1.6 percent, and exports declined 5.7 percent. The demand for ethane (including ethylene) was 87,744,000 barrels in 1971, compared with 83,757,000 barrels in 1970.

More detailed information on liquefied gases may be found in the chapter on natural gas liquids.

ASPHALT AND ROAD OIL

Shipments of asphalt and asphaltic products in the United States in 1971 were 30,727,000 short tons, compared with 29,712,000 short tons in 1970. Asphalt for paving, which represents 79.6 percent of the total sales, was 24,450,000 short tons, an increase of 3.6 percent for the year. Shipments of roofing products increased 4.1 percent in 1971 to 4,422,000 short tons, while shipments for all other products declined 0.8 percent. The shipment data include, in addition to refinery production and imports, various emulsifiers and blenders.

The domestic demand for asphalt in 1971 was 28,823,000 short tons, an increase for the year of 3.3 percent.

The demand for road oil decreased from 9,641,000 barrels in 1970 to 8,487,000 barrels in 1971.

OTHER PRODUCTS

Special Naphthas.—Special naphthas are used primarily for paint thinners, cleaning agents, and solvents. The domestic demand for special naphthas declined 5.1 percent in 1971 to 29.8 million barrels, while exports declined from 1.6 million barrels in 1970 to 1.5 million in 1971.

Wax.—The total demand for petroleum wax in 1971 was 967,120 short tons, an exceptionally high increase of 7.7 percent for the year. Exports were 231,560 tons, 21.6 thousand less than in 1970. The annual survey of wax sales conducted by the API for 1971 represents about 76 percent of the domestic demand reported by the Bureau of Mines. A breakdown of the 1971 data, by end use and percentage change from 1970, is as follows: Paperboard containers, 130,193 tons, down 6.7 percent; paper wrappers, 93,660 tons, up 8.0 percent; corrugated paperboard, 71,816 tons, up 12.4 percent; candles, molded novelties, and decorative items, 85,852 tons, down 11.8 percent; and all other uses, 180,216 tons, down 4.1 percent.

Coke.—The domestic demand for petroleum coke increased 3.6 percent in 1971 to 15,995,000 short tons; however, exports declined 11.7 percent for the year to 5,398,000 short tons so that total demand was off 0.7 percent. Refineries used 10,444,000 short tons as fuel in 1971, including 9,365,000 short tons of catalyst coke and 1,079,000 short tons of marketable coke. Catalyst coke is formed on the catalytic cracking units in the refining process and can only be used as a refinery fuel.

Still Gas.—Refineries used 156,967,000 barrels (981,558 million cubic feet) of still gas as fuel in 1971, 4.2 percent less than in 1970. Still gas used as petrochemical feedstocks in 1971 totaled 16,158,000 barrels, 28.6 percent more than in 1970.

Petrochemical Feedstocks.—Petroleum refineries supplied the petrochemical industry in the United States with 110,521,000 barrels of feedstocks (other than LRG) in 1971 and exported 5,269,000 barrels. Compared with 1970, domestic demand increased 9.2 percent and exports increased 39.5 percent.

Unfinished Oils.—Unfinished oils are oils that have been partially refined and will be further processed by a refinery. The rerun (net) of unfinished oil represents the receipts of domestic or foreign oil plus or minus the stock change. Unfinished oils are included with crude oil under the quotas established by the Oil Import Administration. By regulation, unfinished oil imports are restricted to 15 percent of the crude oil and unfinished oil quota in Districts I–IV and to 25 percent in District V.

Miscellaneous Finished Products.—The petroleum industry produces a variety of miscellaneous products that are sold directly to consumers or are sold in bulk to specialty companies which package and distribute them under various trade names. Included in this category are absorption oils, medicinal oils, insecticides, petrochemicals, and solvents. The domestic demand for these products in 1971 was 14,920,000 barrels.

TRANSPORTATION AND DISTRIBUTION

CRUDE OIL

A transportation system consisting of pipelines, tankers, barges, tank cars, and tank trucks moves the crude petroleum to refineries for processing. Refineries received 75.8 percent of their crude oil supply by pipeline, 23.1 percent by water, and the remaining 1.1 percent by tank cars and tank trucks in 1971.

States in PAD district I account for 40 percent of the petroleum product demand in the United States, but produce less than 1 percent of the crude oil to meet this demand. Refineries in this district supply about 25 percent of the product demand. The supply of crude oil processed at these refineries in 1971 was 52 percent from foreign sources, 45 percent from other PAD districts, and 3 percent from within the district. PAD district II, the second largest consuming district, is also a deficit producing and refining area; however, output of refineries in that district represented 84 percent of demand in 1971. About 32 percent of the crude oil processed in refineries in PAD district II was produced in that district, 48 percent was received from PAD district III, 8 percent came from PAD district IV; and 12 percent was imported from foreign sources. Both PAD districts III and IV produce and refine petroleum in excess of their demand requirements and help meet the supply deficits of other districts.

The refined products produced at refineries in PAD district V in 1971 represented almost 94 percent of the domestic product demand for that district. Crude oil produced in the district supplied 69 percent of refinery input; foreign crude oil, 29 percent; and other PAD districts, 2 percent.

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, and 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.

The total receipts of crude oil at refineries in 1971 were 4,080.8 million barrels, an increase of 107.6 million barrels for the year. Receipts from domestic sources decreased 24.5 million barrels in 1971, overland receipts of foreign crude oil (from Canada) were 21.0 million barrels higher, and foreign receipts from overseas sources increased 111.1 million barrels. There were some unusual foreign crude oil shipments in 1971. The high shipping rates during the first few months of the year curtailed imports. When rates dropped, holders of import licenses had to maintain high schedules of imports for the balance of the year to avoid loss of quotas. Normally, inland refiners are able to trade these licenses with east coast refiners for domestic crude. During July, it became apparent that the east coast refineries would be unable to handle the remaining import licenses for crude oil, and cargoes were shipped to the gulf coast. Some was refined in Texas and Louisiana, and some was shipped by pipeline to refineries in PAD district II.

Refineries processed 4,087.8 million barrels of crude oil in 1971, reported a net of 0.3 million barrels used for refinery fuel and losses, and withdrew 7.3 million barrels from stocks.

REFINED PRODUCTS

The domestic demand for petroleum products in the United States in 1971 averaged 15,207,000 barrels daily, an increase of 3.5 percent for the year. The demand, broken down by PAD districts, is as follows: district I, 6,047,000; district II, 4,127,000; district III, 2,578,000; district IV, 421,000; and district V, 2,034,000.

In addition to the products produced in the district, PAD district I imported an average 1,873,000 barrels daily of refined petroleum products and received 2,754,000 barrels daily from other districts. Shipments from PAD district I to PAD district II averaged 120,000 barrels daily, and 19,000 barrels per day of petroleum products were exported.

PAD district II received an average of 674,000 barrels daily of refined products from other districts in 1971 and imported 50,000. Shipments from the district were as follows: 60,000 barrels daily to PAD district I; 74,000 barrels daily to PAD district III; and exports, 11,000 barrels daily.

PAD district III shipped an average of 3,331,000 barrels daily of refined products to the other districts in 1971. PAD district I received 2,691,000 barrels daily; PAD district II, 533,000; PAD district IV, 30,000; and PAD district V, 77,000. Exports from the district averaged 103,000 barrels daily. PAD district III receipts of petroleum products in 1971 include 48,000 barrels daily from foreign sources and 74,000 barrels daily from PAD district II.

PAD district IV shipped an average of 95,000 barrels daily, but received 71,000 barrels daily in 1971 (30,000 from PAD district III, 33,000 from PAD district V and imports of 8,000 from Canada).

PAD district V received 250,000 barrels daily of refined products in 1971. PAD district III supplied 77,000 barrels daily, PAD district IV supplied 74,000 barrels daily, and 99,000 barrels daily was imported. PAD district V shipped 3,000 barrels daily to PAD district I, and 33,000 barrels daily to PAD district IV, and exported 89,000 barrels daily.

PIPELINES

As of January 1, 1971, there were 218,604 miles of pipelines transporting crude oil and refined products in the United States. This represents an increase of 9,126 miles from the total reported in the previous Bureau of Mines survey for January 1, 1968. The mileage of gathering lines declined by 2,992 miles during the 3-year period; crude trunkline mileage increased 4,241 miles, and 7,877 additional miles were reported for product pipelines.

Crude oil pipelines delivered 3,094.9 million barrels to refineries in 1971, compared with 3,076.7 million barrels in 1970. Petroleum products pipelines delivered 2,644.8 million barrels in 1971, an increase of 85.0 million barrels for the year.

The total crude oil required for pipeline fill as of January 1, 1971, was 73,642,000 barrels. Line fill for product pipelines required 39,908,000 barrels.

RAIL, TANK TRUCK, BARGE AND TANKERS

According to the annual study of the Association of Oil Pipelines, the total tonnage of crude petroleum and petroleum products transported in 1970 was 1,685,742,000 short tons, of which 46.9 percent was moved by pipelines, 23.9 percent by water carriers, 27.6 by motor carriers, and 1.6 percent by railroads. Petroleum products represent 63.5 percent of the total volume transported, 42.1 percent of the pipeline movements, 71.1 percent of the water carrier movements, 91.2 percent of motor carrier movements, and 96.6 percent of the railroad movement.

STOCKS

The total stock of all oils at the end of 1971 was 1,043.9 million barrels, an increase of 26.1 million barrels for the year. Refined product stocks were up 42.1 million barrels, while crude oil stocks declined 16.7 million barrels.

The large increase in refined product stocks that occurred between the end of 1970 and December 31, 1971, were mostly in four products: liquefied gases, up 25.6 million barrels; motor gasoline, up 10.1 million barrels; residual fuel oil, up 5.7 million barrels; and asphalt, up 5.4 million barrels.

PRICES

Crude Oil.—There were very few changes in the posted price of crude oils in 1971. The changes reported in April were for Pennsylvania crude oils which were not covered in the increases in November–December 1970. Other changes in June were adjustments by purchasers to certain Rocky Mountain and West Texas-New Mexico crude oils to keep them in line with other postings for similar crude oils. The average value of crude oil at the wellhead in 1971 was $3.39 per barrel, an increase of 21 cents for the year.

Refined Products.—The wholesale price index for refined petroleum products increased from 101.1 in 1970 to 106.8 in 1971. As in 1970, the heavy fuel oils accounted for much of the increase and could reflect changes in quality. Restrictions on the sulfur content of fuel oils in several areas have increased the cost substantially. As an example of this, Platt's Oil Price Handbook lists a posted price for No. 6 residual fuel oil with a 1 percent maximum sulfur content sold in cargo lots in New York Harbor at an average of $2.73 in 1970. The average for 1971 is $3.92; however, the sulfur maximum was reduced to 0.3 percent in September.

The average posted price for barge lots of No. 2 distillate fuel oil in New York Harbor increased from an average of 10.6 cents per gallon in 1970 to 11.3 cents in 1971.

The average posted price of regular grade gasoline at Oklahoma refineries for shipments to northern destinations for 1971 was 12.9 cents per gallon, compared with 12.6 cents per gallon in 1970. Platt's Oilgram Price Service publishes a series showing the average prices for regular-grade gasolines in 55 representative cities. For the year 1971, this series shows that the service station price, including State, local, and Federal taxes, was 36.43 cents per gallon, an increase of 0.74 cent per gallon. The taxes increased from 11.14 cents in 1970 to 11.23 cents in 1971.

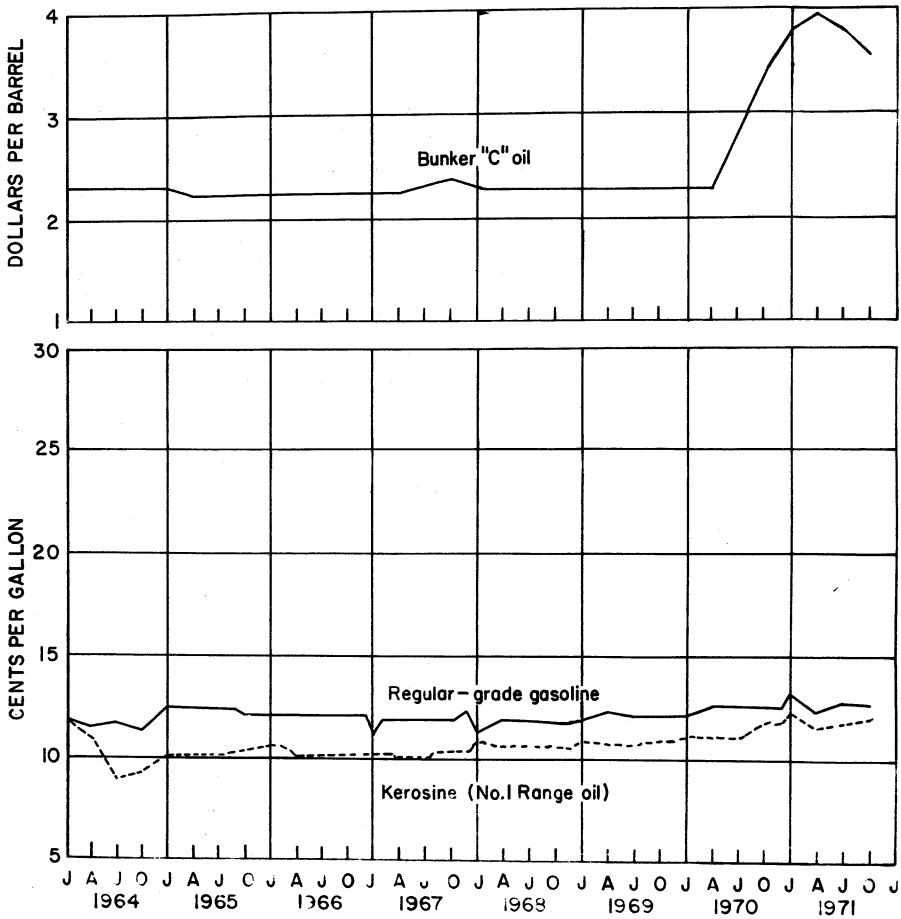

Figure 6.—Prices of Bunker "C" oil at New York Harbor, No. 1 Range oil at Chicago district, and regular-grade gasoline at refineries in Oklahoma, by quarters.

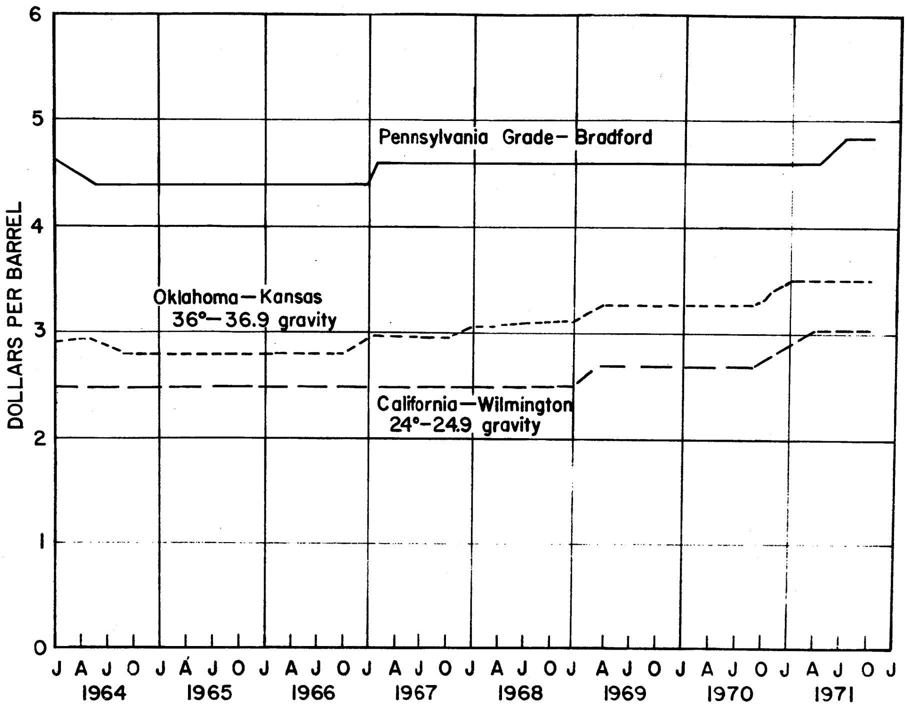

Figure 7.—Posted prices of selected grades of crude petroleum in the United States, by quarters.

FOREIGN TRADE

Foreign trade statistics reported in this section were compiled from the following sources: The imports of crude petroleum and unfinished oils were obtained from the petroleum-refining companies. All imports of residual fuel oil, distillate fuel oil, and military jet fuel for onshore use are from data collected by the Office of Oil and Gas. Imports from Puerto Rico and the Virgin Islands are from Bureau of Mines and Office of Oil and Gas data. Imports of all other products and all bonded fuels for bunkering are from data compiled by the Bureau of the Census.

Imports of crude oil and refined products totaled 1,430.6 million barrels in 1971, compared with 1,248.1 million in 1970. Crude oil accounted for 130.1 million barrels of the 182.5-million-barrel increase. Several importers were unable to use or trade all of their crude and unfinished oil import licenses in 1970 because of the high shipping cost and short tanker supply. The tanker market eased in April 1971 with the reopening of the pipeline from the Middle East to the Mediterranean and the settlement of the dispute between Libya and the producing companies. Although settlement of the dispute resulted in a higher price for the foreign crudes, with the lower shipping cost it again had a price advantage over domestic crude oil. High import levels were maintained through the balance of the year.

Crude oil imports for the year were 613,417,000 barrels of which 42.9 percent was from Canada, 18.7 percent from South America, 20.2 percent from the Middle East countries, 11.2 percent from Africa, and 7.0 percent from Indonesia and Australia.

The sources of the 817,204,000 barrels of refined products and unfinished oils imported in 1971 were as follows: Central

America and the Caribbean, 50.7 percent; South America, 32.9 percent; Canada and Mexico, 7.3 percent; Europe, 6.0 percent; Middle East, 1.8 percent; Africa, 0.7 percent; and the Far Eastern countries, 0.6 percent.

Imports of bonded fuels and military imports for offshore use were 101.5 million barrels in 1971. This represented 12 percent of the total imports of refined petroleum products. These imports, which are exempted from oil import controls, include jet fuels, distillate fuel oil, and residual fuel oil. Residual fuel oil and No. 4 distillate fuel oil can be imported into PAD district I by all licensed terminal operators, but in the other PAD districts, these imports are under quota restrictions unless they originate in Canada or Mexico.

Exports of petroleum in 1971 declined 12.8 million barrels to 81.7 million barrels. This is the lowest level of exports since 1966. Crude oil exports were only 0.5 million barrels, compared with 5.0 million in 1970; exports of petroleum coke were down 3.6 million barrels, and residual fuel oil, 6.6 million barrels.

After settlement of disputes between the companies and the Middle East and North African countries early in 1971, normal supply patterns from the Mediterranean were restored. The surplus of shipping available for charter caused a drastic reduction in shipping rates. Rates for shipments from the Persian Gulf to the United Kingdom dropped from an average of $18.98 per long ton in January to a low of $4.68 per long ton in October. Shipping rates for clean vessels of less than 30,000 deadweight tons from the gulf coast to destinations north of Cape Hatteras averaged $5.93 per long ton in January 1971, declined to $2.14 in October, but by December were $3.97 per long ton. Rates for dirty vessels of the same size on the gulf coast run were $7.84 per long ton in January, $2.57 in October, and $3.78 in December. For shipments from the Caribbean to destinations north of Hatteras in dirty vessels of less than 30,000 deadweight tons, the average charter rate was $4.01 per long ton in January 1971, dropped to a low of $1.25 in September, and increased to $2.16 for December.

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.—Natural rock asphalt and limestone rock asphalt are produced in Alabama, Missouri, and Texas and are used for roadbuilding material. Gilsonite is produced in Utah, and most of the production is shipped to a refinery in Colorado and converted to petroleum products. The total production of native asphalts and related bitumens in 1971 was 1,668,928 short tons with a value of $8,291,000.

WORLD REVIEW [4]

Crude oil production in 1971 increased 5.7 percent to an average of about 48 million barrels per day. This compares with a growth rate of over 9 percent in 1970 and with rates averaging about 7 percent in the 1960's. The lower 1971 rate reflects the termination of stockpile expansion programs in Western Europe and Japan and the generally slowing pace of economic growth in those areas. The year's growth in the free world was chiefly concentrated in the Middle East. Elsewhere, small production increases in Canada, Australia, and Nigeria were outweighed by declines, notably in the United States, Venezuela, Libya, and Algeria.

Exploration also declined in 1971, again a reflection of economic conditions and the limited availability of risk capital. Major areas of exploration outside the United States in 1971 were Arctic Canada, Trinidad, Ecuador, Peru, Nigeria, the North Sea, and Indonesia. The North Sea (Norway) and offshore Indonesia were the key new production areas.

The Organization of Petroleum Exporting Countries (OPEC) established itself as a formidable factor in international oil policy. In March 1971, six Persian Gulf OPEC member nations and representatives of 22 international oil companies reached a settlement after protracted negotiations. Major points in the agreement were a $0.33-per-barrel increase in all the posted (reference) prices concerned, regu-

[4] By David A. Carleton, petroleum specialist.

lar increases in posted prices up to 1975, and a stabilized profits tax of 55 percent for the term of the agreement. It was estimated that the new settlement will boost total oil revenues of the six nations by $1.0 billion annually.

During spring 1971 three OPEC members with crude oil pipeline terminals on the Mediterranean coast negotiated separately with the international oil companies, gaining an approximate $0.80-per-barrel increase in crude oil postings. Other provisions were similar to the Persian Gulf settlement. At OPEC's Beirut Conference in September, two important resolutions were passed. They call for "effective participation" by member nations in the existing concessions and for negotiation with the oil companies to offset the adverse effects on the exporting countries by the devaluation of the U.S. dollar in August 1971. At yearend, 20 percent was considered the minimum participation percentage acceptable to OPEC.

The volatile nature of tanker freight rates, which was displayed in 1970, continued into 1971. The average rates on the spot market, which increased to a record high of Worldscale 298 in October 1970, more than double the corresponding 1969 rate, plunged to Worldscale 57 by mid-1971. The slump was caused by preemptive chartering during the OPEC negotiations, overestimates of demand forecasts, and increased tanker construction. Because of the low freight rates Persian Gulf and Venezuelan crudes gained a competitive advantage over the "short-haul" North African crudes shipped to Western Europe.

Algeria.—Settlement of the long and bitter dispute between the Algerian state-company Société Nationale pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures (SONATRACH) and France's two largest petroleum companies was reached during 1971. The two producers, Compagnie Française du Pétroles and the Elf group of companies, retain only one-half and one-third, respectively, of their former output, becoming minority partners of SONATRACH. In most cases, compensations are to be paid in cash. The holdings of four U.S. companies were nationalized without compensation. The only remaining oil producing company other than SONATRACH and the French companies was the U.S. firm Getty Oil Co.

Argentina.—Although Argentina is virtually self-sufficient in petroleum, proven reserves will last only 12 years at the current production rate. Because of this the Government allocated to the state-owned entity Yacimientos Petrolíferos Fiscales (YPF) two new exploration areas covering a total of 62,100 square miles. One area is in the extreme north near the Bolivian border, and the other is offshore the mainland opposite the Falkland Islands.

Government policy continued to advance the YPF's position in the domestic oil industry by granting that company the exclusive right to import crude oil and to refine it. This will operate to the disadvantage of the foreign private companies which in the past had imported their own crude and in the future will have to purchase import requirements from YPF.

Australia.—Whereas more than 200 wells were drilled in 1970, only half as many were drilled in 1971. The oil companies have called for greater incentives, including an increase in the Federal Government's exploration subsidy, more liberal concessions for the companies, and fixed prices. Currently all onshore exploration is subsidized 30 percent while offshore exploration is subsidized up to 30 percent. Oil production in 1971 averaged 309,000 barrels per day; an increase of 131,000 barrels per day over the 1970 level. Offshore Bass Strait fields in Victoria provided the largest increase in production in 1971.

Bahamas.—The Bahamas Oil Refining Co. (BORCO) announced plans in October 1971 to expand the throughput capacity of its refinery at Freeport from 250,000 barrels per day to 450,000 barrels per day by 1973. The BORCO refinery will then have a throughput capacity equal to that of the St. Croix refinery in the Virgin Islands, now North America's largest. The expansion scheme includes a large desulfurization unit and a new deep water port to accommodate tankers of 350,000 deadweight tons.

Bolivia.—Crude oil production, which was down significantly in 1970, rose in 1971 to 37,000 barrels per day, almost the 1969 level. The increase reflects the success the Government company has had in finding markets for the oil it sequestered from Gulf Oil Corp. in 1969. During the year sales contracts were signed with Peru, Chile, and Argentina.

The State entity Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) embarked on a new exploration program for drilling six wells in the high Andean Plateau near Camiri. The U.S.S.R. provided $40 million in technical assistance in addition to the $27 million provided in 1970, and Mexico's Pemex offered technical aid. The Soviet studies revealed the existence of oil in the region, which is estimated to have reserves of 5 to 25 million tons.

Following the ouster of the Torres Administration and the installation of Colonel Suarez as President, the Government announced that the country would again encourage foreign investment in petroleum exploration and development.

Brazil.—Crude oil output increased in 1971, the result of secondary recovery operations, not new productive wells. Output will improve once the five major offshore fields begin full production. Exploration and development are expected to continue at a slow pace, as the country's only oil company, the state entity, Petróleo Brazileira, S.A. (PETROBRÁS), lacks the capital resources for rapid expansion. In July 1971 a decree was signed which permits PETROBRÁS to explore in foreign areas.

Canada.—Mobil Oil Co. of Canada found oil, condensate, and natural gas in a discovery well on Sable Island offshore from Eastern Canada. If other planned wells prove successful, the Sable Island find could be the first field in the North American Atlantic Continental Shelf. A confirmation well was being drilled at yearend.

The major area of exploration activity was the Canadian Arctic. Many companies representing Canadian, U.S., and West European interests have entered this area. During the year there were possibly three or four successful gas wells. A major find was the well which confirmed the 1970 King Christian Island discovery. Another was the Taglu field in the Mackenzie Delta.

Syncrude Canada, Ltd., has applied to the Alberta Energy Resources Board for permission to increase the capacity of its new Athabasca tar sands project from the previously approved 80,000 barrels per day to 125,000 barrels per day.

Chile.—Although crude oil production rose slightly during 1971, prospects for substantial increases in the future are poor as the nationalized oil industry lacks the financial resources to embark on a broad exploration program. Early in the year the Government established a state petroleum marketing monopoly. Plans were to take over the three existing marketing companies: a Chilean private firm, and subsidiaries of Standard Oil Co. (New Jersey) and the Royal Dutch/Shell group of companies.

China, People's Republic of.—It was officially reported that crude oil production in the People's Republic of China increased 27 percent in 1971, raising the total to 510,000 barrels per day. Crude oil reserves were recently estimated at 5.7 billion barrels, not including recently discovered reserves in western Tsaidam and elsewhere, but many of the fields are remote and cannot be easily developed. The official statement also asserts that output was in excess of what had been planned. Production from the Taching area increased by about 26 percent, and new wells also were placed in production in Yumen, Chinghai, Sinkiang, and Swechwan.

Colombia.—Exploration in Colombia has moved for the first time offshore the western coast of the Guajira Peninsula in the Caribbean Sea with the drilling of a well 40 miles northeast of Riohacha. The most promising offshore area in Colombia is considered to be along the eastern coast of the Guajira Peninsula, near Venezuela's oil-rich Maracaibo basin; however, exploration here will have to await settlement with Venezuela of the offshore median line boundary.

Denmark.—Dansk Undergrunds Consortium (DUC), of which Gulf Oil Corp. is the operator, continued to drill its offshore North Sea Dan oilfield (formerly "M" structure), scheduled to start producing in mid-1972 at a rate of 10,000 barrels per day. Future development of the field depends on the success DUC has with producing from the difficult chalk formation. The field has a potential of at least 40,000 barrels per day.

Onshore and offshore geological structures in the West Greenland basin have been prospected by at least 32 groups of companies since 1968. The Minister for Greenland plans to grant exploration (drilling) concessions in early 1972.

Ecuador.—Construction of the trans-Andean pipeline from Ecuador's Oriente region to the Pacific coast continued with completion scheduled for mid-1972. When it is completed, Oriente Province is expected to produce 250,000 barrels per day.

Drilling continued in Oriente, having a high success ratio. Two principal finds during 1971 were the Tiguino field by Anglo-Ecuadorian Oilfields, Ltd., and the Mariann field by Cayman Corp. The discovery wells produced 1,300 and 3,300 barrels per day, respectively.

Government activities included the formation of the state oil entity Corporacion Estatal, Petrolera Ecuadoriana (CEPE) to run the industry, preparation of a new petroleum law, and the announcement of plans for a 32,000-barrel-per-day refinery near Quito.

Egypt, Arab Republic of.—Crude oil production dropped for the first time in some years because of production problems at the country's major oilfield, Morgan. Much of the decline will be offset by production from two new fields in the Western Desert, Abu Ghardig and Yidma. Amoco UAR Oil Co., in partnership with the Government company, plans to produce the former at a rate of 50,000 barrels per day by the close of 1972. Phillips Petroleum Co., operator of the latter, plans to commence production at 8,000 barrels per day in 1973.

The long negotiations for financing the construction of the Suez-Mediterranean pipeline (Sumed) were finalized in 1971. Construction of the 207-mile, 42-inch, 1.2-million-barrel-per-day line is scheduled for 1972.

Gabon.—A new offshore field was found 18 miles south of Mayumba near the Congolese border. The well, located in about 120 feet of water, tested up to 2,700 barrels per day of oil and 700,000 cubic feet of natural gas. Another well 25 miles offshore encountered oil in 200 feet of water which was produced at 1,400 barrels per day.

Germany, West.—West Germany's petroleum and natural gas situation is characterized by crude oil production, which has declined each year since 1967, and natural gas production, which continues on the rise. With West German-controlled production in Libya adversely affected by events in the country, the state-supported Deutsche Erdolversorgungsgesellshaft m.b.H. (Deminex) has made efforts to purchase production interests in the Middle East. A striking increase in domestic natural gas production reflects development of West Germany's share of the Groningen gasfield underlying the Ems Estuary. Marketed production of 15.4 billion cubic meters in 1971 was the second largest in Western Europe and sixth largest in the world.

India.—Expansion of India's petroleum exploration, producing, and processing industry continued at a slow pace. Exploration is officially a "public sector" activity, and while foreign partners do participate, conditions offered have not been attractive. The Government's 50,000-barrel-per-day Haldia refinery, which has been under construction for about 5 years, is expected to be completed by mid-1973. Construction of a 20,000-barrel-per-day refinery at Bongaigaon in Assam began in 1971, the completion date being set optimistically for 1974.

The Government gained additional control of the petroleum refining and distribution industry by not approving requests by the private refining companies for price increases due to producer country tax increases. This means that the companies will have to reduce imports and that the Government must make up the difference by importing crude, probably from Iraq and/or the U.S.S.R.

Indonesia.—Indonesia's crude oil production rose in 1971 by a moderate 4.5 percent to 892,000 barrels per day. However, the country is poised for a big increase in production. Caltex Pacific Indonesia, Inc. (CPI), operator of Pertamina's Riau Province fields, has been rapidly developing four fields west of Duri oilfield, while to the west of prolific Minas oilfield it discovered two more fields. It was also announced that the offshore Cinta field, which came on stream during September 1971 at 60,000 barrels per day, and the offshore Kitty field, which will come on stream at 14,000 barrels per day in 1972, will together have an ultimate capacity of 150,000 barrels per day. Other fields scheduled for production in 1972 are expected to have an additional ultimate capacity of 250,000 barrels per day.

Iran.—Even with production running as high as 4 to 5 million barrels per day, exploration continued at a rapid pace with five companies exploring onshore and three offshore. Exploration drilling results were not especially favorable.

A second crude oil pipeline will be built from Ahwaz to the National Iranian Oil Co. (NIOC) Tehran refinery, where the capacity of 90,000 barrels per day will be doubled. NIOC also will build a products pipeline from Tehran to Tabriz and double the capacity of the Tehran-Meshed products pipeline. In addition, the Iranians signed agreements with separate Japanese firms to develop gas found on Qeshm Island in the Persian Gulf and to construct a $358 million petrochemical complex at Bandar Shahpur.

Work was completed to make three jetties accessible to tankers up to 250,000 deadweight tons (dwt) at Kharg Island, the largest crude oil export terminal in the world. In May 1971 a record 6.5 million barrels were loaded in a single day. At yearend a two-berth sea island facility was being built off Kharg Island which will take simultaneously one tanker of 500,000 dwt and one of 300,000 dwt.

Iraq.—Highlighting developments was Iraq's plan to produce and export production from the North Rumaila, the oilfield the Government expropriated in 1961. Because ownership of the field has been in dispute since expropriation, it has been necessary for Iraq to arrange with East European countries for assistance in developing the field. The most important creditor-customer is the U.S.S.R., which has been providing complete facilities as well as exploration and refining equipment. Similar arrangements have been made with most other East European countries.

Brazil's Petróleo Brazileira, S.A., has agreed to take 2 million tons of crude over a 5-year period beginning in 1972, to become the first free world country to purchase nationalized Iraqi crude oil. A 10-year exploration program was announced in 1971, the target being a 10-percent-per-year production increase.

Italy.—During 1971, the area covered by onshore and offshore exploration permits decreased by 7 percent. The more significant decreases were onshore in Sicily and peninsular Italy. Seismic surveying decreased in both peninsular Italy and the offshore area; exploratory drilling however, increased in the Po Valley and offshore. With the discovery of one gas well in each of these two areas and two more in the peninsular area, overall, natural gas production increased 2 percent whereas crude oil production fell 7 percent.

Provisional figures show that the petroleum market in Italy experienced a 5 percent increase in 1971 compared to a 14 percent increase the year before. The decline reflects a slowdown in overall industrial activity and a gasoline tax increase.

Japan.—As the world's leading importer of petroleum, Japan again increased its annual crude oil imports, but the 8-percent increase, which is well below the 20 percent recorded in recent years, is a reflection of the economy's declining growth. The long-promised geographical diversification of crude oil sources finally began to take place in 1971 as Libya, Nigeria, and Australia have joined the list of sources.

Under the terms of a new contract, the amount of Japanese imports of liquefied natural gas from Brunei, due to start in 1973, was increased substantially, from 3.7 million tons annually to 5.2 million tons.

Kuwait.—The year 1971 was a period of improvement and expansion of producing facilities as production in Kuwait, including its share of the former Kuwait-Saudi Arabia Neutral Zone increased 7.1 percent to more than 3.2 million barrels per day. The "all-hydrogen" Shuaiba refinery, which experienced processing difficulties for the first several years of operation, refined 10 percent above capacity in 1971. Plans were developed to increase crude oil loading capacity at the new sea island facility from 15,000 tons per hour to 35,000 tons per hour to accommodate the increased number of large tankers.

Libya.—Declining production highlighted nationalization of certain producing properties. The decline in production below allowables set by the Government reflects the declining competitive position of North African crudes because of the substantial reduction in tanker rates during the year.

In late 1971, Concession 65 (that share of Sarir oilfield produced by BP Exploration Co. (Libya), Ltd.) was nationalized as a reprisal for alleged British collusion with the Iranians when the latter occupied three small islands in the Persian Gulf.

Mexico.—Petróleos Mexicanos (Pemex) drilled 129 exploration wells in 1971, one less than in 1970, and although the number of development wells drilled declined to 287 from 393 in 1970, the results were better. Of the exploration wells, 31 were producers compared with eight the previous year. The main fields discovered were Ponton in Tampico, Terregal and Tigrillo in Reynosa, and Coyula and Tajin in Poza Rica.

Production in 1971 was virtually unchanged from that of 1970, whereas inland demand rose about 10 percent. As refining throughput rose only slightly, it was necessary to meet demand by doubling refined products imports. The major obstacle to meeting demand with domestic production is the low fixed prices for finished products which do not permit Pemex to generate profits to adequately develop Mexico's potential.

Nigeria.—Nigeria became Africa's second largest crude oil producer in 1971 and became a member of the OPEC. With production over 1.7 million barrels per day at the end of the year, Nigeria was the world's eighth largest crude oil producer. Major developments were the steadily expanding drilling of fields whose development was delayed because of the civil war and the formation of the state-owned Nigerian National Oil Co. (NNOC). The latter has achieved a considerable stake in existing and future production and has laid plans to extend its operations into natural gas processing and crude oil refining. The success or failure of the Government's expressed desire to increase its participation in oil industry operations will depend on the rate at which it wishes to achieve these goals.

Norway.—Norway's offshore Ekofisk oilfield began initial production during June 1971 at a rate of 10,000 barrels per day. Later in the year production was increased to 40,000 barrels per day. Loading is accomplished at a temporary mooring which will be replaced by permanent facilities, including a 1-million-barrel underwater storage unit scheduled for completion in 1973. The new facilities will be able to handle 300,000 barrels per day.

A major discovery was the Frigg gasfield located 125 miles west of Bergen. At yearend further evaluation drilling was under way in the five established fields. In July the Ministry of Industry released estimates of reserves at the country's five established fields at 1.5 to 2.0 billion barrels of crude oil and 6.0 billion cubic feet of natural gas.

Oman.—Declining production because of water encroachment was the keynote to operations in 1971. Production from Oman's four oilfields, including the new al-Huwaisah field, fell 11 percent to an average of 294,000 barrels per day. Because of the application of the Tehran OPEC agreement, which increased posted prices, Government petroleum revenue increased 8 percent.

Peru.—Petróleos del Perú (Petroperu), the state oil company set up in 1969 to run the oilfields and installations expropriated from International Petroleum Corp., formulated a plan during 1971 to regain the country's former self-sufficiency in crude oil. The plan involves a $36 million exploration program concentrating on the offshore areas south of Talara and in the extreme north just east of the successful Ecuadorian discoveries. Private companies have followed the Petroperu initiative. Belco Petroleum Corp. announced plans to spend $20 million during 1972–73 in building six offshore drilling platforms to drill about 60 wells in its offshore concession north of Talara. In addition Occidental Petroleum Corp. signed a 35-year contract for exploration and development of about 2 million acres of jungle south of the Ecuadorian border.

Qatar.—The principal area of concentration in 1971 was the Bul Hanine oilfield of Shell Oil Co. of Qatar (Shell). The production and gas-oil separation platform and the 20-inch pipeline to Halul Island were essentially complete at yearend. In addition Shell installed the world's largest single-point mooring buoy south of the island. It can handle tankers up to 500,000 deadweight tons.

Saudi Arabia.—Saudi Arabia crude oil production, including that from the former Kuwait-Saudi Arabia Neutral Zone, increased a phenomenal 26 percent, recording a rise of approximately 1 million barrels per day. This was possible because of the country's huge reserves (about 150 billion barrels) and the improved competitive position of Persian Gulf crudes in West European markets. During 1971 Saudi Arabia overtook Iran to become the world's third largest oil producer averaging about 4.8 million barrels per day.

Major developments by Arabian American Oil Co. (Aramco), the producer, included development drilling, increasing stabilizer and separater capacity, and expanding crude oil transportation and storage facilities. General Petroleum and Mineral Organization (Petromin), the Government company, expanded its petroleum industry activity by purchasing several tankers, gaining a partnership in exploration, expanding its refining capacity, and expanding its petroleum and natural gas distribution facilities.

Spain.—Interest in Spain's offshore Mediterranean area accelerated in 1971 following the 1970 discovery of the Amposta structure off the Ebro River delta. It was found by Shell España, Inc., operator for a consortium of companies including Spanish Government interests. Discovery of a second find, the Castellon structure near the Amposta structure, was announced in 1971. At yearend at least eight companies had entered bids to explore adjacent areas.

Trinidad and Tobago.—The decline in crude oil production which began in 1968 continued through 1971; however, it is anticipated that production may soon increase again, as Amoco Trinidad Oil Co. (Amoco) announced the discovery of a major oil and gas discovery 22 miles off the east coast of Trinidad. This new find is 11 miles north of Amoco's Point Radix field, which is planned to commence production near the end of 1972 at a rate of 50,000 barrels per day.

U.S.S.R.—The U.S.S.R. and the United States established closer ties during exploratory talks near the end of 1971. Natural gas was one sphere where cooperation could be mutually beneficial; specifically, U.S. natural gas development technology in return for U.S.S.R. LNG.

The final version of the 1971–75 5-year plan, adopted by the Supreme Soviet near the end of 1971, calls for a production of approximately 10 million barrels per day of crude oil and 31 billlion cubic feet of natural gas per day by 1975. This would equal a 33-percent increase in crude oil and a 50-percent increase in natural gas over the 1971 production levels. Earlier in the year it was announced that the Orenburg district of the Ural-Volga region will be developed into a major gas-producing area. A study by Soviet geologists revealed the potential of highly promising structures in a new region offshore from eastern Siberia which extends into North Korea and Japan.

The construction of the U.S.S.R.'s first supertanker, a 180,000-deadweight-ton vessel, began at Leningrad and is expected to be completed in 1974.

Two major pipeline projects were under construction, both originating in Western Siberia; one was a 2,850-mile pipeline to the west and the other a 3,700-mile line to the east terminating in the Vladivostok area on the Pacific Coast. The latter line, which has reached Irkutsk, would not only serve the Soviet Far East but would also be essential to any scheme for large-scale exports to Japan.

United Arab Emirates.—On July 18, 1971, six of the seven independent sheikhdoms of the former Trucial States formally federated into the United Arab Emirates. The seventh joined in early 1972. Production from Abu Dhabi increased a substantial 35 percent, averaging nearly 1 million barrels per day. In addition to expanding production facilities, time was spent evaluating the drilling results of several wildcat wells.

Dubai, which became a crude oil producer in 1969, increased its output to 125,000 barrels per day in 1971. A construction program was underway to raise production to at least 300,000 barrels per day by 1973.

United Kingdom.—During December, British Petroleum Co., Ltd., announced a $380 million first-stage development program for its new Forties oilfield 110 miles east of Scotland in the North Sea. Production from two platforms is expected to reach 250,000 barrels per day in 1975. The ultimate output of the field is estimated at 400,000 barrels per day, which would equal about 12 percent of the country's consumption in the late 1970's. By the end of 1971, the United Kingdom had three confirmed North Sea oilfields and three promising discoveries. The latest discovery, drilled by the Amoco-Gas Council group, about 15 miles southeast of the Forties field, tested 4,000 barrels per day of crude oil and 2 million cubic feet per day of natural gas.

The United Kingdom was the first European country to introduce the U.S. style of sealed bidding for 15 promising blocks near oil and gas strikes in the North Sea. The British auction brought the Government an equivalent of $90 million. At the same time the Government also opened an additional 436 blocks for allocation to prospective applicants. Under the latter system, Government officials will assign the concessions to companies judged on their proposed program, financial status, and other economic and technical factors. The Government plans to evaluate the two systems for future licensing.

Venezuela.—Other than the announcement that the capacity of the Crude Petroleum Corp. refinery at Amuay will be increased in 1972–73 to 630,000 barrels per day to become the world's largest, most developments in Venezuela involved political and legislative activities. In March 1971 the Government published new tax reference prices which increased reference prices by about $0.60 per barrel for crude oil and $0.83 per barrel for refined products. Tax reference prices (prices used to compute taxes paid by the companies) were originally authorized in December 1970 to increase the Government's share of petroleum income per barrel and to stabilize Government income.

In July an oil revision law was passed which requires the companies to cede to the state without compensation all assets when their concessions expire. These are scheduled to begin in 1983. Furthermore, the companies were required to deposit in the Central Bank an amount totaling an estimated $500 million refundable at reversion, but without tax exemption, to guarantee the maintenance of equipment and facilities at the time these became Government property.

In December 1971, the Government of Venezuela, for the second time during the year, increased tax reference prices for crude oil and refined petroleum products effective January 1, 1972. The average increase for crude was U.S. $0.32, and for refined petroleum products, $0.36. The crude oil tax reference prices vary according to the API gravity, whereas new prices of residual fuel oil (major product exported) vary according to sulfur content. The most controversial part of the new legislation is the introduction of penalties for fluctuation in exports beyond certain maximum and minimum levels. Purpose of penalties is to prevent income erosion and to maintain the present reserves-to-production ratio.

Because of the decline in Venezuela's competitive position in the world petroleum market resulting from the various legislative developments during 1971, crude oil production declined 4 percent from that of 1970.

Virgin Islands.—The St. Croix refinery of Amerada Hess Corp., expanded to 290,000 barrels per day in 1970, was further expanded in 1971 to 450,000 barrels per day. The plant now has the largest throughput capacity in North America, slightly exceeding that of the Humble Oil and Refining Co. plant at Baton Rouge, La.

Table 2.—Supply and demand of all oils in the United States, by month

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1970													
New supply:													
Domestic production:													
Crude petroleum	278,821	254,379	279,945	274,132	281,255	267,467	271,433	282,744	282,636	296,592	287,065	294,197	3,350,666
Lease condensate	15,011	13,585	14,796	13,605	13,962	13,298	13,794	13,622	12,957	13,818	14,266	14,070	166,784
Natural gas plant liquids	50,635	47,258	51,874	49,642	51,479	49,595	50,338	50,364	49,105	51,375	51,066	53,185	605,916
Imports: [1]													
Crude petroleum	43,795	41,114	46,350	35,142	37,468	41,178	39,056	36,515	40,310	36,875	37,815	47,675	483,293
Unfinished oils	3,889	3,233	3,975	2,915	3,279	2,879	2,943	2,476	3,003	2,603	2,780	5,286	39,261
Refined products	71,622	70,511	73,280	60,862	48,472	55,121	57,560	54,529	51,783	58,262	56,906	66,600	725,508
Other hydrocarbons and hydrogen refinery input	403	450	469	350	358	437	540	956	468	583	745	479	6,238
Total new supply	464,176	430,530	470,689	436,648	436,273	429,975	435,664	441,206	440,262	460,108	450,643	481,492	5,377,666
Crude petroleum unaccounted for [2]	+2,052	−1,034	+780	−255	−1,070	+377	−961	−3,074	+159	−1,650	−305	−2,740	−7,721
Processing gain	11,302	10,089	10,923	9,587	9,529	10,338	11,338	12,296	10,747	10,054	11,502	13,347	131,052
Total supply	477,530	439,585	482,392	445,980	444,732	440,690	446,041	450,428	451,168	468,512	461,840	492,099	5,500,997
Change in stocks, all oils [3]	−52,268	−20,750	−951	+17,281	+28,128	+14,979	+4,463	+11,774	+26,989	+15,650	+17,897	−25,454	+37,738
Total disposition of primary supply	529,798	460,335	483,343	428,699	416,604	425,711	441,578	438,654	424,179	452,862	443,943	517,553	5,463,259
Exports: [4]													
Crude petroleum	93	--	70	94	--	302	97	11	--	1,962	1,616	746	4,991
Refined products	6,709	7,304	7,193	7,713	7,821	7,434	8,274	6,440	8,143	7,713	6,307	8,416	89,467
Crude losses	367	335	366	348	354	356	365	372	360	367	361	377	4,328
Domestic demand for products:													
Gasoline:													
Motor gasoline	162,605	149,552	171,672	169,526	181,712	185,786	193,651	188,143	178,034	183,114	167,085	180,469	2,111,349
Aviation gasoline	1,343	1,422	1,756	1,766	1,852	1,596	1,586	2,289	1,775	1,645	1,309	1,564	19,903
Total	163,948	150,974	173,428	171,292	183,564	187,382	195,237	190,432	179,809	184,759	168,394	182,033	2,131,252
Jet fuel:													
Naphtha type	6,718	7,153	7,153	6,729	7,503	7,060	8,911	7,937	7,890	8,524	7,369	7,980	90,927
Kerosine type	22,127	21,532	21,082	20,430	20,210	22,400	22,239	23,078	23,336	21,669	21,397	22,551	262,051
Total	28,845	28,685	28,235	27,159	27,713	29,460	31,150	31,015	31,226	30,193	28,766	30,531	352,978
Ethane (including ethylene)	6,929	6,420	6,962	6,367	6,917	6,560	6,919	7,068	7,139	7,734	7,287	7,455	83,757

Liquefied gases:													
LRG [5] for fuel use	8,521	6,578	6,068	5,792	5,520	6,598	6,721	7,077	6,386	6,215	7,010	7,733	80,219
LRG [5] for chemical use	2,501	2,638	2,758	2,889	2,809	2,569	2,912	2,325	2,417	2,819	2,613	2,539	31,789
LPG [6] for fuel and chemical use	36,800	25,942	23,000	16,788	13,673	13,092	14,348	14,708	16,387	21,717	25,835	28,761	251,051
Total	47,822	35,158	31,826	25,469	22,002	22,259	23,981	24,110	25,190	30,751	35,458	39,033	363,059
Kerosine	16,624	11,732	8,937	5,363	5,045	4,311	5,023	4,848	5,535	7,481	8,728	12,347	95,974
Distillate fuel oil	127,190	96,774	95,817	74,193	60,334	52,572	50,267	52,891	58,645	69,922	78,559	110,047	927,211
Residual fuel oil	89,716	82,169	87,252	63,642	51,276	58,221	59,166	61,226	50,654	58,864	61,706	80,396	804,288
Petrochemical feedstocks: [7]													
Still gas	850	825	875	1,062	1,309	1,250	1,019	1,052	929	1,131	968	1,294	12,564
Naphtha—400°	4,488	5,372	5,068	3,756	4,891	4,489	4,884	4,884	4,708	4,849	4,670	5,220	57,279
Other	2,377	2,602	3,014	2,513	2,551	2,393	2,820	2,492	2,557	2,475	2,684	2,862	31,340
Total	7,715	8,799	8,957	7,331	8,751	8,132	8,723	8,428	8,194	8,455	8,322	9,376	101,183
Special naphthas	2,218	2,403	2,069	2,952	2,327	2,682	2,583	2,822	2,785	3,262	2,498	2,789	31,390
Lubricants	4,054	3,424	4,084	4,431	3,971	4,661	4,200	4,046	4,245	4,458	4,069	4,050	49,693
Wax	348	337	405	397	319	407	377	354	443	449	348	423	4,607
Coke	6,684	6,093	6,586	6,449	6,712	6,397	6,464	6,731	6,424	5,816	6,235	6,624	77,215
Asphalt	4,388	4,724	6,250	10,005	14,265	18,782	21,318	20,606	18,759	15,903	10,649	7,828	153,477
Road oil	241	107	192	400	910	1,309	1,879	1,739	1,329	934	429	172	9,641
Still gas	14,283	13,742	13,284	13,739	13,218	13,548	14,259	14,527	13,917	12,823	13,004	13,561	163,905
Miscellaneous products	1,624	1,155	1,430	1,355	1,105	936	1,296	988	1,382	1,016	1,207	1,349	14,843
Total domestic demand	522,629	452,696	475,714	420,544	408,429	417,619	432,842	431,831	415,676	442,820	435,659	508,014	5,364,473
Stocks, all oils:													
Crude oil and lease condensate	267,087	269,628	274,643	278,037	284,824	279,894	266,854	254,144	259,196	265,479	271,303	276,367	276,367
Unfinished oils	99,739	98,488	101,720	106,009	107,854	108,058	106,050	105,414	99,322	100,751	102,081	98,989	98,989
Natural gasoline and plant condensate [8]	5,647	5,813	6,123	6,536	7,132	7,402	7,713	7,671	7,572	6,886	6,941	7,046	7,046
Refined products	555,382	533,176	523,668	532,853	551,753	571,188	590,388	615,550	643,678	652,302	662,990	635,459	635,459
Total	927,855	907,105	906,154	923,435	951,563	966,542	971,005	982,779	1,009,768	1,025,418	1,043,315	1,017,861	1,017,861
1971 [p]													
New supply:													
Domestic production:													
Crude petroleum	285,104	259,303	288,790	279,595	285,458	275,261	280,394	279,021	262,279	271,662	261,260	268,485	3,296,612
Lease condensate	14,201	13,101	14,019	13,473	13,522	12,856	12,760	12,709	11,778	12,370	12,910	13,603	157,302
Natural gas plant liquids	52,275	48,170	52,356	50,774	52,330	49,801	51,213	52,265	50,412	52,102	50,659	55,458	617,815
Imports: [1]													
Crude petroleum	34,772	37,655	43,235	45,207	46,540	50,337	54,768	58,755	57,012	59,617	59,557	65,962	613,417
Unfinished oils	3,019	2,591	2,674	3,268	3,020	3,527	4,420	4,686	4,367	4,358	3,884	5,379	45,193
Refined products	71,881	65,478	73,046	59,125	59,368	59,142	60,575	55,188	59,395	57,950	64,926	85,937	772,011
Other hydrocarbons and hydrogen refinery input	448	343	449	478	430	532	552	443	439	732	563	665	6,074
Total new supply	461,700	426,641	474,569	451,920	460,668	451,456	464,682	463,067	445,682	458,791	453,759	495,489	5,508,424

See footnotes at end of table.

Table 2.—Supply and demand 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
Crude petroleum unaccounted for [2]	+5,053	+31	+338	+3,287	+974	+1,985	+1,901	+2,048	+1,358	−979	+336	−1,509	+14,823
Processing gain	12,793	10,881	11,252	12,753	9,939	10,655	11,183	12,975	11,792	12,010	10,728	12,472	139,433
Total supply	479,546	437,553	486,159	467,960	471,581	464,096	477,766	478,090	458,832	469,822	464,823	506,452	5,662,680
Change in stocks, all oils [3]	−37,434	−36,587	−9,435	+11,313	+40,247	+17,557	+32,450	+29,699	+17,817	+13,942	−22,226	−31,257	+26,086
Total disposition of primary supply	516,980	474,140	495,594	456,647	431,334	446,539	445,316	448,391	441,015	455,880	487,049	537,709	5,636,594
Exports: [4]													
Crude petroleum	--	2	1	313	8	--	--	--	143	36	--	--	503
Refined products	6,112	6,742	7,724	8,025	6,883	7,180	5,511	6,724	5,660	5,877	8,133	6,611	81,182
Crude losses	375	342	375	366	363	375	385	382	364	376	364	381	4,448
Domestic demand for products:													
Gasoline:													
Motor gasoline	163,173	153,369	181,003	185,948	182,974	193,543	199,393	195,184	182,067	187,032	183,414	188,179	2,195,279
Aviation gasoline	1,422	1,196	1,607	1,695	1,527	1,526	1,576	1,815	1,576	1,610	1,182	1,157	17,889
Total	164,595	154,565	182,610	187,643	184,501	195,069	200,969	196,999	183,643	188,642	184,596	189,336	2,213,168
Jet fuel:													
Naphtha type	7,070	7,159	7,650	7,640	7,616	8,103	7,608	8,445	8,726	8,141	8,206	8,369	94,733
Kerosine type	22,248	22,429	23,094	21,097	21,770	23,050	22,843	23,564	21,558	24,078	22,272	23,890	271,893
Total	29,318	29,588	30,744	28,737	29,386	31,153	30,451	32,009	30,284	32,219	30,478	32,259	366,626
Ethane (including ethylene)	6,975	6,536	6,855	6,865	7,153	7,362	7,567	7,738	7,373	7,568	7,635	8,117	87,744
Liquefied gases:													
LRG [5] for fuel use	7,791	7,575	7,545	6,980	6,449	6,986	7,527	7,588	6,270	7,118	6,956	8,304	87,089
LRG [5] for chemical use	2,247	2,351	2,663	2,684	2,659	2,792	2,998	2,676	2,595	2,781	2,869	2,837	32,152
LPG [6] for fuel and chemical use	34,567	27,269	21,151	14,799	12,900	12,174	11,472	15,459	18,802	21,917	26,741	32,515	249,766
Total	44,605	37,195	31,359	24,463	22,008	21,952	21,997	25,723	27,667	31,816	36,566	43,656	369,007
Kerosine	13,366	12,671	8,761	6,339	3,876	4,520	4,378	4,475	5,868	6,800	8,536	11,327	90,917
Distillate fuel oil	123,724	107,336	99,137	79,053	65,710	60,092	54,358	56,098	61,167	65,612	85,434	113,599	971,320
Residual fuel oil	86,464	80,728	82,564	66,857	60,022	59,501	59,590	55,725	62,177	59,834	77,162	87,245	837,869
Petrochemical feedstocks: [7]													
Still gas	1,135	1,575	1,242	1,433	1,131	1,372	1,509	1,966	1,688	1,158	984	965	16,158
Naphtha–400°	5,005	4,313	5,069	4,673	4,713	4,912	4,191	4,930	4,805	5,003	4,277	4,930	56,821
Other	2,237	2,322	2,183	3,172	3,469	2,782	3,451	2,839	3,700	3,548	3,663	4,176	37,542
Total	8,377	8,210	8,494	9,278	9,313	9,066	9,151	9,735	10,193	9,709	8,924	10,071	110,521
Special naphthas	2,401	2,384	2,946	2,160	2,504	2,372	2,501	2,276	2,686	2,526	2,406	2,619	29,781
Lubricants	3,575	3,653	4,137	4,469	4,041	4,818	4,550	4,297	3,627	4,549	3,785	3,877	49,378

Wax	315	390	520	456	457	475	347	478	485	418	512	401	5,254
Coke	6,677	6,152	6,663	6,851	5,992	6,735	7,301	7,339	5,555	7,977	6,139	6,593	79,974
Asphalt	4,830	4,861	8,084	10,364	14,045	19,904	19,440	21,884	19,283	17,159	12,246	6,428	158,528
Road oil	122	81	146	300	692	1,268	1,479	1,693	1,174	777	499	256	8,487
Still gas	13,616	11,433	13,129	12,664	13,326	13,505	14,002	13,639	12,748	12,860	12,464	13,581	156,967
Miscellaneous products	1,533	1,271	1,345	1,444	1,054	1,192	1,339	1,177	918	1,125	1,170	1,352	14,920
Total domestic demand	510,493	467,054	487,494	447,943	424,080	438,984	439,420	441,285	434,848	449,591	478,552	530,717	5,550,461
Stocks, all oils:													
Crude oil and lease condensate	269,806	266,864	267,246	271,445	284,320	279,337	273,235	272,417	269,771	265,899	265,552	259,648	259,648
Unfinished oils	94,379	90,562	90,492	98,636	100,648	102,891	103,625	100,322	99,378	103,355	103,921	100,574	100,574
Natural gasoline and plant condensate [8]	6,805	6,609	6,258	6,791	6,869	6,585	6,755	6,668	6,527	6,442	6,340	6,176	6,176
Refined products	609,437	579,805	570,409	568,846	594,128	614,709	652,357	686,264	707,812	721,734	699,391	677,549	677,549
Total	980,427	943,840	934,405	945,718	985,965	1,003,522	1,035,972	1,065,671	1,083,488	1,097,430	1,075,204	1,043,947	1,043,947

[p] Preliminary.
[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] Represents the difference between supply and indicated demand for crude petroleum.
[3] Minus represents withdrawal from stock, which is added to total disposition; plus represents stock increase, which is subtracted from total disposition.
[4] U.S. Department of Commerce data.
[5] Liquefied refinery gas.
[6] Liquefied petroleum gas.
[7] Produced at petroleum refineries. Data for LPG for petrochemical feedstocks are included with those for "Liquefied gases."
[8] Includes isopentane.

Table 3.—Estimates of proved crude-oil reserves in the United States on December 31, by State [1]

(Million barrels)

State	1967	1968	1969	1970	1971
Eastern States:					
Illinois	336	314	272	229	209
Indiana	47	40	41	37	31
Kentucky	94	80	73	61	52
Michigan	63	55	52	46	59
New York	15	13	12	11	10
Ohio	114	132	127	128	129
Pennsylvania	63	59	55	51	47
West Virginia	56	54	53	53	52
Total	788	747	685	616	589
Central and Southern States:					
Alabama	79	73	67	65	61
Arkansas	176	159	127	130	118
Kansas	625	601	566	539	502
Louisiana [2]	5,456	5,608	5,689	5,710	5,399
Mississippi	357	326	360	355	342
Nebraska	63	55	47	41	36
New Mexico	926	865	840	761	657
North Dakota	290	287	235	192	174
Oklahoma	1,459	1,395	1,390	1,351	1,405
Texas [2]	14,494	13,810	13,063	13,195	13,023
Total	23,925	23,179	22,384	22,339	21,717
Mountain States:					
Colorado	340	420	401	389	333
Montana	308	345	276	242	228
Utah	201	180	195	182	166
Wyoming	1,044	1,101	997	1,017	997
Total	1,893	2,046	1,869	1,830	1,724
Pacific Coast States:					
Alaska	381	373	432	10,149	[3] 10,116
California [2]	4,369	4,341	4,243	3,984	3,706
Total [1]	4,750	4,714	4,675	14,133	13,822
Other States [4]	21	21	19	83	211
Total United States	31,377	30,707	29,632	39,001	38,063

[1] From reports of Committee of Petroleum Reserves, American Petroleum Institute. Includes crude oil that may be extracted by present methods from fields completely developed or sufficiently explored to permit reasonably accurate calculations. The change in reserves during any year represents total new discoveries extensions, and revisions, minus production.

[2] Includes offshore reserves.

[3] This number includes the estimate of proved reserves in the Prudhoe Bay Permo-Triassic reservoir, discovered in 1968 and not previously included in this report. This estimate is based on the analysis of extensive engineering and geologic data; however, revisions may be required when actual production performance becomes available.

[4] Includes Arizona, Florida, Missouri, Nevada, South Dakota, Tennessee, and Virginia.

Table 4.—Supply and disposition of crude petroleum (including lease condensate) in the United States

(Thousand barrels)

Supply and disposition	1967	1968	1969	1970	1971 p
Supply:					
Production	3,215,742	3,329,042	3,371,751	3,517,450	3,453,914
Imports [1]	411,649	472,323	514,114	483,293	613,417
Total new supply	3,627,391	3,801,365	3,885,865	4,000,743	4,067,331
Stock changes: [2]					
Domestic crude	+7,799	+17,653	−4,668	+10,380	−23,239
Foreign crude	+2,780	+5,570	−2,298	+760	+6,520
Unaccounted for [3]	--	+7,138	−2,561	−7,721	+14,823
Disposition by use:					
Runs of domestic crude	3,174,004	3,308,044	3,363,602	3,485,332	3,481,543
Runs of foreign crude	408,590	466,316	516,003	482,171	606,266
Exports [4]	26,541	1,802	1,436	4,991	503
Transfers:					
Distillate	730	712	654	743	1,548
Residual	3,671	4,272	4,334	4,317	4,565
Losses	3,276	4,134	4,241	4,328	4,448
Total disposition by use	3,616,812	3,785,280	3,890,270	3,981,882	4,098,873

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 beginning with 1968.
[4] U.S. Department of Commerce data.

Table 5.—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
1970													
New supply:													
Production	293,832	267,964	294,741	287,737	295,217	280,765	285,227	296,366	295,593	310,410	301,331	308,267	3,517,450
Imports [1]	43,795	41,114	46,350	35,142	37,468	41,178	39,056	36,515	40,310	36,875	37,815	47,675	483,293
Total new supply	337,627	309,078	341,091	322,879	332,685	321,943	324,283	332,881	335,903	347,285	339,146	355,942	4,000,743
Change in stocks, end of period:													
Domestic crude	+2,625	+6,823	+2,640	+5,083	+5,053	−6,616	−11,559	−11,506	+4,547	+7,316	+6,088	−114	+10,380
Foreign crude	−765	−4,282	+2,375	−1,689	+1,734	+1,686	−1,481	−1,204	+505	−1,033	−264	+5,178	+760
Unaccounted for [2]	+2,052	−1,034	+780	−255	−1,070	+377	−961	−3,074	+159	−1,650	−305	−2,740	−7,721
Disposition by use:													
Runs of domestic crude	292,385	259,432	291,919	281,533	288,280	286,741	294,960	304,018	290,538	298,766	292,569	304,191	3,485,332
Runs of foreign crude	44,537	45,348	43,955	36,839	35,697	39,425	40,522	37,684	39,755	37,875	38,059	42,475	482,171
Exports [3]	93	--	70	94	--	302	97	11	--	1,962	1,616	746	4,991
Transfers:													
Distillate	59	55	67	61	55	85	46	57	65	67	68	58	743
Residual	378	333	479	355	442	341	372	375	292	315	344	291	4,317
Losses	367	335	366	348	354	356	365	372	360	367	361	377	4,328
Total disposition by use	337,819	305,503	336,856	319,230	324,828	327,250	336,362	342,517	331,010	339,352	333,017	348,138	3,981,882
1971 [p]													
New supply:													
Production	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
Imports [1]	34,772	37,655	43,235	45,207	46,540	50,337	54,768	58,755	57,012	59,617	59,557	65,962	613,417
Total new supply	334,077	310,059	346,044	338,275	345,520	338,454	347,922	350,485	331,069	343,649	333,727	348,050	4,067,331
Change in stocks, end of period:													
Domestic crude	−1,987	−4,707	−1,837	+2,420	+11,545	−4,597	−8,530	−1,631	−1,869	−6,366	+2,865	−8,545	−23,239
Foreign crude	−4,574	+1,765	+2,219	+1,779	+1,330	−386	+2,428	+813	−777	+2,494	−3,212	+2,641	+6,520
Unaccounted for [2]	+5,053	+31	+338	+3,287	+974	+1,985	+1,901	+2,048	+1,358	−979	+336	−1,509	+14,823
Disposition by use:													
Runs of domestic crude	305,620	276,397	304,104	292,953	287,682	293,854	302,703	294,498	276,284	288,419	270,829	288,200	3,481,543
Runs of foreign crude	39,316	35,869	40,974	43,269	45,117	50,651	52,304	57,907	57,750	57,097	62,732	63,280	606,266
Exports [3]	--	2	1	313	8	--	--	--	143	36	--	--	503
Transfers:													
Distillate	52	51	67	125	124	166	166	184	159	142	131	181	1,548
Residual	328	371	479	337	325	376	367	380	373	472	354	403	4,565
Losses	375	342	375	366	363	375	385	382	364	376	364	381	4,448
Total disposition by use	345,691	313,032	346,000	337,363	333,619	345,422	355,925	353,351	335,073	346,542	334,410	352,445	4,098,873

[p] Preliminary except for crude petroleum production.
[1] Bureau of Mines data.
[2] Represents the difference between supply and indicated demand for crude petroleum.
[3] U.S. Department of Commerce.

Table 6.—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
1970													
Alabama	603	550	622	602	628	598	610	617	598	620	590	625	7,263
Alaska	7,293	6,092	6,959	6,771	7,337	6,859	7,152	6,891	6,648	7,387	6,223	7,004	83,616
Arizona	179	157	165	157	158	148	150	143	137	141	127	122	1,784
Arkansas	1,517	1,382	1,507	1,475	1,500	1,443	1,548	1,547	1,494	1,543	1,504	1,575	18,035
California:													
South	14,207	12,724	13,856	13,300	13,595	12,937	13,145	13,051	12,526	12,858	12,300	12,610	157,109
Central Coastal	6,386	5,971	6,636	6,512	6,833	6,691	6,980	7,070	6,776	7,138	6,916	7,153	81,062
East Central	11,572	10,406	11,602	11,193	11,471	10,974	11,235	11,222	10,878	11,130	10,668	11,086	133,437
North	54	53	56	59	58	54	42	47	43	41	37	39	583
Total California	32,219	29,154	32,150	31,064	31,957	30,656	31,402	31,390	30,223	31,167	29,921	30,888	372,191
Colorado	2,104	1,942	2,123	2,019	2,096	2,018	2,063	2,093	2,084	1,819	2,282	2,080	24,723
Florida	186	173	183	180	203	225	259	271	280	335	340	364	2,999
Illinois	3,707	3,490	3,836	3,741	3,726	3,654	3,765	3,654	3,549	3,595	3,424	3,606	43,747
Indiana	612	576	666	601	585	649	702	644	620	628	588	616	7,487
Kansas	7,189	6,734	7,265	7,235	7,195	7,057	7,131	7,032	6,872	7,118	6,735	7,290	84,853
Kentucky	924	917	1,007	969	974	1,014	1,005	971	947	967	922	958	11,575
Louisiana:													
Gulf Coast	69,467	62,833	68,773	67,967	70,992	67,619	68,587	73,448	74,198	79,293	77,462	78,930	859,569
Rest of State	3,959	3,644	4,083	3,914	3,978	3,853	3,903	3,937	3,957	4,093	3,956	4,064	47,338
Total Louisiana	73,426	66,477	72,856	71,881	74,970	71,472	72,490	77,402	78,135	83,386	81,418	82,994	906,907
Michigan	972	905	974	979	970	962	990	978	941	1,037	982	1,003	11,693
Mississippi	5,502	4,974	5,588	5,417	5,500	5,221	5,419	5,490	5,386	5,640	5,373	5,609	65,119
Missouri	3	3	5	7	6	5	6	7	6	6	6	6	66
Montana	3,354	3,057	3,333	3,061	3,299	3,087	3,153	3,132	3,055	3,168	3,045	3,135	37,879
Nebraska	981	920	994	944	976	950	961	981	926	945	915	958	11,451
Nevada	20	11	12	14	13	10	11	12	10	11	12	13	149
New Mexico:													
Southeastern	10,326	9,551	10,510	10,115	10,357	9,833	10,108	10,030	9,569	9,919	9,504	9,675	119,497
Northwestern	792	708	781	752	732	685	669	679	673	712	715	789	8,687
Total New Mexico	11,118	10,259	11,291	10,867	11,089	10,518	10,777	10,709	10,242	10,631	10,219	10,464	128,184
New York	91	88	99	111	88	105	109	119	100	98	93	93	1,194
North Dakota	1,882	1,717	1,925	1,792	1,856	1,814	1,877	1,843	1,803	1,877	1,785	1,827	21,998
Ohio	802	807	868	880	781	834	832	777	898	797	729	859	9,864
Oklahoma	18,443	17,309	18,940	18,654	19,447	18,641	19,204	18,618	18,293	18,908	18,080	19,037	223,574
Pennsylvania	369	334	373	344	341	306	327	342	326	345	340	346	4,093
South Dakota	12	13	14	13	13	13	13	14	14	14	14	13	160
Tennessee	8	8	8	8	8	8	8	32	41	50	64	66	309
Texas:													
District 01	1,521	1,382	1,541	1,471	1,495	1,461	1,486	1,503	1,503	1,599	1,570	1,665	18,197
District 02	7,031	6,339	7,044	6,761	6,817	6,192	6,151	6,762	7,043	7,487	7,243	7,266	82,136
District 03	14,326	13,038	14,385	13,833	14,039	12,906	12,882	14,274	14,820	15,735	15,332	15,488	171,058
District 04	7,832	7,228	8,017	7,556	7,658	7,158	7,185	7,086	7,287	7,592	7,313	7,444	89,356
District 05	1,444	1,269	1,389	1,347	1,338	1,211	1,208	1,433	1,541	1,722	1,650	1,644	17,196
District 06, except East Texas	6,880	6,111	6,724	6,528	6,499	5,845	5,881	6,811	7,326	7,703	7,446	7,470	81,224
East Texas	6,014	5,420	5,997	5,764	5,678	5,092	4,952	6,027	6,532	7,232	7,027	6,940	72,675
District 07B	3,279	3,012	3,277	3,174	3,197	3,036	3,068	3,183	3,149	3,251	3,210	3,297	38,133

See footnotes at end of table.

Table 6.—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
Texas—Continued													
District 07C	3,874	3,510	3,849	3,716	3,741	3,525	3,563	3,566	3,477	3,655	3,587	3,633	43,696
District 08	25,542	23,300	25,628	24,728	25,161	23,964	24,298	25,082	24,796	25,861	25,140	25,724	299,224
District 08A	20,612	18,771	20,895	20,362	20,599	19,396	19,575	21,809	22,122	23,502	22,610	23,380	253,633
District 09	4,718	4,334	4,706	4,527	4,647	4,434	4,499	4,534	4,476	4,640	4,478	4,663	54,656
District 10	2,459	2,291	2,513	2,411	2,441	2,340	2,376	2,369	2,321	2,373	2,280	2,339	28,513
Total Texas	105,532	96,005	105,965	102,178	103,310	96,560	97,124	104,439	106,393	112,352	108,886	110,953	1,249,697
Utah	1,876	1,809	1,949	1,875	1,971	1,952	2,042	2,057	1,924	2,018	1,941	1,956	23,370
Virginia	--	--	--	--	--	--	--	--	--	--	--	1	1
West Virginia	238	243	271	274	249	266	281	248	266	278	232	278	3,124
Wyoming	12,670	11,858	12,793	13,624	13,971	13,720	13,816	13,913	13,382	13,529	13,541	13,528	160,345
Total United States:													
1970	293,832	267,964	294,741	287,737	295,217	280,765	285,227	296,366	295,593	310,410	301,331	308,267	3,517,450
1969	275,521	249,979	280,715	277,154	290,022	288,942	288,160	281,074	278,852	285,592	280,367	295,373	3,371,751
Daily average, 1970	9,478	9,570	9,508	9,591	9,523	9,359	9,201	9,560	9,853	10,013	10,044	9,944	9,637
Pennsylvania grade (included in U.S. total)	948	909	997	1,044	1,025	1,094	1,135	1,090	1,207	1,132	1,098	1,170	12,849
1971													
Alabama	628	601	658	646	663	638	659	661	653	663	674	688	7,832
Alaska	6,174	5,904	6,481	6,467	7,177	6,831	7,121	6,923	6,613	6,837	6,529	6,437	79,494
Arizona	123	106	120	108	110	103	106	103	93	83	90	91	1,236
Arkansas	1,568	1,395	1,586	1,551	1,561	1,511	1,513	1,528	1,423	1,551	1,511	1,565	18,263
California:													
South	12,456	11,113	12,332	11,940	12,251	11,867	12,146	12,017	11,546	11,923	11,478	11,836	142,905
Central Coastal	7,308	6,539	7,320	7,218	7,508	7,317	7,391	7,359	7,086	7,183	6,865	6,884	85,978
East Central	10,927	10,000	11,436	10,722	11,023	10,613	10,898	10,841	10,524	10,774	10,543	10,648	128,949
North	53	53	53	56	57	57	54	54	48	50	57	60	652
Total California	30,744	27,705	31,141	29,936	30,839	29,854	30,489	30,271	29,204	29,930	28,943	29,428	358,484
Colorado	2,094	1,950	2,242	2,311	2,062	1,784	3,107	2,362	2,196	2,275	2,580	2,428	27,391
Florida	433	399	479	506	434	406	438	434	430	439	451	498	5,347
Illinois	3,383	3,104	3,538	3,322	3,323	3,305	3,262	3,285	3,091	3,210	3,114	3,147	39,084
Indiana	552	495	592	560	560	563	563	570	543	543	552	565	6,658
Kansas	6,532	5,676	7,135	6,711	6,627	6,680	6,636	6,680	6,425	6,486	6,386	6,558	78,532
Kentucky	875	817	958	917	905	903	890	911	867	857	878	914	10,692
Louisiana:													
Gulf Coast	75,882	70,052	76,387	75,023	77,245	74,957	76,668	78,014	69,108	73,788	70,214	72,490	889,828
Rest of State	3,957	3,580	3,884	3,794	3,895	3,793	3,858	3,817	3,677	3,778	3,641	3,741	45,415
Total Louisiana	79,839	73,632	80,271	78,817	81,140	78,750	80,526	81,831	72,785	77,566	73,855	76,231	935,243
Michigan	937	881	995	976	1,033	987	984	996	1,009	1,014	1,019	1,062	11,893
Mississippi	5,539	5,057	5,647	5,542	5,576	5,313	5,410	5,444	5,222	5,222	4,964	5,130	64,066
Missouri	6	5	6	5	6	5	6	5	5	6	5	6	66
Montana	3,107	2,762	3,058	2,880	2,912	2,892	2,889	2,893	2,807	2,826	2,746	2,827	34,599
Nebraska	925	834	886	854	857	814	822	814	788	818	808	842	10,062
Nevada	7	9	12	10	11	10	8	9	9	9	10	9	113
New Mexico:													
Southeastern	9,611	8,793	9,693	9,331	9,564	9,148	9,162	9,095	8,439	9,269	8,657	8,835	109,597
Northwestern	760	728	801	738	749	714	919	904	523	394	780	805	8,815
Total New Mexico	10,371	9,521	10,494	10,069	10,313	9,862	10,081	9,999	8,962	9,663	9,437	9,640	118,412

New York	98	86	99	85	103	99	101	86	100	97	92	80	1,126
North Dakota	1,823	1,658	1,862	1,788	1,859	1,784	1,853	1,840	1,791	1,834	1,756	1,805	21,653
Ohio	753	594	750	707	656	700	654	623	689	783	679	698	8,286
Oklahoma	18,031	16,048	18,695	17,967	18,146	17,785	18,099	18,271	17,409	17,586	17,186	18,090	213,313
Pennsylvania	292	269	330	319	318	339	326	327	331	322	316	309	3,798
South Dakota	12	11	20	25	25	21	22	17	20	19	22	19	233
Tennessee	34	30	34	33	34	33	34	34	32	34	32	34	398
Texas:													
District 01	1,738	1,648	1,871	1,835	1,948	1,924	1,985	1,879	1,913	1,962	1,891	1,997	22,591
District 02	7,162	6,446	7,035	6,888	6,913	6,420	6,262	6,106	5,778	5,885	5,689	5,844	76,428
District 03	15,022	13,502	15,013	14,492	14,622	13,825	13,531	13,016	12,334	12,593	12,054	12,365	162,369
District 04	7,313	6,565	7,072	6,748	6,733	6,361	6,412	6,287	5,838	6,068	5,923	6,029	77,349
District 05	2,436	2,219	2,455	2,448	2,427	2,301	2,231	2,159	2,048	2,088	2,026	2,082	26,920
District 06, except East Texas	6,947	6,218	6,958	6,641	6,619	6,341	6,027	5,921	5,730	5,723	5,463	5,661	74,249
East Texas	6,581	5,897	6,552	6,224	6,131	5,787	5,444	5,264	5,027	5,079	4,851	5,023	67,860
District 07B	3,258	2,930	3,270	3,163	3,162	3,038	3,033	2,992	2,898	2,950	2,884	2,912	36,490
District 07C	3,835	3,541	3,898	3,702	3,722	3,526	3,520	3,544	3,400	3,521	3,437	3,554	43,200
District 08	25,180	22,933	25,433	24,382	24,866	23,907	24,212	24,179	23,345	24,162	23,323	24,036	289,958
District 08A	23,227	21,068	23,247	22,400	23,198	22,160	22,725	22,415	21,366	22,081	21,321	22,298	267,506
District 09	4,637	4,208	4,655	4,467	4,517	4,228	4,290	4,284	4,073	4,234	4,121	4,141	51,855
District 10	2,260	1,968	2,339	2,243	2,294	2,166	2,170	2,183	2,135	2,143	2,102	2,148	26,151
Total Texas	109,596	99,143	109,798	105,633	107,152	101,984	101,842	100,229	95,885	98,489	95,085	98,090	1,222,926
Utah	1,898	1,764	1,967	1,858	1,897	1,872	1,952	2,082	2,081	2,112	2,010	2,137	23,630
Virginia	--	--	--	--	--	--	--	--	--	--	--	1	1
West Virginia	235	208	265	252	263	260	245	259	257	244	226	255	2,969
Wyoming	12,696	11,740	12,690	12,213	12,418	12,029	12,516	12,243	12,337	12,514	12,214	12,504	148,114
Total United States:													
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
1970	293,832	267,964	294,741	287,737	295,217	280,765	285,227	296,366	295,593	310,410	301,331	308,267	3,517,450
Daily average, 1971	9,655.0	9,728.7	9,768.0	9,768.9	9,644.5	9,603.9	9,456.6	9,410.6	9,135.2	9,162.3	9,139.0	9,099.6	9,462.8
Pennsylvania grade (included in U.S. total)	946	866	1,066	1,024	1,029	1,056	1,012	1,017	1,119	1,105	1,067	1,091	12,398

Sources of 1971 data:

Alabama —State Oil and Gas Board of Alabama.
Alaska —Alaska Department of Natural Resources.
Arizona —Arizona Oil and Gas Conservation Commission.
Arkansas —Arkansas Oil and Gas Commission.
California —Division of Oil and Gas, California Department of Conservation.
Colorado —Colorado Oil and 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 —Geological Survey, New York State Museum and Science Service.
North Dakota—North Dakota Geological Survey.
Ohio —Division of Oil and Gas, Ohio Department of Natural Resources.
Oklahoma —Oklahoma Corporation Commission and Oklahoma Tax Commission.
Pennsylvania —Topographic and Geologic Survey, Pennsylvania Department of Environmental Resources.
South Dakota—South Dakota Geological Survey.
Tennessee —Tennessee Department of Conservation.
Texas —Oil and Gas Division, The Railroad Commission of Texas.
Utah —Utah Department of Natural Resources.
Virginia —Division of Mines and Quarries, Virginia Department of Labor and Industry.
West Virginia —Oil and Gas Division, West Virginia Department of Mines.
Wyoming —Wyoming State Oil and Gas Conservation Commission.

Table 7.—Percentage of total U.S. crude petroleum produced, by State

State	1967	1968	1969	1970	1971
Texas	34.8	34.1	34.2	35.5	35.4
Louisiana	24.1	24.6	25.0	25.8	27.1
California	11.2	11.2	11.1	10.6	10.4
Oklahoma	7.2	6.7	6.7	6.4	6.2
Wyoming	4.2	4.3	4.6	4.6	4.3
New Mexico	3.9	3.8	3.8	3.6	3.4
Alaska	.9	2.0	2.2	2.4	2.3
Kansas	3.1	2.9	2.6	2.4	2.3
Mississippi	1.8	1.7	1.9	1.9	1.9
Illinois	1.8	1.7	1.5	1.2	1.1
Montana	1.1	1.5	1.3	1.1	1.0
Colorado	1.1	1.0	.8	.7	.8
Utah	.7	.7	.7	.7	.7
North Dakota	.8	.7	.7	.6	.6
Arkansas	.7	.6	.5	.5	.5
Michigan	.4	.4	.4	.3	.3
Kentucky	.5	.4	.4	.3	.3
Nebraska	.4	.4	.4	.3	.3
Other States	1.3	1.3	1.2	1.1	1.1
Total	100.0	100.0	100.0	100.0	100.0

Table 8.—Production and reserves of crude petroleum in leading fields in the United States

(Thousand barrels)

Field [1]	State	Production 1970	Production 1971	Total since discovery [2]	Estimated reserves
Wilmington	California	81,842	72,859	1,479,185	900,500
East Texas	Texas	71,854	71,139	4,016,474	1,986,020
Kelly-Snyder	do	45,798	52,487	547,600	619,232
Wasson	do	46,078	51,210	637,298	848,790
McArthur River	Alaska	40,382	40,683	134,682	190,935
Sho-Vel-Tum	Oklahoma	23,425	36,500	901,086	243,500
Slaughter	Texas	32,005	35,515	462,676	284,485
Midway Sunset	California	32,792	33,583	1,123,340	526,417
Caillou Island	Louisiana	37,673	31,828	444,044	297,333
Timbalier Bay	do	35,443	30,988	331,223	319,519
Bay Marchand Block 2	do	32,407	30,806	335,193	446,728
Hawkins	Texas	29,122	29,054	419,316	270,946
Dos Cuadras	California	19,783	27,739	50,738	125,000
West Delta Block 30	Louisiana	23,854	26,390	240,644	156,944
Kern River	California	25,322	25,542	552,534	424,458
Tom O'Connor	Texas	22,904	23,360	392,831	154,329
Grand Isle Block 43	Louisiana	21,018	22,776	99,057	169,416
Grand Isle Block 16	do	20,721	21,681	159,813	190,469
South Pass Block 27	do	22,440	21,425	217,375	198,575
Goldsmith All	Texas	21,564	20,951	522,989	129,049
South Pass Block 24	Louisiana	22,685	20,330	321,802	384,841
Spraberry Trend	Texas	27,191	18,688	319,899	111,805
Main Pass Block 41	Louisiana	22,751	18,469	102,203	202,061
Hastings, East and West	Texas	16,850	17,191	430,818	190,476
Vacuum	New Mexico	16,673	17,030	209,360	82,970
West Ranch	Texas	17,972	17,009	230,106	143,003
Huntington Beach	California	16,386	16,249	862,321	107,880
Webster	Texas	15,597	16,206	346,596	96,125
Garden Island Bay	Louisiana	18,816	16,096	143,410	153,904
West Delta Block 73	do	17,256	15,987	94,957	144,013
Cote Blanche Bay West	do	10,533	15,658	115,694	78,870
Sooner Trend	Oklahoma	17,624	15,240	150,464	97,136
Elk Basin	Montana, Wyoming	13,062	14,380	404,075	90,116
Fairway	Texas	13,812	14,271	74,734	120,881
Panhandle	do	16,237	14,235	1,244,889	170,765
Cogdell Area	do	13,575	14,235	158,001	77,908
Cowden South (Foster, Johnson)	do	12,681	14,198	267,100	70,802
Timbalier South Block 135	Louisiana	18,384	13,578	101,337	166,422
Yates	Texas	12,809	13,359	551,987	1,048,175
Conroe	do	12,875	12,994	479,474	119,775
Thompson (all fields)	do	12,612	12,885	322,437	127,150
Main Pass Block 69	Louisiana	11,322	12,775	161,038	137,571
Van and Van Shallow	Texas	11,906	12,337	370,364	80,463
Golden Trend	Oklahoma	12,770	12,330	372,124	123,026
Oregon Basin	Wyoming	13,758	12,260	205,122	82,740
Salt Creek	do	11,593	11,750	499,239	77,074
Swanson River	Alaska	12,476	11,709	125,839	80,871
Dune	Texas	10,929	11,425	98,074	51,154
Hilight	Wyoming	12,402	11,300	26,443	108,700
Middle Ground Shoal	Alaska	12,792	11,277	58,685	125,931
Lake Washington	Louisiana	12,651	10,913	176,216	114,284
La Fitte	do	11,936	10,877	189,464	99,623

See footnotes at end of table.

Table 8.—Production and reserves of crude petroleum in leading fields in the United States—Continued

(Thousand barrels)

Field [1]	State	Production 1970	Production 1971	Total since discovery [2]	Estimated reserves
Ventura	California	9,905	10,188	760,716	50,853
Ward-Estes North	Texas	12,629	10,184	287,935	89,885
Weeks Island	Louisiana	9,445	10,183	172,966	64,431
Rangely	Colorado	10,413	10,040	460,110	143,391
Ship Shoal Block 208	Louisiana	13,301	10,038	52,100	120,820
San Ardo	California	10,384	9,939	237,885	90,061
Black Bay West	Louisiana	(3)	9,892	67,501	82,117
Cowden North	Texas	9,428	9,782	237,927	75,214
Levelland	do	9,743	9,746	198,850	150,254
West Bay	Louisiana	9,810	9,563	152,915	56,093
Empire Abo	New Mexico	9,162	9,520	79,171	80,480
Baxterville	Mississippi	6,139	9,300	142,628	57,372
Salt Creek	Texas	9,345	9,271	88,566	70,729
Belridge South	California	9,107	9,211	168,971	90,789
Seminole All	Texas	8,284	9,125	172,698	140,875
Anahuac	do	7,950	9,052	213,051	80,948
McElroy	do	8,510	9,015	276,602	80,985
Cote Blanche Island	Louisiana	7,867	8,797	58,030	63,482
Beverly Hills	California	9,886	8,400	63,588	47,952
Keystone	Texas	9,465	8,322	255,536	61,678
Means All	do	7,568	7,921	124,021	71,185
Coalinga	California	8,112	7,866	611,732	67,134
Bay St. Elaine	Louisiana	7,642	7,775	125,302	54,601
Greater Aneth	Utah	8,460	7,660	236,190	77,340
Lake Barre	Louisiana	8,741	7,592	154,105	91,709
Dollarhide	Texas	8,041	7,592	131,579	62,408
Diamond M	do	8,093	7,373	174,779	97,627
Quarantine Bay	Louisiana	9,813	7,117	138,052	67,883

[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 9.—Well completions in the United States, by quarter [1]

	1st quarter	2d quarter	3d quarter	4th quarter	Total Number	Total Percent
1970:						
Oil	3,282	3,124	3,298	3,316	13,020	46.3
Gas [2]	902	936	920	1,082	3,840	13.7
Dry	2,677	2,440	2,742	3,401	11,260	40.0
Total	6,861	6,500	6,960	7,799	28,120	100.0
1971:						
Oil	2,972	2,851	2,769	3,266	11,858	45.9
Gas [2]	937	858	902	1,133	3,830	14.8
Dry	2,257	2,260	2,563	3,083	10,163	39.3
Total	6,166	5,969	6,234	7,482	25,851	100.0

[1] Excludes service wells.
[2] Includes condensate wells.
Note.—Data by quarters adjusted to agree with annual totals.
Source: American Petroleum Institute.

Table 10.—Well completions in the United States, by State and district [1]

State and district	1970				1971			
	Oil	Gas [2]	Dry	Total	Oil	Gas [2]	Dry	Total
Alabama	7	5	33	45	8	6	48	62
Alaska	67	5	40	112	27	1	4	32
Arizona	1	--	11	12	--	2	6	8
Arkansas	100	36	171	307	127	29	186	342
California	1,697	56	331	2,084	1,459	60	286	1,805
Colorado	142	47	521	710	154	148	635	937
Florida	14	--	11	25	8	--	13	21
Georgia	--	--	4	4	--	--	2	2
Illinois	311	5	381	697	252	16	296	564
Indiana	93	4	190	287	81	2	132	215
Iowa	--	--	3	3	--	--	1	1
Kansas	1,044	108	1,269	2,421	1,099	112	1,138	2,349
Kentucky	275	111	423	809	244	135	382	761
Louisiana:								
North	263	157	343	763	390	237	365	992
South	497	232	618	1,347	398	200	544	1,142
Offshore	382	150	306	838	258	184	359	801
Total Louisiana	1,142	539	1,267	2,948	1,046	621	1,268	2,935
Michigan	49	19	215	283	81	33	188	302
Mississippi	211	12	333	556	175	13	298	486
Missouri	10	--	4	14	6	1	6	13
Montana	64	74	465	603	45	33	349	427
Nebraska	39	2	196	237	47	1	139	187
Nevada	--	--	10	10	--	--	13	13
New Mexico:								
West	60	127	42	229	44	139	79	262
East	281	32	186	499	357	47	150	554
Total New Mexico	341	159	228	728	401	186	229	816
New York	69	17	13	99	83	7	10	100
North Carolina	--	--	--	--	--	--	12	12
North Dakota	48	1	118	167	49	1	109	159
Ohio	503	683	164	1,350	391	608	158	1,157
Oklahoma	1,343	321	1,021	2,685	1,174	238	843	2,255
Pennsylvania	441	250	32	723	394	199	48	641
South Dakota	--	--	83	83	2	--	33	35
Tennessee	24	4	22	50	57	23	115	195
Texas:								
District 01	281	18	226	525	430	16	196	642
District 02	83	70	211	364	70	102	175	347
District 03	338	124	373	835	311	133	334	778
District 04	250	197	355	802	172	166	298	636
District 05	23	15	92	130	27	24	92	143
District 06	169	38	132	339	201	36	131	368
District 07B	471	39	432	942	417	52	438	907
District 07C	160	85	169	414	202	90	170	462
District 08	865	75	238	1,178	961	85	169	1,215
District 08A	878	4	164	1,046	510	2	153	665
District 09	519	17	308	844	503	26	338	867
District 10	96	74	73	243	76	68	53	197
Offshore	4	18	38	60	--	10	34	44
Total Texas	4,137	774	2,811	7,722	3,880	810	2,581	7,271
Utah	29	10	44	83	30	6	51	87
West Virginia	192	553	119	864	133	496	139	768
Wyoming	627	45	727	1,399	405	43	445	893
Total United States	13,020	3,840	11,260	28,120	11,858	3,830	10,163	25,851

[1] Excludes service wells.
[2] Includes condensate wells.
Source: American Petroleum Institute.

Table 11.—Producing oil wells in the United States and average production per well per day, by State

State	Producing oil wells 1970: Approximate number of oil wells producing Dec. 31	1970: Average production per well per day (barrels) [1]	1971: Approximate number of oil wells producing Dec. 31	1971: Average production per well per day (barrels) [1]
Alabama	562	35.8	556	38.4
Alaska	202	1,190.1	173	1,161.6
Arizona	28	171.5	30	116.8
Arkansas	7,082	7.5	7,110	7.1
California:				
South	10,717	39.3	10,513	36.9
Central Coastal	5,480	40.5	5,376	43.4
East Central	24,181	15.1	23,721	14.8
North	59	26.8	58	30.5
Total California	40,437	25.0	39,668	24.5
Colorado	1,770	37.8	1,785	42.2
Illinois	26,134	4.5	25,361	4.2
Indiana	[2] 4,055	5.0	[2] 3,605	4.8
Kansas	43,490	5.3	42,180	5.0
Kentucky	[2] 11,659	2.7	14,657	2.2
Louisiana:				
Gulf Coast	[2] 14,944	153.5	[2] 13,988	168.5
Northern	12,990	9.7	12,841	9.6
Total Louisiana	[2] 27,934	86.7	[2] 26,829	93.6
Michigan	4,311	7.8	4,046	7.8
Mississippi	3,102	63.2	3,109	56.5
Montana	3,243	31.6	3,145	29.7
Nebraska	1,244	24.6	1,191	22.6
New Mexico:				
Southeastern	15,751	20.9	15,679	19.1
Northwestern	1,563	15.2	1,531	15.6
Total New Mexico	17,314	20.4	17,210	18.8
New York	5,861	.6	5,860	.5
North Dakota	1,457	35.0	1,466	40.6
Ohio	[2] 15,860	1.7	14,771	1.5
Oklahoma	78,019	7.7	75,572	7.6
Pennsylvania	36,801	.3	34,029	.3
South Dakota	26	16.9	33	21.6
Texas:				
District 01	10,572	4.7	10,553	5.9
District 02	5,367	40.7	5,144	39.8
District 03	11,442	39.7	11,071	39.5
District 04	8,754	27.2	8,254	24.9
District 05	2,990	15.5	3,024	24.5
District 06, except East Texas	5,722	38.1	5,581	36.0
East Texas	14,970	13.1	14,516	12.6
District 07B	12,258	8.2	11,566	8.4
District 07C	7,846	15.0	7,510	15.4
District 08	36,964	21.8	36,564	21.6
District 08A	17,648	39.3	17,189	42.1
District 09	29,468	5.0	28,938	4.9
District 10	13,220	5.8	12,786	5.5
Total Texas	177,221	19.0	172,696	19.2
Utah	889	73.9	870	73.6
West Virginia	[2] 12,750	.7	[2] 12,112	.7
Wyoming	[2] 9,280	48.1	8,952	44.5
Other States:				
Florida	60	156.5	78	212.3
Missouri	126	1.2	139	1.4
Nevada	9	40.8	6	41.3
Tennessee	[2] 59	18.0	78	15.9
Virginia	[2] 5	.5	1	.9
Total	259	37.2	302	57.9
Total United States	530,990	18.0	517,318	18.1

[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.

Table 12.—Daily average demand for crude petroleum (including lease condensate) in the United States, by State of origin and month

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1970													
Alabama	17.2	16.4	27.5	15.2	24.1	17.6	14.1	25.4	21.5	12.5	22.2	14.5	19.0
Alaska	241.1	238.3	255.4	216.4	246.0	248.8	172.7	240.9	242.8	229.3	215.1	169.8	226.2
Arizona	4.4	5.8	5.6	5.0	3.5	6.8	5.1	4.7	4.5	4.5	5.9	3.1	4.9
Arkansas	48.2	47.9	49.9	51.4	51.3	47.4	51.0	50.1	51.4	46.3	48.9	51.2	49.6
California	1,019.3	1,000.9	926.6	1,069.2	997.2	1,074.6	1,143.3	1,075.9	1,072.9	1,032.4	917.6	1,103.0	1,036.4
Colorado	73.0	66.1	67.8	58.2	55.6	89.1	79.2	72.7	74.4	64.5	60.8	71.5	69.4
Florida	8.6	3.3	4.3	6.7	7.2	12.1	4.6	8.9	10.1	7.7	15.3	7.1	8.0
Illinois	131.9	118.3	130.9	97.5	133.0	111.8	128.9	131.6	106.8	120.0	122.3	126.0	121.7
Indiana	23.8	17.8	21.6	18.7	19.7	22.6	24.9	19.7	17.9	20.0	16.4	20.0	20.3
Kansas	238.0	196.8	229.7	244.8	213.1	261.8	232.3	247.6	241.5	239.3	202.1	217.4	230.6
Kentucky	27.1	24.1	35.7	30.2	34.1	25.5	38.2	37.7	27.0	31.8	29.6	29.5	31.0
Louisiana	2,405.1	2,325.4	2,359.4	2,320.7	2,353.0	2,464.0	2,393.2	2,453.5	2,480.9	2,652.4	2,775.0	2,715.0	2,475.6
Michigan	32.4	29.4	33.3	28.8	33.1	32.4	31.0	31.7	30.8	32.9	36.1	35.0	32.3
Mississippi	170.4	174.0	166.8	190.5	176.7	191.3	180.1	181.2	176.2	183.3	176.6	193.6	180.1
Missouri	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Montana	115.5	111.0	103.3	108.6	91.2	96.3	100.5	123.0	100.4	119.6	86.8	81.4	103.1
Nebraska	22.5	26.8	44.2	30.4	40.1	30.9	30.7	34.9	31.3	38.6	22.9	30.0	32.0
Nevada	.6	.5	.4	.4	.4	.4	.3	.4	.3	.4	.4	.4	.4
New Mexico	329.5	393.1	357.9	351.1	334.7	375.7	350.7	351.8	350.6	350.0	342.8	312.2	349.6
New York	2.9	3.1	3.2	3.7	2.8	3.5	3.5	3.8	3.3	3.2	3.1	3.0	3.3
North Dakota	63.0	59.8	60.9	61.0	57.1	58.8	54.6	58.3	63.0	59.3	72.0	58.7	60.5
Ohio	27.7	30.7	27.4	28.9	22.2	25.2	23.2	24.7	27.9	22.6	22.1	29.5	26.0
Oklahoma	631.3	612.7	625.3	578.8	632.6	590.8	627.2	637.0	653.1	592.3	581.8	609.0	614.5
Pennsylvania	15.3	10.3	15.0	12.7	13.2	11.8	13.3	10.8	9.9	12.0	12.3	10.3	12.3
South Dakota	.4	.5	.5	.5	.4	.4	.4	.5	.5	.5	.5	.4	.4
Tennessee	.3	.3	.3	.3	.3	.3	.3	1.0	1.4	1.6	2.1	2.1	.8
Texas	3,280.3	3,330.8	3,390.7	3,401.4	3,322.4	3,252.8	3,286.1	3,528.7	3,342.4	3,398.8	3,539.4	3,615.0	3,391.3
Utah	62.7	61.3	59.3	70.4	64.6	62.1	65.5	64.6	65.1	65.2	64.2	67.5	64.4
Virginia	--	--	--	--	--	--	--	--	--	--	--	.0	.0
West Virginia	12.6	11.8	12.2	7.8	7.7	8.6	6.0	7.6	9.4	8.6	9.9	10.3	9.4
Wyoming	388.6	409.2	407.3	412.3	422.6	455.8	512.6	502.5	484.0	427.4	437.0	361.1	435.1
Total domestic crude	9,393.8	9,326.5	9,422.6	9,421.8	9,360.1	9,579.4	9,573.7	9,931.4	9,701.5	9,777.2	9,841.4	9,947.8	9,608.4
Foreign crude	1,437.4	1,621.3	1,418.5	1,227.7	1,152.7	1,316.4	1,307.7	1,216.7	1,326.8	1,222.8	1,269.3	1,370.9	1,322.0
Grand total 1970	10,831.2	10,947.8	10,841.1	10,649.5	10,512.8	10,895.8	10,881.4	11,148.1	11,028.3	11,000.0	11,110.7	11,318.7	10,930.4
Pennsylvania grade (included in total domestic crude above)	40.5	33.0	38.3	34.6	32.0	34.5	36.5	33.5	38.1	33.2	38.4	39.9	36.2

1971													
Alabama	20.4	16.4	20.1	19.4	32.7	20.3	27.5	18.2	7.1	29.5	31.8	9.5	21.1
Alaska	274.5	179.0	245.9	212.8	185.6	271.8	218.5	246.9	208.6	234.9	230.0	180.9	224.4
Arizona	4.5	4.1	3.6	3.8	3.6	3.4	3.5	2.6	3.0	3.1	2.9	2.7	3.4
Arkansas	50.4	52.1	50.5	51.5	45.2	52.2	49.9	49.6	49.1	40.2	52.9	51.6	49.6
California	949.3	1,018.8	967.6	973.9	990.9	980.7	1,015.1	957.2	912.8	978.4	917.6	1,013.7	972.9
Colorado	71.2	67.9	74.1	70.5	46.6	69.4	95.2	90.8	59.9	76.8	79.1	88.2	74.2
Florida	13.4	16.3	11.4	15.0	14.9	21.5	15.3	16.5	11.8	17.8	14.0	9.8	14.8
Illinois	109.1	105.4	108.1	131.8	87.6	115.1	105.5	111.2	108.9	97.7	71.4	112.2	105.3
Indiana	20.1	18.0	19.3	20.6	14.8	19.2	22.3	17.3	15.2	19.3	18.3	18.3	18.6
Kansas	210.0	205.4	230.7	213.1	175.8	241.5	222.8	229.6	232.2	214.2	193.4	197.3	213.8
Kentucky	26.9	33.0	30.0	24.1	32.4	28.0	32.6	27.3	29.3	25.0	26.8	30.0	28.8
Louisiana	2,603.4	2,620.3	2,651.8	2,595.9	2,500.4	2,690.8	2,648.2	2,608.8	2,463.4	2,515.6	2,457.1	2,573.8	2,577.4
Michigan	29.6	32.8	29.2	30.2	34.4	32.5	29.4	33.0	30.5	32.4	35.6	39.8	32.5
Mississippi	179.3	175.4	185.9	179.8	166.3	180.5	185.5	189.6	173.7	157.2	174.7	175.9	177.0
Missouri	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Montana	117.9	111.6	95.2	109.5	75.8	100.9	99.2	90.0	103.0	86.5	100.1	91.6	98.3
Nebraska	28.2	36.5	28.5	28.0	19.8	25.6	31.2	27.9	26.0	23.2	26.2	27.3	27.3
Nevada	.2	.4	.4	.4	.4	.3	.3	.3	.3	.3	.1	.5	.3
New Mexico	363.0	360.6	314.5	336.1	298.1	343.3	328.1	321.4	293.0	338.5	317.8	286.9	324.8
New York	3.2	3.1	3.2	2.8	3.3	3.3	3.2	2.8	3.3	3.1	3.1	2.6	3.1
North Dakota	62.5	55.0	59.2	56.1	56.6	63.8	60.1	42.7	75.4	68.9	58.5	57.8	59.7
Ohio	26.5	21.5	23.7	20.8	20.6	26.2	21.2	17.6	21.8	22.7	23.1	21.7	22.3
Oklahoma	596.4	603.3	590.3	606.4	576.8	561.2	612.4	611.6	591.2	574.9	576.1	569.4	589.1
Pennsylvania	9.6	11.6	12.2	7.4	11.6	10.5	10.0	11.0	11.2	12.1	10.7	8.3	10.5
South Dakota	.4	.4	.6	.8	.8	.7	.7	.5	.7	.6	.7	.6	.6
Tennessee	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1
Texas	3,498.4	3,687.5	3,593.9	3,503.2	3,463.4	3,391.2	3,370.8	3,224.5	3,262.2	3,306.2	3,150.4	3,334.3	3,397.3
Utah	63.9	59.3	60.8	71.6	51.7	66.7	68.5	57.6	69.1	81.7	68.0	60.5	64.9
Virginia	--	--	--	--	--	--	--	--	--	--	--	.0	.0
West Virginia	12.1	8.9	8.0	7.3	9.1	9.0	8.3	6.8	7.8	9.2	6.0	9.4	8.5
Wyoming	373.4	390.9	407.3	394.2	351.6	426.2	445.1	448.7	425.6	396.4	395.8	399.4	404.6
Total domestic crude	9,719.1	9,896.8	9,827.3	9,688.3	9,272.1	9,757.1	9,731.7	9,463.3	9,197.5	9,367.7	9,043.5	9,375.3	9,526.4
Foreign crude	1,269.2	1,281.8	1,323.1	1,447.6	1,458.4	1,690.8	1,688.4	1,869.1	1,926.3	1,842.7	2,092.3	2,042.6	1,662.7
Grand total 1971	10,988.3	11,178.6	11,150.4	11,135.9	10.730.5	11,447.9	11,420.1	11,332.4	11,123.8	11,210.4	11,135.8	11,417.9	11,189.1
Pennsylvania grade (included in total domestic crude above)	57.9	12.8	35.3	26.5	34.4	36.9	31.1	30.5	35.9	36.5	35.0	34.7	34.1

Table 13.—Indicated demand for crude petroleum (including lease condensate) in the United States, by State of origin and month

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1970													
Alabama	534	459	853	457	747	529	438	786	646	387	665	449	6,950
Alaska	7,474	6,672	7,920	6,492	7,625	7,463	5,355	7,467	7,284	7,109	6,454	5,264	82,579
Arizona	137	163	175	150	110	204	157	146	136	140	177	97	1,792
Arkansas	1,495	1,341	1,548	1,542	1,589	1,421	1,581	1,554	1,542	1,436	1,467	1,588	18,104
California	31,597	28,026	28,724	32,077	30,913	32,238	35,443	33,353	32,186	32,003	27,527	34,192	378,279
Colorado	2,262	1,852	2,102	1,746	1,723	2,672	2,454	2,255	2,232	2,001	1,823	2,216	25,338
Florida	265	91	132	200	225	361	144	275	303	239	459	221	2,915
Illinois	4,089	3,312	4,059	2,924	4,123	3,354	3,996	4,078	3,203	3,720	3,669	3,906	44,433
Indiana	739	498	671	562	612	679	773	609	537	621	492	619	7,412
Kansas	7,378	5,511	7,122	7,345	6,605	7,854	7,200	7,674	7,244	7,418	6,064	6,738	84,153
Kentucky	841	675	1,107	907	1,058	766	1,183	1,167	809	985	887	916	11,301
Louisiana	74,558	65,110	73,140	69,621	72,943	73,920	74,188	76,058	74,428	82,224	83,252	84,166	903,608
Michigan	1,005	824	1,033	863	1,026	972	961	982	924	1,021	1,082	1,085	11,778
Mississippi	5,282	4,871	5,172	5,716	5,478	5,740	5,583	5,618	5,287	5,681	5,297	6,001	65,726
Missouri	3	3	5	7	6	5	6	7	6	6	6	6	66
Montana	3,580	3,107	3,203	3,259	2,826	2,888	3,115	3,814	3,013	3,707	2,603	2,523	37,638
Nebraska	696	751	1,369	911	1,242	927	952	1,083	938	1,197	688	930	11,684
Nevada	19	13	13	12	13	11	9	13	10	12	11	12	148
New Mexico	10,215	11,008	11,094	10,534	10,375	11,272	10,871	10,907	10,518	10,851	10,285	9,677	127,607
New York	91	88	99	111	88	105	109	119	100	98	93	93	1,194
North Dakota	1,952	1,674	1,889	1,831	1,770	1,764	1,693	1,806	1,890	1,840	2,161	1,821	22,091
Ohio	859	860	848	867	688	755	718	767	838	701	663	916	9,480
Oklahoma	19,571	17,156	19,383	17,363	19,611	17,724	19,445	19,748	19,594	18,361	17,455	18,878	224,289
Pennsylvania	475	287	464	381	409	354	411	336	297	372	368	319	4,473
South Dakota	12	13	14	13	13	13	13	14	14	14	14	13	160
Tennessee	8	8	8	8	8	8	8	32	41	50	64	66	309
Texas	101,690	93,262	105,112	102,041	102,994	97,585	101,870	109,388	100,272	105,364	106,182	112,064	1,237,824
Utah	1,943	1,716	1,837	2,112	2,003	1,864	2,032	2,003	1,953	2,022	1,926	2,091	23,502
Virginia	--	--	--	--	--	--	--	--	--	--	--	1	1
West Virginia	392	331	378	232	239	259	187	236	282	266	297	319	3,418
Wyoming	12,045	11,459	12,627	12,370	13,102	13,674	15,891	15,577	14,519	13,248	13,112	11,194	158,818
Total domestic crude	291,207	261,141	292,101	282,654	290,164	287,381	296,786	307,872	291,046	303,094	295,243	308,381	3,507,070
Foreign crude	44,560	45,396	43,975	36,831	35,734	39,492	40,537	37,719	39,805	37,908	38,079	42,497	482,533
Grand total 1970	335,767	306,537	336,076	319,485	325,898	326,873	337,323	345,591	330,851	341,002	333,322	350,878	3,989,603
Daily average:													
Domestic crude	9,394	9,327	9,423	9,422	9,360	9,579	9,574	9,931	9,701	9,777	9,842	9,948	9,608
Domestic and foreign crude	10,831	10,948	10,841	10,650	10,513	10,896	10,881	11,148	11,028	11,000	11,111	11,319	10,930
Pennsylvania grade (included in total domestic above)	1,256	924	1,186	1,039	993	1,034	1,130	1,040	1,182	1,030	1,151	1,238	13,203

1971													
Alabama	631	458	623	581	1,013	608	853	564	212	916	953	296	7,708
Alaska	8,510	5,013	7,622	6,384	5,754	8,153	6,773	7,653	6,260	7,283	6,900	5,608	81,913
Arizona	138	115	112	115	112	101	107	80	90	96	86	83	1,235
Arkansas	1,562	1,460	1,566	1,545	1,401	1,566	1,546	1,538	1,473	1,247	1,586	1,601	18,091
California	29,428	28,528	29,995	29,218	30,719	29,421	31,469	29,673	27,384	30,330	27,529	31,424	355,118
Colorado	2,208	1,902	2,296	2,115	1,445	2,081	2,951	2,814	1,798	2,382	2,374	2,734	27,100
Florida	415	456	353	449	462	645	475	512	353	551	420	304	5,395
Illinois	3,383	2,952	3,352	3,954	2,717	3,452	3,270	3,446	3,268	3,028	2,142	3,479	38,443
Indiana	622	505	599	617	458	577	692	535	456	599	550	567	6,777
Kansas	6,511	5,750	7,153	6,394	5,450	7,245	6,906	7,118	6,968	6,640	5,803	6,115	78,053
Kentucky	834	923	931	722	1,004	841	1,010	845	878	775	803	931	10,497
Louisiana	80,705	73,367	82,207	77,876	77,513	80,725	82,094	80,872	73,903	77,983	73,712	79,788	940,745
Michigan	919	919	905	906	1,066	976	911	1,023	916	1,003	1,069	1,233	11,846
Mississippi	5,557	4,912	5,764	5,395	5,156	5,414	5,752	5,878	5,210	4,874	5,243	5,454	64,609
Missouri	6	5	6	5	6	5	6	5	5	6	5	6	66
Montana	3,656	3,126	2,950	3,285	2,351	3,027	3,075	2,791	3,089	2,681	3,004	2,840	35,875
Nebraska	875	1,022	882	839	615	769	964	865	781	716	786	845	9,959
Nevada	5	12	12	11	11	10	8	9	10	9	3	15	115
New Mexico	11,254	10,096	9,749	10,083	9,240	10,300	10,170	9,964	8,790	10,494	9,534	8,894	118,568
New York	98	86	99	85	103	99	101	86	100	97	92	80	1,126
North Dakota	1,939	1,540	1,835	1,684	1,753	1,915	1,863	1,325	2,261	2,137	1,755	1,792	21,799
Ohio	821	601	736	623	637	787	661	546	655	702	693	671	8,133
Oklahoma	18,490	16,893	18,298	18,193	17,881	16,835	18,985	18,961	17,735	17,822	17,284	17,652	215,029
Pennsylvania	297	325	378	223	359	316	311	341	336	376	321	257	3,840
South Dakota	12	11	20	25	25	21	22	17	20	19	22	19	233
Tennessee	34	30	34	33	34	33	34	34	32	34	32	34	398
Texas	108,452	103,251	111,411	105,096	107,366	101,736	104,494	99,959	97,866	102,492	94,511	103,364	1,239,998
Utah	1,982	1,659	1,885	2,148	1,602	2,000	2,123	1,787	2,072	2,532	2,040	1,874	23,704
Virginia	--	--	--	--	--	--	--	--	--	--	--	1	1
West Virginia	374	249	247	218	283	270	259	212	235	285	179	292	3,103
Wyoming	11,574	10,945	12,626	11,826	10,899	12,786	13,799	13,908	12,770	12,289	11,874	12,380	147,676
Total domestic crude	301,292	277,111	304,646	290,648	287,435	292,714	301,684	293,361	275,926	290,398	271,305	290,633	3,477,153
Foreign crude	39,346	35,890	41,016	43,428	45,210	50,723	52,340	57,942	57,789	57,123	62,769	63,321	606,897
Grand total 1971	340,638	313,001	345,662	334,076	332,645	343,437	354,024	351,303	333,715	347,521	334,074	353,954	4,084,050
Daily average:													
Domestic crude	9,719.1	9,896.8	9,827.3	9,688.3	9,272.1	9,757.1	9,731.7	9,463.3	9,197.5	9,367.7	9,043.5	9,375.3	9,526.4
Domestic and foreign crude	10,988.3	11,178.6	11,150.4	11,135.9	10,730.5	11,447.9	11,420.1	11,332.4	11,123.8	11,210.4	11,135.8	11,417.9	11,189.1
Pennsylvania grade (included in total domestic above)	1,795	357	1,093	795	1,067	1,108	964	945	1,077	1,131	1,051	1,076	12,459

Table 14.—Refinery receipts of domestic

(Thousand

Location of refineries receiving crude oil	Total receipts of domestic crude oil	Intra-state receipts	Interstate receipts from— PAD dist. I, total	PAD district II: Ill., Ind., Mich.	Kans.	Ky., Ohio, Tenn.	Nebr., N. Dak., S. Dak.	Okla.	Total
District I:									
Delaware, Maryland	8,240	--	4,133	--	--	--	--	--	--
Florida, Georgia, Virginia	2,425	--	--	--	--	--	--	--	--
New Jersey	88,505	--	1,057	--	--	--	--	--	--
New York	--	--	--	--	--	--	--	--	--
Pennsylvania:									
East	112,624	--	--	--	--	--	--	--	--
West	16,416	4,386	3,453	279	--	4,272	--	1,475	6,026
West Virginia	3,143	1,671	--	--	--	1,472	--	--	1,472
Total	231,353	6,057	8,643	279	--	5,744	--	1,475	7,498
District II:									
Illinois	275,704	18,037	--	--	3,049	--	1,114	27,190	31,353
Indiana	168,537	6,648	--	729	8,497	--	4,802	32,906	46,934
Kansas	130,490	75,048	--	--	--	--	279	19,837	20,116
Kentucky, Tennessee	66,248	4,339	12	12,527	--	97	--	--	12,624
Michigan	38,228	10,847	--	832	--	--	5	--	837
Minnesota, Wisconsin	5,673	--	--	--	--	--	4,319	--	4,319
Missouri, Nebraska	31,435	--	--	--	1,945	--	423	2,704	5,072
North Dakota	17,290	16,204	--	--	--	--	--	--	--
Ohio:									
East	19,518	2,102	--	1,213	--	--	--	--	1,213
West	123,248	34	--	12,946	--	--	10	237	13,193
Oklahoma	165,144	110,218	--	--	3,160	--	--	--	3,160
Total	1,041,515	243,477	12	28,247	16,651	97	10,952	82,874	138,821
District III:									
Alabama	9,174	1,368	14	--	--	--	--	--	--
Arkansas	29,241	15,614	--	--	--	--	--	--	--
Louisiana	432,041	361,703	--	--	--	--	--	7	7
Mississippi	82,817	12,228	--	--	--	--	--	--	--
New Mexico	15,666	15,666	--	--	--	--	--	--	--
Texas	1,046,490	796,387	--	--	12	--	--	679	691
Total	1,615,429	1,202,966	14	--	12	--	--	686	698
District IV:									
Colorado	14,558	2,148	--	--	--	--	--	--	--
Montana	26,756	11,972	--	--	--	--	--	--	--
Utah	42,084	13,272	--	--	--	--	--	--	--
Wyoming	47,598	46,691	--	--	--	--	2	--	2
Total	130,996	74,083	--	--	--	--	2	--	2
District V:									
California	427,831	358,079	--	--	--	--	--	--	--
Other States	20,775	15,499	--	--	--	--	--	--	--
Total	448,606	373,578	--	--	--	--	--	--	--
Total United States	3,467,899	1,900,161	[1] 8,669	28,526	16,663	5,841	10,954	85,035	147,019
Daily average	9,501	5,206	24	78	46	16	30	233	403

[1] Florida, 5,204; New York, 1,337; West Virginia, 2,128.
[2] Alaska, 58,242; Arizona, 691; California, 4,408; Nevada, 128.

crude oil in 1971, by State and district

barrels)

	Interstate receipts from—											
	PAD district III					PAD district IV					PAD dist. V, total	Total interstate receipts
	Ala., Ark., Miss.	La.	New Mex.	Tex.	Total	Colo.	Mont.	Utah	Wyo.	Total		
	2,580	417	--	1,110	4,107	--	--	--	--	--	--	8,240
	1,568	--	--	857	2,425	--	--	--	--	--	--	2,425
	6,448	52,826	--	28,174	87,448	--	--	--	--	--	--	88,505
	--	--	--	--	--	--	--	--	--	--	--	--
	--	66,359	1,242	45,023	112,624	--	--	--	--	--	--	112,624
	--	--	--	297	297	--	2,254	--	--	2,254	--	12,030
	--	--	--	--	--	--	--	--	--	--	--	1,472
	10,596	119,602	1,242	75,461	206,901	--	2,254	--	--	2,254	--	225,296
	2,642	95,472	16,183	99,788	214,085	4,138	1,182	--	6,909	12,229	--	257,667
	--	11,467	13,303	58,313	83,083	1,077	5,843	--	24,952	31,872	--	161,889
	--	--	825	12,748	13,573	3,112	1,273	--	17,368	21,753	--	55,442
	1,457	46,143	--	1,673	49,273	--	--	--	--	--	--	61,909
	--	1,661	--	15,466	17,127	--	--	--	9,417	9,417	--	27,381
	--	--	--	--	--	--	1,354	--	--	1,354	--	5,673
	--	--	4,569	16,074	20,643	--	--	--	5,720	5,720	--	31,435
	--	--	--	--	--	--	1,086	--	--	1,086	--	1,086
	--	13,887	--	359	14,246	--	--	--	1,957	1,957	--	17,416
	3,806	45,670	2,570	54,496	106,542	--	--	--	3,479	3,479	--	123,214
	--	--	1,091	49,217	50,308	1,458	--	--	--	1,458	--	54,926
	7,905	214,300	38,541	308,134	568,880	9,785	10,738	--	69,802	90,325	--	798,038
	4,739	3,053	--	--	7,792	--	--	--	--	--	--	7,806
	--	2,176	--	11,451	13,627	--	--	--	--	--	--	13,627
	21,253	--	--	49,078	70,331	--	--	--	--	--	--	70,338
	--	70,589	--	--	70,589	--	--	--	--	--	--	70,589
	--	--	--	--	--	--	--	--	--	--	--	--
	--	183,555	62,702	--	246,257	22	--	3,133	--	3,155	--	250,103
	25,992	259,373	62,702	60,529	408,596	22	--	3,133	--	3,155	--	412,463
	--	--	--	--	--	--	900	24	11,486	12,410	--	12,410
	--	--	--	--	--	--	--	--	14,784	14,784	--	14,784
	--	--	16	--	16	12,815	1,035	--	14,815	28,665	131	28,812
	--	--	--	--	--	800	105	--	--	905	--	907
	--	--	16	--	16	13,615	2,040	24	41,085	56,764	131	56,913
	--	--	2,041	--	2,041	--	--	9,649	--	9,649	58,062	69,752
	--	--	--	--	--	--	--	--	--	--	5,276	5,276
	--	--	2,041	--	2,041	--	--	9,649	--	9,649	63,338	75,028
	44,493	593,275	104,542	444,124	1,186,434	23,422	15,032	12,806	110,887	162,147	[2] 63,469	1,567,738
	122	1,625	286	1,217	3,250	64	41	35	304	444	174	4,295

Table 15.—Crude runs to stills and refinery receipts of crude oil in 1971, by origin of the crude and method of transportation

(Thousand barrels)

District and State	Crude runs to stills	Refinery fuel use and losses	Refinery receipts of domestic crude—By State of origin of domestic crude	Change in refinery stocks	By receiving State and method of transportation: Intrastate			Interstate			Refinery receipts of foreign crude	
					Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tankers and barges
District I:												
Delaware, Maryland	38,548	3	--	−681	--	--	--	--	--	8,240	--	29,630
Florida, Georgia, Virginia	16,558	166	5,204	+341	--	--	--	--	580	1,845	--	14,640
New Jersey	173,390	61	--	−944	--	--	--	--	--	88,505	--	84,002
New York	30,898	--	1,337	−115	--	--	--	--	--	--	30,783	--
Pennsylvania:												
East	202,382	13	--	−1,504	--	--	--	--	--	112,624	--	88,267
West	20,795	1	4,386	+386	4,269	117	--	9,365	1,182	1,483	4,766	--
West Virginia	3,139	--	3,799	+4	1,609	62	--	843	629	--	--	--
Total	[1]485,710	244	14,726	−2,513	5,878	179	--	10,208	2,391	212,697	35,549	216,539
District II:												
Illinois	292,706	37	45,882	+252	17,952	85	--	257,667	--	--	17,291	--
Indiana	185,526	5	6,648	+92	6,616	32	--	161,879	10	--	17,086	--
Kansas	132,355	105	91,711	+252	73,484	1,564	--	55,391	51	--	2,222	--
Kentucky, Tennessee	66,658	11	4,351	−42	2,872	1,196	271	43,577	39	18,293	379	--
Michigan	56,395	6	11,528	−237	9,317	1,530	--	27,381	--	--	17,932	--
Minnesota, Wisconsin	61,163	--	--	−700	--	--	--	5,673	--	--	54,790	--
Missouri, Nebraska	32,144	--	6,633	−35	--	--	--	31,279	156	--	674	--
North Dakota	18,204	−1	[2]20,525	−155	16,203	1	--	1,085	1	--	758	--
Ohio:												
East	19,995	--	2,102	−45	1,541	561	--	17,416	--	--	432	--
West	[3]148,508	52	5,863	+77	--	34	--	123,214	--	--	[3]25,389	--
Oklahoma	165,383	39	195,253	−278	106,745	3,473	--	54,926	--	--	--	--
Total	1,179,037	254	390,496	−819	234,730	8,476	271	779,488	257	18,293	136,953	--
District III:												
Alabama	9,503	14	8,280	−49	--	--	1,368	--	1	7,805	--	294
Arkansas	29,219	11	16,242	+11	14,678	936	--	13,331	296	--	--	--
Louisiana	434,764	−2	954,978	−331	290,406	4,545	66,752	58,123	908	11,307	--	2,447
Mississippi	83,022	3	49,181	−208	10,624	1,604	--	70,589	--	--	--	--
New Mexico	15,480	181	120,208	+5	13,206	2,460	--	--	--	--	--	--
Texas	1,067,427	182	1,240,511	−3,412	768,361	7,405	20,621	132,674	122	117,307	--	17,707
Total	1,639,415	389	2,389,400	−3,984	1,097,275	16,950	88,741	274,717	1,327	136,419	--	20,448

District IV:												
Colorado	15,224	35	25,570	−173	--	2,148	--	12,346	64	--	528	--
Montana	41,899	26	27,004	−402	11,109	863	--	14,784	--	--	14,767	--
Utah	42,021	4	26,078	+59	10,014	3,258	--	27,557	1,255	--	--	--
Wyoming	48,739	4	157,578	+52	45,803	888	--	806	101	--	1,197	--
Total	147,883	69	236,230	−464	66,926	7,157	--	55,493	1,420	--	16,492	--
District V:												
California	527,109	−813	362,487	−352	281,912	4,270	71,897	12,378	--	57,374	--	98,113
Other States [4]	108,655	114	74,560	+840	15,493	6	--	--	--	5,276	71,367	17,467
Total	635,764	−699	437,047	+488	297,405	4,276	71,897	12,378	--	62,650	71,367	115,580
Total United States	4,087,809	257	3,467,899	−7,292	1,702,214	37,038	160,909	1,132,284	5,395	430,059	[5] 260,361	352,567
Daily average	11,199	1	9,501	−20	4,664	101	441	3,102	15	1,178	713	966

[1] Includes 297,872,000 barrels in Delaware River Valley.
[2] Includes 2,000 barrels from South Dakota.
[3] Includes some Athabasca hydrocarbons.
[4] Alaska, Arizona, Hawaii, Nevada, Oregon, and Washington.
[5] Excludes crude oil imported for direct fuel use by pipelines.

Table 16.—Transportation of petroleum products by pipelines in the United States in 1971, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1970 total
Turned into lines:														
Gasoline:														
Motor	115,080	102,587	119,739	117,736	125,332	126,054	132,619	130,935	123,405	122,697	121,810	130,687	1,468,681	1,416,412
Aviation	280	350	356	413	401	277	366	467	416	336	243	201	4,106	4,619
Total gasoline	115,360	102,937	120,095	118,149	125,733	126,331	132,985	131,402	123,821	123,033	122,053	130,888	1,472,787	1,421,031
Jet fuel:														
Naphtha type	2,018	1,954	2,386	2,317	2,554	2,108	2,086	2,142	1,741	1,854	1,893	1,914	24,967	24,479
Kerosine type	15,682	13,839	15,046	13,968	14,764	14,149	14,664	14,771	16,287	15,476	16,798	16,690	182,134	164,955
Total jet fuel	17,700	15,793	17,432	16,285	17,318	16,257	16,750	16,913	18,028	17,330	18,691	18,604	207,101	189,434
Kerosine	7,692	6,294	4,947	3,811	2,654	3,115	3,301	2,869	3,532	4,496	3,846	5,538	52,095	62,472
Distillate fuel oil	60,828	56,339	51,220	45,625	43,345	43,786	43,578	42,383	43,940	46,708	50,365	57,118	585,235	562,077
Natural gas liquids	30,296	26,332	28,179	27,219	26,297	25,906	26,500	28,531	27,318	29,573	30,098	34,341	340,590	331,630
Delivered from lines:														
Gasoline:														
Motor	112,581	102,352	118,194	118,084	124,776	128,653	131,608	132,484	124,064	122,738	121,421	125,897	1,462,852	1,418,942
Aviation	286	311	324	385	387	311	354	409	419	308	297	173	3,964	4,453
Total gasoline	112,867	102,663	118,518	118,469	125,163	128,964	131,962	132,893	124,483	123,046	121,718	126,070	1,466,816	1,423,395
Jet fuel:														
Naphtha type	1,786	2,076	2,335	2,361	2,470	2,208	2,008	2,073	1,778	1,834	1,909	1,987	24,825	24,674
Kerosine type	15,483	13,698	15,165	13,757	14,315	14,271	14,380	14,775	15,814	15,601	16,488	16,164	179,911	163,254
Total jet fuel	17,269	15,774	17,500	16,118	16,785	16,479	16,388	16,848	17,592	17,435	18,397	18,151	204,736	187,928
Kerosine	7,062	7,390	5,245	3,632	2,834	2,589	2,845	2,841	2,939	4,551	4,069	5,205	51,202	61,359
Distillate fuel oil	62,881	58,159	53,932	47,736	43,654	40,900	42,103	40,456	41,853	44,073	48,280	59,203	583,230	559,785
Natural gas liquids	32,709	27,444	28,550	26,755	25,306	26,047	25,344	28,219	26,767	28,474	28,796	34,385	338,796	327,296
Shortage or overage:[1]														
Gasoline:														
Motor	(136)	(288)	(48)	(272)	123	(65)	(122)	(48)	(225)	12	(211)	(138)	(1,418)	(1,593)
Aviation	(3)	15	1	38	24	3	1	(4)	29	12	14	3	133	221
Total gasoline	(139)	(273)	(47)	(234)	147	(62)	(121)	(52)	(196)	24	(197)	(135)	(1,285)	(1,372)
Jet fuel:														
Naphtha type	85	(20)	(4)	9	(39)	5	26	(1)	(7)	8	9	12	83	(57)
Kerosine type	87	163	159	76	56	35	67	36	124	179	16	187	1,185	1,361
Total jet fuel	172	143	155	85	17	40	93	35	117	187	25	199	1,268	1,304
Kerosine	134	143	92	110	119	124	90	87	75	170	89	123	1,356	1,313
Distillate fuel oil	37	(269)	(87)	(42)	8	14	(93)	220	124	47	(46)	(125)	(212)	(209)
Natural gas liquids	125	221	47	(165)	(67)	(48)	57	9	(79)	322	188	231	841	1,179

Stocks in lines and working tanks at end of month:														
Gasoline:														
Motor	39,721	40,244	41,837	41,761	42,194	39,660	40,793	39,292	38,858	38,805	39,405	44,333	44,333	37,086
Aviation	166	190	221	211	201	164	175	237	205	221	153	178	178	169
Total gasoline	39,887	40,434	42,058	41,972	42,395	39,824	40,968	39,529	39,063	39,026	39,558	44,511	44,511	37,255
Jet fuel:														
Naphtha type	638	536	591	538	661	556	608	678	648	660	635	550	550	491
Kerosine type	3,947	3,925	3,647	3,782	4,175	4,018	4,235	4,195	4,544	4,240	4,534	4,873	4,873	3,835
Total jet fuel	4,585	4,461	4,238	4,320	4,836	4,574	4,843	4,873	5,192	4,900	5,169	5,423	5,423	4,326
Kerosine	3,579	2,340	1,950	2,019	1,720	2,122	2,488	2,429	2,947	2,722	2,410	2,620	2,620	3,083
Distillate fuel oil	23,497	21,946	19,321	17,252	16,935	19,807	21,375	23,082	25,045	27,633	29,764	27,804	27,804	25,587
Natural gas liquids	11,434	10,101	9,683	10,312	11,370	11,277	12,376	12,679	13,309	14,086	15,200	14,925	14,925	13,972

[1] Figures in parentheses denote shortage.

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States in 1971, by month

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1970 total
From District I to District II:														
Gasoline:														
Motor	2,626	1,989	2,590	2,776	3,089	3,166	3,202	3,211	2,826	2,756	2,617	2,644	33,492	33,995
Aviation	3	8	--	8	5	5	--	9	6	8	--	--	52	40
Total gasoline	2,629	1,997	2,590	2,784	3,094	3,171	3,202	3,220	2,832	2,764	2,617	2,644	33,544	34,035
Jet fuel:														
Naphtha type	46	19	57	93	52	35	43	24	18	46	62	114	609	342
Kerosine type	168	116	103	89	78	34	30	32	62	122	104	87	1,025	1,020
Total jet fuel	214	135	160	182	130	69	73	56	80	168	166	201	1,634	1,362
Kerosine	87	80	54	53	59	25	56	37	85	117	82	52	787	1,039
Distillate fuel oil	551	710	599	629	599	702	666	701	583	739	622	640	7,741	7,314
Natural gas liquids	--	--	--	--	--	--	--	--	--	--	--	--	--	19
From District II to District I:														
Gasoline (motor)	968	843	997	1,006	937	1,074	1,001	1,146	800	626	535	834	10,767	9,244
Jet fuel (kerosine-type)	--	20	--	29	--	35	--	--	--	28	--	--	112	286
Distillate fuel oil	154	205	87	73	50	46	53	56	40	59	50	61	934	349
Natural gas liquids	1,061	733	356	1,023	1,086	822	1,085	1,190	692	784	829	1,012	10,673	10,414
From District II to District III:														
Gasoline (motor)	1,756	1,493	1,644	1,652	1,742	1,648	1,648	1,633	1,547	1,504	1,641	1,518	19,426	19,175
Jet fuel:														
Naphtha type	35	60	40	40	38	30	30	60	69	66	69	69	606	306
Kerosine type	--	1	1	--	--	2	1	--	--	--	--	--	5	--
Total jet fuel	35	61	41	40	38	32	31	60	69	66	69	69	611	306
Distillate fuel oil	391	275	383	331	346	373	382	308	360	383	360	364	4,256	4,022
Natural gas liquids	225	217	258	285	268	248	287	264	299	224	217	234	3,026	2,691
From District III to District I:														
Gasoline:														
Motor	22,276	18,873	22,050	24,064	25,275	26,006	25,727	28,724	25,056	28,878	22,909	21,188	286,026	298,669
Aviation	27	22	30	50	27	52	--	22	50	8	48	17	353	353
Total gasoline	22,303	18,895	22,080	24,114	25,302	26,058	25,727	28,746	25,106	28,886	22,957	21,205	286,379	299,022
Jet fuel:														
Naphtha type	135	121	121	171	131	156	101	120	120	156	131	111	1,574	1,896
Kerosine type	4,052	3,229	3,632	3,176	2,849	2,707	2,583	3,079	3,217	3,804	3,722	3,570	39,620	40,189
Total jet fuel	4,187	3,350	3,753	3,347	2,980	2,863	2,684	3,199	3,337	3,960	3,853	3,681	41,194	42,085
Kerosine	2,131	1,867	1,429	750	608	725	873	976	859	1,292	1,387	1,749	14,646	15,478
Distillate fuel oil	16,357	14,702	15,588	12,738	12,270	12,067	12,023	11,258	10,773	10,637	12,229	14,892	155,534	156,875
Natural gas liquids	1,894	1,608	1,273	827	465	798	1,220	1,374	1,051	1,035	1,459	1,701	14,705	13,009

From District III to District II:														
Gasoline:														
Motor	3,688	3,488	5,124	3,884	3,891	4,408	4,359	4,469	4,166	3,929	4,140	3,162	48,708	47,201
Aviation	94	53	134	96	132	84	88	131	176	80	114	64	1,246	1,307
Total gasoline	3,782	3,541	5,258	3,980	4,023	4,492	4,447	4,600	4,342	4,009	4,254	3,226	49,954	48,508
Jet fuel:														
Naphtha type	--	--	--	2	1	--	1	--	--	1	--	--	5	54
Kerosine type	180	296	303	193	165	496	309	229	342	239	125	238	3,115	2,743
Total jet fuel	180	296	303	195	166	496	310	229	342	240	125	238	3,120	2,797
Kerosine	393	476	219	345	108	133	190	62	218	353	250	279	3,026	1,979
Distillate fuel oil	1,289	705	1,191	940	826	971	605	713	729	1,269	991	1,364	11,593	12,712
Natural gas liquids	5,574	5,017	2,888	3,024	3,622	2,747	3,084	3,361	3,757	5,173	5,140	6,517	49,904	51,429
From District III to District IV:														
Gasoline:														
Motor	320	302	396	390	426	480	534	503	520	522	503	375	5,271	4,077
Aviation	15	15	18	22	18	20	22	21	20	18	19	17	225	249
Total gasoline	335	317	414	412	444	500	556	524	540	540	522	392	5,496	4,326
Jet fuel (kerosine-type)	319	262	313	268	290	307	302	318	293	309	309	316	3,606	3,787
Kerosine	4	2	2	2	2	1	1	2	3	2	4	2	27	49
Distillate fuel oil	38	45	60	58	52	66	59	65	64	66	64	32	669	567
Natural gas liquids	150	115	129	58	52	37	32	46	89	91	146	211	1,156	1,070
From District III to District V:														
Gasoline (motor)	944	814	974	919	973	938	974	911	772	977	963	784	10,943	9,895
Jet fuel:														
Naphtha type	267	251	288	245	310	214	280	236	167	170	205	166	2,799	3,409
Kerosine type	201	161	206	216	205	164	186	177	131	207	142	183	2,179	2,248
Total jet fuel	468	412	494	461	515	378	466	413	298	377	347	349	4,978	5,657
Distillate fuel oil	308	303	309	336	301	270	324	258	325	321	326	309	3,690	2,891
From District IV to District II:														
Gasoline (motor)	281	273	282	339	384	395	401	457	433	326	305	364	4,240	4,146
Jet fuel (naphtha-type)	31	43	43	47	39	64	38	36	37	35	40	48	501	259
Kerosine	4	5	6	5	3	--	5	5	5	5	6	2	51	63
Distillate fuel oil	302	213	268	251	241	272	279	200	266	324	305	285	3,206	3,190
From District IV to District V:														
Gasoline:														
Motor	935	815	907	849	864	995	933	829	743	869	757	862	10,358	10,830
Aviation	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Total gasoline	935	815	907	849	864	995	933	829	743	869	757	862	10,358	10,835
Jet fuel:														
Naphtha type	72	86	105	102	88	93	89	102	95	214	107	107	1,260	1,089
Kerosine type	30	61	103	97	75	59	57	83	83	--	48	3	699	671
Total jet fuel	102	147	208	199	163	152	146	185	178	214	155	110	1,959	1,760
Distillate fuel oil	595	459	430	400	347	289	356	463	515	493	559	547	5,453	5,563

Table 18.—Pipeline tariff rates for crude petroleum and products, January 1
(Cents per barrel)

Origin	Destination	1971	1972
Crude oil:			
West Texas	Houston, Texas	$0.14–$0.16	$0.13–$0.16
Do	East Chicago, Ind	.28	.28
Do	Wood River, Ill	.26	.28
Oklahoma	Chicago, Ill	.22	.22
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	.36
Do	New York, N.Y	.31	.31
Tulsa, Okla	Minneapolis, Minn	.65	.68
Salt Lake City, Utah	Spokane, Wash	.52	.52
Philadelphia, Pa	Rochester, N.Y	.24	.24

Source: Interstate Commerce Commission.

Table 19.—Receipts of domestic and foreign crude petroleum at refineries in the United States
(Million barrels)

Method of transportation	1967	1968	1969	1970	1971 p
By water:					
Intrastate	129.1	136.8	138.0	148.2	160.9
Interstate	428.4	428.8	408.8	461.8	430.0
Foreign	265.3	303.0	314.7	244.0	352.6
Total by water	822.8	868.6	861.5	854.0	943.5
By pipeline:					
Intrastate	1,581.1	1,673.0	1,715.1	1,730.5	1,702.2
Interstate	995.9	1,023.7	1,054.9	1,109.4	1,132.3
Foreign	146.6	169.2	199.2	236.8	260.4
Total by pipeline	2,723.6	2,865.9	2,969.2	3,076.7	3,094.9
By tank cars and trucks:					
Intrastate	40.0	40.8	41.8	37.1	37.0
Interstate	5.7	6.8	6.0	5.5	5.4
Foreign	--	--	--	--	--
Total by tank cars and trucks	45.7	47.6	47.8	42.6	42.4
Grand total	3,592.1	3,782.1	3,878.5	3,973.3	4,080.8

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Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports in 1971, by month

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1970 total
Gulf coast to east coast:														
Crude oil	26,287	21,121	23,474	21,533	20,167	16,744	14,118	13,924	13,747	10,889	12,458	11,936	206,398	235,860
Unfinished oils	1,299	2,074	2,598	3,292	2,937	2,352	1,920	302	1,948	1,115	1,820	1,152	22,809	26,912
Gasoline:														
Motor	15,708	15,160	18,140	16,020	15,562	15,750	15,039	17,957	13,843	16,783	15,159	17,190	192,311	172,627
Aviation	197	233	300	350	277	374	351	402	408	347	260	689	4,188	3,277
Total	15,905	15,393	18,440	16,370	15,839	16,124	15,390	18,359	14,251	17,130	15,419	17,879	196,499	175,904
Special naphthas	557	342	302	483	295	330	519	326	276	267	367	396	4,460	4,248
Kerosine	2,498	2,291	1,587	1,764	1,379	1,376	1,046	1,216	1,071	1,581	1,629	2,666	20,104	16,543
Distillate fuel oil	16,199	14,507	11,642	10,532	10,208	9,911	9,199	8,183	6,260	9,137	8,536	14,626	128,940	147,272
Residual fuel oil	3,569	3,441	3,304	1,612	2,043	2,344	2,611	1,644	2,160	2,533	2,775	2,891	30,927	28,514
Jet fuel:														
Naphtha type	998	1,098	1,055	1,559	1,291	926	1,137	1,340	1,661	1,453	1,335	1,857	15,710	14,427
Kerosine type	2,974	2,841	2,971	1,937	2,099	2,401	1,974	2,249	1,989	2,543	2,659	1,966	28,603	26,187
Total	3,972	3,939	4,026	3,496	3,390	3,327	3,111	3,589	3,650	3,996	3,994	3,823	44,313	40,614
Lubricating oil	379	756	725	674	922	786	1,053	794	848	917	594	914	9,362	8,944
Wax	71	96	93	49	75	72	75	89	63	65	56	64	868	354
Asphalt and road oil	197	502	293	505	507	369	550	567	491	437	322	401	5,141	4,601
Liquefied gases	15	41	35	140	81	65	87	114	155	151	194	213	1,291	2,572
Petrochemical feedstocks	389	299	327	252	137	291	211	205	254	156	192	139	2,852	3,715
Other products	33	26	157	172	152	95	126	91	98	159	123	137	1,369	1,430
Grand total	71,370	64,828	67,003	60,874	58,132	54,186	50,016	49,403	45,272	48,533	48,479	57,237	675,333	697,483
West coast to east coast:														
Crude oil	--	--	--	--	--	--	--	--	--	--	--	--	--	252
Unfinished oils	--	--	--	--	--	--	--	--	--	--	--	--	--	579
Gasoline (motor)	--	--	--	--	9	--	--	--	--	5	--	--	14	151
Special naphthas	2	2	--	--	--	--	--	--	--	--	--	--	4	--
Distillate fuel oil	--	--	--	--	--	--	--	40	--	--	--	--	40	--
Residual fuel oil	--	--	--	--	--	--	--	69	--	--	--	--	69	--
Jet fuel (kerosine type)	--	--	--	--	--	--	--	--	--	--	--	--	--	40
Lubricating oil	7	91	17	97	97	20	88	99	19	74	87	37	733	894
Wax	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Other products	--	25	--	35	21	--	31	21	--	31	25	--	189	25
Total	9	118	17	132	127	20	119	229	19	110	112	37	1,049	1,946

Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports in 1971, by month—Continued

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1970 Total
Gulf coast to west coast:														
Crude oil	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unfinished oils	--	--	--	--	--	--	--	--	--	200	--	--	200	--
Gasoline (motor)	--	14	312	302	95	--	388	--	734	807	564	396	3,612	334
Special naphthas	5	--	18	--	--	--	--	--	--	--	--	--	23	39
Kerosine	--	2	--	--	--	--	--	--	--	--	2	--	4	92
Distillate fuel oil	--	--	--	--	--	--	--	--	--	--	--	251	251	18
Residual fuel oil	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Jet fuel:														
Naphtha type	--	266	--	164	--	--	192	--	--	--	--	--	622	--
Kerosine type	--	--	--	--	--	126	--	--	--	--	--	--	126	807
Total	--	266	--	164	--	126	192	--	--	--	--	--	748	807
Lubricating oil	30	122	236	187	226	77	97	82	155	--	180	216	1,608	1,647
Petrochemical feedstocks	--	11	--	4	22	26	30	17	17	10	17	16	170	100
Other products	--	--	--	2	--	--	3	--	12	--	15	--	32	80
Grand total	35	415	566	659	343	229	710	99	918	1,017	778	879	6,648	3,122

Table 21.—Barge movements via the Mississippi River of crude oil and products from PAD district III to PAD district I and II in 1971, by month
(Thousand barrels)

Movements from District III to—	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1970 total
DISTRICT I														
Gasoline:														
Motor gasoline	1,107	705	1,106	1,157	1,185	1,338	1,368	826	1,251	1,069	927	1,032	13,071	15,294
Aviation gasoline	2	14	8	13	--	25	28	17	14	24	23	21	189	167
Total	1,109	719	1,114	1,170	1,185	1,363	1,396	843	1,265	1,093	950	1,053	13,260	15,461
Special naphthas	9	33	15	15	26	8	27	15	18	8	16	16	206	220
Kerosine	129	134	116	228	143	126	296	125	138	191	190	228	2,044	1,541
Distillate fuel oil	119	351	236	259	193	247	347	214	494	309	232	200	3,201	2,373
Residual fuel oil	20	196	118	193	136	116	155	52	225	140	163	147	1,661	190
Jet fuel:														
Naphtha type	--	--	12	--	--	--	--	--	--	--	--	--	12	--
Kerosine type	50	90	64	126	99	36	88	100	54	104	81	93	985	757
Total	50	90	76	126	99	36	88	100	54	104	81	93	997	757
Lubricating oil	225	128	172	102	199	184	150	132	123	160	173	175	1,923	2,159
Wax	--	--	--	--	--	--	2	--	--	--	--	--	2	31
Petrochemical feedstocks	33	38	22	23	56	43	34	72	51	30	3	4	409	433
Other products	--	3	13	12	19	9	--	5	12	--	3	6	82	65
Total	1,694	1,692	1,882	2,128	2,056	2,132	2,495	1,558	2,380	2,035	1,811	1,922	23,785	23,230
DISTRICT II														
Crude oil	1,528	1,475	1,698	1,331	1,215	1,427	1,640	1,766	1,515	1,549	1,652	1,474	18,270	17,736
Unfinished oils	5	9	4	11	4	6	4	11	4	13	--	124	195	73
Gasoline:														
Motor gasoline	4,034	2,894	2,980	3,819	3,796	3,466	4,394	4,761	4,238	3,895	3,633	3,984	45,894	41,267
Aviation gasoline	33	153	52	63	20	37	50	59	69	59	26	48	669	689
Total	4,067	3,047	3,032	3,882	3,816	3,503	4,444	4,820	4,307	3,954	3,659	4,032	46,563	41,956
Special naphthas	131	156	209	233	251	153	181	223	150	191	239	159	2,276	2,267
Kerosine	455	319	386	224	269	355	237	378	339	276	594	268	4,100	3,782
Distillate fuel oil	788	673	607	640	786	1,006	635	694	656	795	830	638	8,748	8,625
Residual fuel oil	597	319	353	314	306	319	437	478	307	303	547	452	4,732	7,785
Jet fuel:														
Naphtha type	9	23	12	--	12	11	9	--	14	9	10	14	123	71
Kerosine type	110	299	269	89	27	154	221	281	377	691	289	630	3,437	5,079
Total	119	322	281	89	39	165	230	281	391	700	299	644	3,560	5,150
Lubricating oil	94	171	250	170	240	206	240	399	260	268	192	193	2,683	2,434
Wax	--	--	--	--	--	--	--	--	--	--	--	--	--	3
Asphalt and road oil	118	25	118	268	154	429	399	459	356	418	214	85	3,043	2,540
Liquefied gases	--	56	--	114	152	113	113	56	121	116	69	12	922	1,305
Petrochemical feedstocks	112	87	80	95	93	113	97	121	111	167	145	126	1,347	1,377
Other products	53	4	57	68	108	76	65	90	77	43	78	61	780	605
Total	8,067	6,663	7,075	7,439	7,433	7,871	8,722	9,776	8,594	8,793	8,518	8,268	97,219	95,638

Table 22.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1967	1968	1969	1970	1971
Crude petroleum:					
At refineries	72,093	78,718	76,088	80,407	73,115
Pipeline and tank farm	158,797	177,133	172,252	181,580	172,309
Producers	18,080	16,342	16,887	14,380	14,224
Total crude petroleum	248,970	272,193	265,227	276,367	259,648
Unfinished oils	90,201	93,399	97,819	98,989	100,574
Natural gasoline, plant condensate, and isopentane	5,782	5,466	5,704	7,046	6,176
Refined products	599,158	628,514	611,373	635,459	677,549
Grand total	944,111	999,572	980,123	1,017,861	1,043,947

Table 23.—Stocks of crude petroleum in the United States in 1971, by State of 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	591	588	731	766	831	481	511	317	414	855	602	323	715
Alaska	6,818	4,482	5,373	4,232	4,315	5,738	4,416	4,764	4,034	4,387	3,941	3,570	4,399
Arizona	98	83	74	82	75	73	75	74	97	100	87	91	99
Arkansas	687	693	628	648	654	814	759	726	716	666	970	895	859
California	23,571	24,887	24,064	25,210	25,928	26,048	26,481	25,501	26,099	27,919	27,519	28,933	26,937
Colorado	2,553	2,439	2,487	2,433	2,629	3,246	2,949	3,105	2,653	3,051	2,944	3,150	2,844
Florida	342	360	303	429	486	458	219	182	104	181	69	100	294
Illinois	5,146	5,146	5,298	5,484	4,852	5,458	5,311	5,303	5,142	4,965	5,147	6,119	5,787
Indiana	506	436	426	419	362	464	450	321	356	443	387	389	387
Kansas	7,287	7,308	7,234	7,216	7,533	8,710	8,145	7,875	7,437	6,894	6,740	7,323	7,766
Kentucky	836	877	771	798	993	894	956	836	902	891	973	1,048	1,031
Louisiana	38,530	37,664	37,929	35,993	36,934	40,561	38,586	37,018	37,977	36,859	36,442	36,585	33,028
Michigan	550	568	530	620	690	657	668	741	714	807	818	768	597
Mississippi	4,671	4,653	4,798	4,681	4,828	5,248	5,147	4,805	4,371	4,383	4,731	4,452	4,128
Montana	4,296	3,747	3,383	3,491	3,086	3,647	3,512	3,326	3,428	3,146	3,291	3,033	3,020
Nebraska	815	865	677	681	696	938	983	841	790	797	899	921	918
Nevada	4	6	3	3	2	2	2	2	2	1	1	8	2
New Mexico	8,369	7,486	6,911	7,656	7,642	8,715	8,277	8,188	8,223	8,395	7,564	7,467	8,213
New York	30	30	30	30	30	30	30	30	30	30	30	30	30
North Dakota	1,533	1,417	1,535	1,562	1,666	1,772	1,641	1,631	2,146	1,676	1,373	1,374	1,387
Ohio	1,197	1,129	1,122	1,136	1,220	1,239	1,152	1,145	1,222	1,256	1,337	1,323	1,350
Oklahoma	17,589	17,130	16,285	16,682	16,456	16,721	17,671	16,785	16,095	15,769	15,533	15,435	15,873
Pennsylvania	811	806	750	702	798	757	780	795	781	776	722	717	769
Texas	110,376	111,520	107,412	105,799	106,336	106,122	106,370	103,718	103,988	102,007	98,004	98,578	93,304
Utah	2,632	2,548	2,653	2,735	2,445	2,740	2,612	2,441	2,736	2,745	2,325	2,295	2,558
West Virginia	673	534	493	511	545	525	515	501	548	570	529	576	539
Wyoming	16,820	17,942	18,737	18,801	19,188	20,707	19,950	18,667	17,002	16,569	16,794	17,134	17,258
Total domestic crude	257,331	255,344	250,637	248,800	251,220	262,765	258,168	249,638	248,007	246,138	239,772	242,637	234,092
Foreign crude:													
Districts I–IV	12,350	9,326	11,178	11,491	13,474	13,538	14,065	16,030	16,136	15,636	17,939	14,911	15,728
District V	6,686	5,136	5,049	6,955	6,751	8,017	7,104	7,567	8,274	7,997	8,188	8,004	9,828
Total foreign crude	19,036	14,462	16,227	18,446	20,225	21,555	21,169	23,597	24,410	23,633	26,127	22,915	25,556
Total crude stocks	276,367	269,806	266,864	267,246	271,445	284,320	279,337	273,235	272,417	269,771	265,899	265,552	259,648
Pennsylvania grade (included in total domestic crude above)	2,219	1,370	1,879	1,852	2,081	2,043	1,991	2,039	2,111	2,153	2,127	2,143	2,158

Table 24.—Stocks of crude petroleum in the United States in 1971, 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	825	888	1,114	962	977	926	1,271	1,151	1,205	1,158	1,467	874	879
Alaska	1,255	516	885	938	740	725	309	1,428	502	821	558	663	1,076
Arizona	451	460	460	459	458	453	452	446	444	444	445	446	447
Arkansas	1,215	1,224	1,158	1,175	1,110	1,346	1,209	1,260	1,250	1,196	1,220	1,196	1,195
California, Nevada, Oregon, Washington	35,308	33,578	33,375	35,219	36,223	38,783	37,583	35,716	37,665	39,213	38,515	39,387	40,552
Colorado	1,971	2,005	1,998	2,185	2,083	2,223	2,337	2,142	1,892	1,943	1,639	1,725	1,590
Florida, Georgia, South Carolina, Virginia	628	804	1,086	897	1,348	1,155	886	484	881	1,207	1,282	1,082	1,117
Hawaii	1,170	1,059	959	1,059	799	1,216	979	1,318	1,084	1,287	1,329	1,230	453
Illinois	16,990	17,984	17,879	17,846	17,899	18,389	19,095	18,179	18,364	17,656	17,825	18,303	17,181
Indiana	4,663	4,629	4,544	4,386	3,853	4,017	4,158	3,931	3,889	3,867	3,760	3,767	4,034
Iowa, Missouri	6,799	6,832	6,361	6,760	6,350	7,093	6,378	6,534	6,149	6,215	6,258	6,787	6,676
Kansas	10,521	10,073	10,783	10,118	10,957	12,088	11,542	11,129	10,609	10,273	10,364	11,066	11,101
Kentucky, Tennessee	4,811	5,040	4,479	4,925	4,958	5,105	4,886	4,822	5,015	5,028	4,810	4,997	4,726
Louisiana	18,826	18,396	18,737	17,505	19,325	20,684	18,691	19,623	18,989	19,185	19,012	19,118	17,990
Maryland	198	229	226	158	319	228	318	318	150	336	384	315	382
Massachusetts, Delaware, Rhode Island	1,562	847	1,548	1,357	1,415	928	1,489	1,347	1,123	1,476	601	569	697
Michigan	1,955	1,707	1,885	1,727	1,759	1,745	1,732	1,647	1,686	2,167	1,782	1,756	1,578
Minnesota, Wisconsin	2,479	2,244	1,925	1,772	2,678	2,374	1,626	2,045	1,889	1,698	1,863	2,214	2,090
Mississippi	6,141	5,569	5,775	5,882	5,822	6,475	6,175	6,155	6,033	5,399	5,819	5,916	5,448
Montana	3,136	2,814	2,585	2,450	2,690	3,225	2,900	2,692	2,594	2,510	2,654	2,689	2,435
Nebraska	1,612	1,579	1,596	1,562	1,482	1,583	1,501	1,619	1,580	1,603	1,589	1,604	1,545
New Jersey	6,393	6,493	6,686	7,459	7,425	6,884	6,953	7,044	9,559	7,513	6,953	5,662	5,449
New Mexico	4,247	4,341	4,389	4,529	4,412	4,276	4,009	3,917	3,743	3,912	3,985	3,988	3,960
New York	270	428	419	354	371	361	360	352	386	366	505	438	155
North Dakota	1,288	1,217	1,295	1,351	1,310	1,350	1,397	1,305	1,185	1,250	1,157	1,102	1,166
Ohio	7,454	7,017	6,942	7,233	6,991	7,716	6,771	6,439	6,915	6,879	6,707	7,932	7,260
Oklahoma	20,059	19,420	17,166	17,479	17,343	18,550	18,752	18,141	18,604	18,590	18,560	17,805	17,508
Pennsylvania	9,660	8,047	9,538	9,058	8,049	9,364	8,768	8,971	8,053	8,631	8,279	7,445	8,399
Texas	94,786	94,032	90,080	89,456	90,698	91,875	93,989	90,985	89,451	87,651	85,719	84,227	81,621
Utah	991	854	930	951	744	1,028	991	911	969	891	1,162	1,324	1,290
West Virginia	614	554	467	507	576	505	525	530	535	511	522	615	555
Wyoming	8,089	8,926	9,594	9,527	10,281	11,650	11,305	10,654	9,524	8,895	9,174	9,310	9,093
Total	276,367	269,806	266,864	267,246	271,445	284,320	279,337	273,235	272,417	269,771	265,899	265,552	259,648

Table 25.—Stocks of crude petroleum in the United States in 1971, 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	197	279	208	252	246	231	258	221	247	255	283	251	148
Alaska	191	107	141	171	123	131	117	188	108	94	121	112	157
Arkansas	159	160	144	158	207	217	236	210	209	195	200	199	170
California, Nevada, Oregon, Washington	19,510	17,143	17,058	17,912	18,061	20,846	20,374	18,951	19,302	20,176	19,325	19,908	20,749
Colorado	529	443	439	524	398	532	515	512	444	503	396	423	356
Florida, Georgia, South Carolina, Virginia	498	605	958	751	1,174	1,016	795	422	825	1,149	1,229	1,036	839
Hawaii	1,170	1,059	959	1,059	799	1,216	979	1,318	1,084	1,287	1,329	1,230	453
Illinois	3,512	3,660	3,542	3,530	3,546	4,067	4,115	3,990	4,197	3,810	4,308	3,997	3,764
Indiana	1,377	1,307	1,250	1,308	1,113	1,332	1,366	1,236	1,377	1,278	1,310	1,407	1,469
Kansas	1,767	1,661	1,667	1,821	2,250	2,188	2,033	2,068	1,951	1,844	1,803	1,977	2,019
Kentucky, Tennessee	1,241	1,283	1,225	1,532	1,320	1,477	1,450	1,279	1,487	1,413	1,198	1,278	1,199
Louisiana	5,590	5,547	5,585	5,468	6,287	6,719	6,229	6,223	5,958	6,275	6,400	6,439	5,259
Maryland	198	229	226	158	319	228	318	318	150	336	384	315	382
Massachusetts, Delaware, Rhode Island	1,562	847	1,548	1,357	1,415	928	1,489	1,347	1,123	1,476	601	569	697
Michigan	894	844	869	963	884	927	848	819	890	965	885	923	657
Minnesota, Wisconsin	1,629	1,449	1,092	1,185	1,623	1,451	1,374	1,260	1,046	1,020	1,102	1,119	929
Mississippi	1,041	725	759	871	919	1,288	1,221	1,386	1,308	899	923	962	833
Missouri	417	313	419	371	237	322	251	267	274	241	293	372	380
Montana	955	729	773	622	680	1,101	957	818	753	781	742	792	553
Nebraska	27	27	27	32	28	30	26	22	24	29	30	26	29
New Jersey	6,393	6,493	6,686	7,459	7,425	6,884	6,953	7,044	9,559	7,513	6,953	5,662	5,449
New Mexico	217	236	252	287	318	353	285	242	179	156	173	191	222
New York	240	398	389	324	341	331	330	322	356	336	475	408	125
North Dakota	308	300	342	345	322	356	288	239	128	176	124	97	153
Ohio	2,079	2,008	2,229	2,270	2,122	2,224	1,749	1,924	2,197	1,814	2,021	2,224	2,111
Oklahoma	1,801	1,749	1,724	1,746	1,950	1,911	2,215	1,964	2,133	2,066	2,020	1,977	1,523
Pennsylvania	8,287	6,772	8,327	7,920	6,918	8,202	7,674	7,806	6,724	7,261	6,980	6,278	7,169
Texas	17,510	17,531	16,427	16,948	16,644	17,214	17,087	18,100	16,423	15,735	17,042	15,082	14,098
Utah	492	404	424	515	385	610	545	492	517	433	423	571	551
West Virginia	79	66	70	79	122	89	82	94	96	102	75	97	83
Wyoming	537	578	602	533	665	863	723	604	552	585	632	667	589
Total at refineries	80,407	74,952	76,361	78,471	78,841	85,284	82,882	81,636	81,621	80,203	79,780	76,589	73,115

Table 25.—Stocks of crude petroleum in the United States in 1971, by classification and State and month—Continued

(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
Pipeline and tank-farm stocks:													
Alabama	538	518	812	618	636	604	922	838	867	813	1,090	525	631
Alaska	1,064	409	744	767	614	593	192	1,240	350	456	268	433	877
Arkansas	962	970	913	914	806	1,032	876	953	944	904	923	893	931
California, Arizona	14,812	15,382	15,045	15,955	16,188	16,445	15,910	15,381	16,659	17,280	17,441	17,980	18,262
Colorado	1,312	1,432	1,435	1,531	1,555	1,561	1,692	1,482	1,321	1,313	1,116	1,175	1,107
Florida	109	166	98	115	153	123	68	35	34	36	34	34	261
Illinois	13,203	14,044	14,053	14,037	14,080	14,046	14,708	13,916	14,399	13,575	13,243	14,038	13,150
Indiana	3,252	3,288	3,260	3,044	2,706	2,651	2,758	2,661	2,478	2,555	2,416	2,326	2,531
Iowa, Missouri	6,382	6,519	5,942	6,389	6,113	6,771	6,127	6,267	5,875	5,974	5,965	6,415	6,296
Kansas	8,463	8,129	8,817	8,008	8,428	9,613	9,235	8,788	8,391	8,155	8,283	8,820	8,826
Kentucky, Tennessee	3,513	3,700	3,197	3,336	3,587	3,577	3,385	3,492	3,477	3,564	3,561	3,668	3,476
Louisiana	10,897	10,461	10,848	9,759	10,687	11,716	10,255	11,136	10,725	10,625	10,351	10,448	10,458
Michigan	990	792	945	688	799	742	808	752	720	1,108	815	751	839
Minnesota, Wisconsin	850	795	833	587	1,055	923	252	785	843	678	761	1,095	1,161
Mississippi	4,796	4,522	4,705	4,715	4,607	4,856	4,631	4,501	4,401	4,193	4,526	4,594	4,244
Montana	1,845	1,749	1,478	1,493	1,690	1,789	1,608	1,574	1,547	1,451	1,616	1,601	1,591
Nebraska	1,487	1,449	1,466	1,432	1,356	1,455	1,377	1,499	1,458	1,476	1,461	1,480	1,418
New Mexico	2,672	2,684	2,750	2,877	2,738	2,573	2,426	2,377	2,261	2,467	2,510	2,569	2,513
New York	--	--	--	--	--	--	--	--	--	--	--	--	--
North Dakota	861	831	834	889	884	883	992	960	946	964	920	896	920
Ohio	5,300	4,934	4,638	4,888	4,794	5,417	4,947	4,440	4,643	4,990	4,611	5,633	5,074
Oklahoma	17,254	16,642	14,400	14,726	14,423	15,619	15,540	15,180	15,489	15,411	15,466	14,829	15,037
Pennsylvania	1,251	1,153	1,089	1,016	1,009	1,040	972	1,043	1,207	1,237	1,166	1,034	1,097
Texas	71,966	71,175	68,312	67,346	68,920	69,408	71,636	67,790	67,902	66,841	63,459	64,158	62,657
Utah	444	370	435	351	291	348	377	359	386	398	665	681	660
West Virginia	370	323	232	263	289	251	278	271	274	244	282	353	307
Wyoming	6,987	7,768	8,405	8,425	9,047	10,209	10,051	9,463	8,395	7,733	7,952	8,108	7,985
Total	181,580	180,205	175,686	174,169	177,455	184,245	182,023	177,183	175,992	174,441	170,901	174,537	172,309
Lease stocks	14,380	14,649	14,817	14,606	15,149	14,791	14,432	14,416	14,804	15,127	15,218	14,426	14,224
Total stocks:													
1971	276,367	269,806	266,864	267,246	271,445	284,320	279,337	273,235	272,417	269,771	265,899	265,552	259,648
1970	265,227	267,087	269,628	274,643	278,037	284,824	279,894	266,854	254,144	259,196	265,479	271,303	276,367

Table 26.—Value of crude petroleum at wells in the United States, by State

State	1970		1971	
	Total value at wells (thousand dollars)	Average value per barrel	Total value at wells (thousand dollars)	Average value per barrel
Alabama	20,627	$2.84	23,496	$3.00
Alaska	251,684	3.01	257,562	3.24
Arizona	5,281	2.96	3,918	3.17
Arkansas	51,760	2.87	56,805	3.11
California	945,365	2.54	975,076	2.72
Colorado	78,619	3.18	92,855	3.39
Illinois	141,994	3.25	135,621	3.47
Indiana	23,958	3.20	22,770	3.42
Kansas	277,469	3.27	276,433	3.52
Kentucky	36,461	3.15	35,925	3.36
Louisiana:				
Gulf Coast	2,905,343	3.38	3,198,487	3.59
Northern	156,215	3.30	161,223	3.55
Total Louisiana	3,061,558	3.38	3,359,710	3.59
Michigan	36,246	3.10	38,859	3.27
Mississippi	194,706	2.99	201,808	3.15
Montana	105,403	2.78	104,128	3.01
Nebraska	35,384	3.09	34,010	3.38
New Mexico:				
Southeastern	384,780	3.22	374,822	3.42
Northwestern	25,540	2.94	27,780	3.15
Total New Mexico	410,320	3.20	402,602	3.40
New York	5,397	4.52	5,292	4.70
North Dakota	67,107	3.05	70,805	3.27
Ohio	32,914	3.34	29,801	3.60
Oklahoma	712,419	3.19	725,611	3.40
Pennsylvania	18,500	4.52	17,699	4.66
South Dakota	374	2.34	604	2.59
Texas:				
Gulf Coast	889,724	3.51	890,658	3.73
East Texas Field	241,281	3.32	240,224	3.54
West Texas	1,914,593	3.21	2,040,348	3.40
Panhandle	92,211	3.23	90,481	3.46
Rest of State	966,196	3.23	1,000,064	3.46
Total Texas	4,104,005	3.28	4,261,775	3.48
Utah	65,603	2.81	71,886	3.04
West Virginia	11,871	3.80	11,609	3.91
Wyoming	469,811	2.93	459,079	3.10
Other States [1]	8,890	2.52	17,259	2.91
Total United States	11,173,726	3.18	11,692,998	3.39

[1] Florida, Missouri, Nevada, Tennessee, and Virginia.

Table 27.—Posted price per barrel of petroleum at wells in the United States in 1971 by grade, with date of price change

(Dollars)

Grade	Date of price change: Jan. 1	May 1	June 11
Pennsylvania grade:			
Bradford and Allegheny districts	$4.63	$4.88	--
Southwest Pennsylvania	3.92	4.17	--
Corning grade	3.42	--	--
Western Kentucky	3.60	--	--
Indiana-Illinois	3.60	--	--
Coldwater, Michigan	3.35	--	--
Oklahoma-Kansas:			
34°–34.9° API	3.42	--	--
36°–36.9° API	3.50	--	--
Panhandle, Tex. (Carson, Gray, Hutchinson, and Wheeler Counties), 35°–35.9° API	3.41	--	--
West Texas 30°–30.9° API (sweet)	3.36	--	--
Lea County, N. Mex., 30°–30.9° API (sour)	3.19	--	$3.25
South Texas, Mirando, 24°–24.9° API	3.65	--	--
East Texas	3.60	--	--
Conroe, Texas	3.70	--	--
Texas:			
30°–30.9° API	3.45	--	--
20°–20.9° API	3.35	--	--
Louisiana: 30°–30.9° API	3.55	--	--
Caddo-Pine Island, La., 36°–36.9° API	3.44	--	--
Magnolia Smackover Limestone, Ark., 31°–31.9° API	3.07	--	--
Elk Basin, Wyo. (including Montana), 30°–30.9° API	3.16	--	--
Coalinga, 32°–32.9° API	3.41	--	--
California:			
Kettleman Hills, 37°–37.9° API	3.66	--	--
Midway Sunset, 19°–19.9° API	2.68	--	--
Wilmington, 24°–24.9° API	3.03	--	--

Source: Platt's Oil Price Handbook.

Table 28.—Wholesale price index, crude petroleum

(1957–59 = 100) [1]

Month	1967	1968	1969	1970 r	1971
January	98.2	99.0	99.7	106.0	113.2
February	98.2	99.0	99.9	106.0	113.2
March	98.3	99.0	103.7	106.0	113.2
April	98.3	99.0	104.8	106.0	113.2
May	98.3	99.0	104.7	106.0	113.2
June	98.3	99.3	104.5	106.0	113.2
July	98.4	99.4	104.5	104.8	113.2
August	99.0	99.7	104.5	104.8	113.2
September	99.0	99.7	104.5	104.8	113.2
October	99.0	99.7	104.5	104.8	113.2
November	99.0	99.7	104.5	104.8	113.2
December	99.0	99.7	104.5	113.2	113.2
Average	98.6	99.4	103.7	106.1	113.2

r Revised.
[1] Reference base for 1970 and 1971, 1967 = 100.
Source: Bureau of Labor Statistics, U.S. Department of Labor.

Table 29.—Average monthly price of petroleum products in the United States, 1970–71

Product and grade	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Gasoline, 92-octane (cents per gallon):														
At refineries in Oklahoma	1970	12.10	12.09	12.00	12.69	12.67	12.54	12.70	12.71	12.66	12.66	12.73	13.24	12.56
	1971	13.16	12.95	12.80	12.49	13.13	12.98	12.88	12.88	12.81	12.75	12.75	12.75	12.86
Tank-wagon prices to dealers at 55 cities on 1st of month	1970	17.26	16.45	17.50	18.40	17.94	17.86	18.40	17.08	17.58	17.66	17.04	19.03	17.68
	1971	18.38	18.26	17.43	17.07	16.81	17.82	18.25	19.35	18.84	19.08	17.43	18.59	18.11
At service station (including all taxes)	1970	35.08	34.01	34.87	36.76	35.98	36.03	36.76	34.95	35.63	35.74	34.85	37.64	35.69
	1971	36.75	36.53	35.24	34.97	34.59	35.95	36.61	38.08	37.70	37.99	35.74	37.13	36.44
Kerosine (cents per gallon):														
No. 1 range at Chicago district	1970	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.35	11.73	11.90	12.24	12.25	11.52
	1971	12.21	12.21	11.84	11.28	11.43	11.75	11.75	11.97	12.00	12.00	12.00	12.00	11.87
No. 1 fuel oil at Oklahoma	1970	10.66	10.79	10.48	10.31	10.23	10.15	10.25	10.25	10.38	10.54	10.74	11.09	10.49
	1971	11.08	10.92	10.64	10.31	10.23	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.41
Kerosine (or No. 1 fuel oil) at New York Harbor	1970	12.00	12.00	12.00	12.00	12.04	12.13	12.20	12.20	12.20	12.24	12.52	12.60	12.18
	1971	12.31	12.43	12.33	12.20	12.22	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.26
Kerosine (or No. 1 fuel oil) at Tampa	1970	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.81	11.00	11.00	11.45	10.69
	1971	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
Distillate and diesel fuel oil (cents per gallon):														
No. 2 fuel oil at refineries, Oklahoma	1970	9.91	10.04	9.73	9.56	9.45	9.40	9.50	9.52	9.63	9.79	9.99	10.34	9.74
	1971	10.33	10.17	9.89	9.56	9.48	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.66
No. 2 fuel oil at New York Harbor	1970	11.00	11.00	11.00	11.00	11.04	11.13	11.20	11.20	11.20	11.24	11.52	11.60	11.18
	1971	11.92	12.00	12.00	12.00	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.89
Diesel oil, shore plants, New York	1970	11.30	11.30	11.30	11.30	11.34	11.43	11.50	11.50	11.50	11.54	11.82	11.90	11.48
	1971	12.22	12.30	12.30	12.30	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.19
Diesel oil for ships (dollars per barrel):														
New York	1970	4.63	4.63	4.69	4.72	4.72	4.78	4.97	5.29	5.42	5.42	5.42	5.42	5.01
	1971	5.42	5.42	5.42	5.42	5.42	5.42	5.32	5.22	5.22	5.36	5.08	5.08	5.32
New Orleans	1970	4.26	4.26	4.36	4.42	4.42	4.48	4.67	4.99	5.12	5.12	5.12	5.12	4.66
	1971	5.12	5.12	5.12	5.12	5.12	5.12	5.02	4.92	4.92	5.07	5.10	5.10	5.07
San Pedro	1970	4.97	4.97	5.06	5.12	5.12	5.12	5.12	5.12	5.12	5.50	6.21	6.21	5.30
	1971	6.21	6.21	5.91	5.91	5.91	5.91	5.91	5.91	5.91	5.91	5.91	5.91	5.96
Residual fuel oil (dollars per barrel):														
No. 6 fuel at refineries, Oklahoma	1970	1.83	2.00	2.00	2.00	2.00	2.26	2.55	2.71	2.73	2.73	2.73	2.73	2.35
	1971	2.68	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.61
No. 5 fuel oil at New York Harbor	1970	2.83	2.83	2.83	2.92	3.33	3.69	3.72	4.00	4.07	4.30	4.43	4.43	3.62
	1971	4.43	4.43	4.47	4.60	4.60	4.60	4.60	4.60	4.60	4.50	4.35	4.35	4.51
Bunker "C" for ships:														
New York	1970	2.28	2.28	2.29	2.30	2.39	2.63	2.83	3.07	3.30	3.46	3.75	3.75	2.86
	[1] 1971	3.75	3.75	3.75	3.92	3.92	3.85	3.73	3.65	3.65	3.54	3.30	3.30	3.68
New Orleans	1970	2.22	2.22	2.27	2.30	2.39	2.63	2.83	3.07	3.30	3.30	--	--	[2] 2.65
	[1] 1971	--	--	--	--	--	--	3.65	3.65	3.65	3.62	3.30	3.30	[2] 3.53
San Pedro	1970	1.90	1.90	2.01	2.03	2.14	2.23	2.33	2.67	2.85	3.01	3.30	3.30	2.47
	1971	3.30	3.30	3.76	3.80	3.80	3.80	3.80	3.80	3.80	3.77	3.45	3.45	3.65
Lubricating oil (cents per gallon):														
East Coast:														
200 viscosity at 100, 0–10 pour test, 95 V.I.	1970	--	--	--	--	--	--	--	--	--	23.00	23.00	23.00	[2] 23.00
	1971	23.39	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.49
500 viscosity at 100, 0–10 pour test, 95 V.I.	1970	--	--	--	--	--	--	--	--	--	24.50	24.50	24.50	[2] 24.50
	1971	25.27	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.44
South Texas: 500 viscosity, No. 2½–3½ color [2]	[3] 1970	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

See footnotes at end of table.

Table 29.—Average monthly price of petroleum products in the United States, 1971–71—Continued

Product and grade	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Liquid petroleum gas (propane) (cents per gallon):														
New York Harbor/Philadelphia	1970	7.90	8.00	8.00	8.00	8.00	8.02	8.50	8.56	8.98	9.00	9.00	9.00	8.41
	1971	9.00	9.00	9.00	8.58	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.63
Oklahoma	1970	4.95	5.22	5.25	5.25	5.25	5.25	5.25	5.59	6.22	6.25	6.25	6.25	5.58
	1971	6.25	6.25	6.13	5.75	5.75	5.75	5.75	5.75	5.75	5.67	5.25	5.25	5.78
Baton Rouge	1970	5.45	5.72	5.75	5.75	5.75	5.75	5.75	5.96	6.70	6.73	6.73	6.73	6.06
	1971	6.73	6.73	6.23	5.73	5.73	5.73	5.73	5.73	5.73	6.14	5.73	5.73	5.97

[1] As of October 29. Includes voluntary trade allowance of 10 cents per barrel.
[2] Partial average.
[3] No change in price during 1971.

Table 30.—Supply, demand and stocks of all oils by PAD districts in 1971

(Thousand barrels)

	PAD districts						
	I	II	III	IV	I–IV	V	United States
Domestic production:							
Crude and lease condensate	13,241	400,870	2,366,742	233,734	3,014,587	439,327	3,453,914
Natural gas plant liquids	7,938	87,501	491,080	13,431	599,950	17,865	617,815
Receipts from other districts	1,245,426	907,741	32,534	23,490	13,452	70,171	--
Imports:							
Natural gasoline and plant condensate	538	4,580	--	4,672	9,790	3,531	13,321
Crude oil	252,088	137,064	20,449	16,869	426,470	186,947	613,417
Unfinished oils	30,651	--	2,217	--	32,868	12,325	45,193
Refined products	683,475	18,338	17,425	3,114	722,352	36,338	758,690
Other hydrocarbons and hydrogen input	--	425	2,558	204	3,187	2,887	6,074
Total new supply	2,233,357	1,556,519	2,933,005	295,514	4,822,656	769,391	5,508,424
Unaccounted for crude oil	1,897	−11,167	15,804	2,290	8,824	5,999	14,823
Processing gain	14,523	35,840	65,276	1,913	117,552	21,881	139,433
Total supply	2,249,777	1,581,192	3,014,085	299,717	4,949,032	797,271	5,662,680
Change in stocks of all oil	−8,626	+10,488	+13,903	+2,508	+18,273	+7,813	+26,086
Total disposition of primary supply	2,258,403	1,570,704	3,000,182	297,209	4,930,759	789,458	5,636,594
Exports:							
Crude oil	36	12	304	12	364	139	503
Refined products	6,947	3,889	37,706	34	48,576	32,606	81,182
Shipments to other districts	43,920	59,307	2,019,554	143,129	70,171	13,452	--
Crude losses (estimate for individual districts I–IV)	678	1,035	1,442	451	3,606	842	4,448
Domestic demand for products:							
Gasoline:							
Motor gasoline	740,617	763,630	301,105	72,596	1,877,948	317,331	2,195,279
Aviation gasoline	5,254	4,295	3,073	697	13,319	4,570	17,889
Total	745,871	767,925	304,178	73,293	1,891,267	321,901	2,213,168
Jet fuel:							
Naphtha type	28,094	17,825	14,616	2,199	62,734	31,999	94,733
Kerosine type	109,358	57,730	17,845	6,766	191,699	80,194	271,893
Total	137,452	75,555	32,461	8,965	254,433	112,193	366,626
Ethane (including ethylene)	1,882	10,396	74,836	19	87,133	611	87,744
Liquefied gases	51,321	96,967	187,877	10,131	346,296	22,711	369,007
Kerosine	47,374	28,065	11,851	1,905	89,195	1,722	90,917
Distillate fuel oil	481,443	288,178	75,216	29,892	874,729	96,591	971,320
Residual fuel oil	624,848	67,270	27,617	9,347	729,082	108,787	837,869
Petrochemical feedstocks	7,536	11,708	81,972	373	101,589	8,932	110,521
Special naphtha	6,910	7,452	10,020	222	24,604	5,177	29,781
Lubricants	20,539	13,234	9,946	334	44,053	5,325	49,378
Wax	2,697	1,094	866	88	4,745	509	5,254
Coke	11,425	28,895	28,116	2,956	71,392	8,582	79,974
Asphalt	43,031	56,660	30,873	9,223	139,787	18,741	158,528
Road oil	674	4,351	182	1,726	6,933	1,554	8,487
Still gas for fuel	20,499	45,218	60,460	4,963	131,140	25,827	156,967
Miscellaneous products	3,320	3,493	4,705	146	11,664	3,256	14,920
Total	2,206,822	1,506,461	941,176	153,583	4,808,042	742,419	5,550,461
Stocks of all oils:							
Crude oil and lease condensate	16,754	74,865	111,093	14,408	217,120	42,528	259,648
Unfinished oils	15,641	21,228	37,126	2,050	76,045	24,529	100,574
Natural gasoline and plant condensate	225	1,014	4,692	55	5,986	190	6,176
Refined products	202,037	191,142	197,689	16,255	607,123	70,426	677,549
Total	234,657	288,249	350,600	32,768	906,274	137,673	1,043,947

Table 31.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

Product	1968	1969	1970	1971 p
Isopentane:				
Production	2,660	3,457	3,865	5,565
Stocks at plants	44	10	7	31
Used at refineries	2,640	3,491	3,868	5,541
Natural gasoline:				
Production	145,214	154,472	161,274	159,732
Stocks end of year:				
At plants	2,584	3,358	4,316	3,647
At refineries	1,860	1,557	1,765	1,485
Total stocks	4,444	4,915	6,081	5,132
Used at refineries	145,492	154,001	160,108	160,681
Plant condensate:				
Production	38,494	34,133	31,972	25,754
Stocks end of year:				
At plants	841	547	507	594
At refineries	137	232	451	419
Total stocks	978	779	958	1,013
Imports	NA	NA	2,258	13,321
Used at refineries	38,552	34,332	34,051	39,020
Finished gasoline:				
Production:				
At refineries	1,933,827	2,022,407	2,099,911	2,197,550
At gas processing plants	6,211	5,745	5,347	5,023
Total gasoline production	1,940,038	2,028,152	2,105,258	2,202,573
Stocks end of year:				
At refineries	211,256	217,084	214,150	223,544
At plants	270	308	198	227
Total stocks	211,526	217,392	214,348	223,771
Imports	21,591	22,709	24,320	21,658
Exports	2,083	2,449	1,370	1,640
Domestic demand	1,956,000	2,042,546	2,131,252	2,213,168
Motor gasoline:				
Production:				
At refineries	1,902,264	1,995,947	2,080,199	2,179,093
At gas processing plants	6,211	5,745	5,347	5,023
Total motor gasoline production	1,908,475	2,001,692	2,085,546	2,184,116
Stocks end of year:				
At refineries	204,226	210,891	209,057	219,125
At plants	270	308	198	227
Total motor gasoline stocks	204,496	211,199	209,255	219,352
Imports	21,591	22,709	24,320	21,658
Exports	249	703	461	398
Domestic demand	1,925,376	2,016,995	2,111,349	2,195,279
Aviation gasoline:				
Production	31,563	26,460	19,712	18,457
Stocks end of year	7,030	6,193	5,093	4,419
Exports	1,834	1,746	909	1,242
Domestic demand	30,624	25,551	19,903	17,889
Jet fuel:				
Production	314,928	321,718	301,913	304,674
Stocks end of year	24,277	28,073	27,610	27,737
Imports	38,507	45,539	52,696	63,614
Exports	2,092	1,730	2,094	1,535
Domestic demand	349,378	361,731	352,978	366,626
Naphtha type:				
Production:				
At refineries	121,165	104,748	84,060	85,317
At gas processing plants	277	18	21	9
Total production	121,442	104,766	84,081	85,326
Stocks end of year:				
At refineries	8,880	8,537	6,618	6,988
At plants	24	19	3	2
Total stocks	8,904	8,556	6,621	6,990
Imports	7,117	5,134	7,005	11,092
Exports	2,091	1,730	2,094	1,316
Domestic demand	126,601	108,518	90,927	94,733

See footnotes at end of table.

Table 31.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1968	1969	1970	1971 p
Jet fuel—Continued				
Kerosine type:				
Production	193,486	216,952	217,832	219,348
Stocks end of year	15,373	19,517	20,989	20,747
Imports	31,390	40,405	45,691	52,522
Exports	1	--	--	219
Domestic demand	222,777	253,213	262,051	271,893
Ethane (including ethylene):				
Production:				
At gas processing plants	45,803	63,027	73,434	80,524
At refineries	9,446	9,159	9,460	9,266
Total production	55,249	72,186	82,894	89,790
Stocks end of year:				
At plants	2,212	2,182	1,319	3,365
At refineries	--	--	--	--
Total stocks	2,212	2,182	[1] 1,319	[1] 3,365
Domestic demand:				
Plant ethane	45,706	63,057	74,297	78,478
Refinery ethane and/or ethylene	9,446	9,159	9,460	9,266
Total domestic demand	55,152	72,216	83,757	87,744
Liquefied gases:				
Production:				
At gas processing plants (LPG)	305,459	315,430	326,177	337,110
At refineries (LRG):				
For fuel use	71,102	75,659	80,870	88,648
For chemical use	37,539	38,703	35,657	32,304
Total production at refineries	108,641	114,362	116,527	120,952
Total production	414,100	429,792	442,704	458,062
Stocks end of year:				
LPG stocks:				
At plants	68,928	51,799	59,276	80,294
At refineries	647	571	794	3,693
Total LPG stocks	69,575	52,370	60,070	83,987
LRG stocks:				
For fuel use	4,225	4,782	5,433	6,992
For chemical use	148	268	221	369
Total LRG stocks	4,373	5,050	5,654	7,361
Total stocks	73,948	57,420	[1] 65,724	[1] 91,348
Imports	11,647	12,651	18,921	25,655
Exports	10,608	12,797	9,955	9,391
LPG used at refineries	72,652	72,764	80,307	79,695
Domestic demand:				
LPG for fuel and chemical use	221,869	263,402	251,051	249,766
LRG for fuel use	71,628	74,447	80,219	87,089
LRG for chemical use	37,092	35,561	31,789	32,152
Total domestic demand	330,589	373,410	363,059	369,007
Propane (including propylene):				
Production:				
At gas processing plants	184,409	195,346	202,494	212,143
At refineries:				
For fuel use	56,847	57,022	63,409	71,934
For chemical use	17,489	19,721	20,090	21,512
Total production at refineries	74,336	76,743	83,499	93,446
Total production	258,745	272,089	285,993	305,589
Stocks end of year:				
Plant propane stocks:				
At plants	44,523	31,375	38,791	56,779
At refineries	5	4	84	769
Total plant propane stocks	44,528	31,379	38,875	57,548

See footnotes at end of table.

Table 31.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1968	1969	1970	1971 p
Propane (including propylene):—Continued				
Stocks end of year:—Continued				
Refinery propane and/or propylene stocks:				
For fuel use	2,947	3,083	4,301	5,050
For chemical use	73	215	146	263
Total refinery propane and/or propylene stocks	3,020	3,298	4,447	5,313
Total stocks	47,548	34,677	43,322	62,861
Imports	5,627	5,251	9,467	11,606
Exports	2,542	2,412	2,165	4,666
Plant propane used at refineries	1,587	1,632	1,530	3,273
Domestic demand:				
Plant propane	178,448	209,702	200,770	197,137
Refinery propane and/or propylene:				
For fuel use	57,345	56,886	62,191	71,185
For chemical use	17,479	19,579	20,159	21,395
Total refinery propane and/or propylene domestic demand	74,824	76,465	82,350	92,580
Total domestic demand	253,272	286,167	283,120	289,717
Butane (including butylene):				
Production:				
At gas processing plants	78,903	86,471	87,253	88,544
At refineries:				
For fuel use	9,584	13,535	13,514	13,765
For chemical use	12,441	10,987	8,693	5,886
Total production at refineries	22,025	24,522	22,207	19,651
Total production	100,928	110,993	109,460	108,195
Stocks end of year:				
Plant butane stocks:				
At plants	16,141	13,330	14,397	13,571
At refineries	357	270	414	1,614
Total plant butane stocks	16,498	13,600	14,811	15,185
Refinery butane and/or butylene stocks:				
For fuel use	936	1,448	912	1,448
For chemical use	42	36	35	11
Total refinery butane and/or butylene stocks	978	1,484	947	1,459
Total stocks	17,476	15,084	15,758	16,644
Imports	6,020	7,400	9,454	14,049
Exports	1,184	3,086	1,655	4,725
Plant butane used at refineries	41,526	40,268	43,758	46,061
Domestic demand:				
Plant butane	40,064	53,415	50,083	51,433
Refinery butane and/or butylene:				
For fuel use	9,785	13,023	14,050	13,229
For chemical use	12,478	10,993	8,694	5,910
Total refinery butane and/or butylene	22,263	24,016	22,744	19,139
Total domestic demand	62,327	77,431	72,827	70,572
Butane-propane mixture:				
Production:				
At gas processing plants	12,367	6,711	5,677	4,173
At refineries:				
For fuel use	4,671	5,102	3,947	2,949
For chemical use	6,494	6,289	5,353	3,029
Total production at refineries	11,165	11,391	9,300	5,978
Total production	23,532	18,102	14,977	10,151
Stocks end of year:				
Plant butane-propane mixture:				
At plants	528	240	733	815
At refineries	12	91	35	38
Total plant butane-propane mixture stocks	540	331	768	853

See footnotes at end of table.

Table 31.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1968	1969	1970	1971 p
Butane-propane mixture:—Continued				
Stocks end of year:—Continued				
Refinery butane-propane mixture:				
For fuel use	342	251	220	494
For chemical use	1	--	--	3
Total refinery butane-propane mixture stocks	343	251	220	497
Total stocks	883	582	988	1,350
Exports	6,882	7,299	6,135	--
Plant butane-propane mixture used at refineries	2,527	3,013	2,822	2,896
Domestic demand:				
Plant butane-propane mixture	3,357	285	198	1,192
Refinery butane-propane mixture:				
For fuel use	4,488	4,538	3,978	2,675
For chemical use	6,020	3,268	1,438	3,026
Total refinery butane-propane mixture	10,508	7,806	5,416	5,701
Total domestic demand	13,865	8,091	5,614	6,893
Isobutane:				
Production:				
At gas processing plants	29,780	26,902	30,753	32,250
At refineries	1,115	1,706	1,521	1,877
Total production	30,895	28,608	32,274	34,127
Stocks end of year:				
Plant isobutane:				
At plants	7,736	6,854	5,355	9,129
At refineries	273	206	261	1,272
Total plant isobutane stocks	8,009	7,060	5,616	10,401
Refinery isobutane	32	17	40	92
Total stocks	8,041	7,077	5,656	10,493
Plant isobutane used at refineries	27,012	27,851	32,197	27,465
Domestic demand: Refinery isobutane for chemical use	1,125	1,721	1,498	1,825
Kerosine (including range oil):				
Production:				
At refineries	100,545	101,738	94,635	86,256
At gas processing plants	1,027	1,121	1,077	1,243
Total production	101,572	102,859	95,712	87,499
Stocks end of year:				
At refineries	23,190	26,531	27,564	24,237
At plants	290	249	284	201
Total stocks	23,480	26,780	27,848	24,438
Imports	190	965	1,451	189
Exports	613	155	121	181
Domestic demand	102,934	100,369	95,974	90,917
Distillate fuel oil:				
Production:				
At refineries	839,373	846,863	895,656	910,727
At gas processing plants	1,308	1,541	1,441	1,370
Total production	840,681	848,404	897,097	912,097
Crude used directly as distillate	712	654	743	1,548
Stocks end of year:				
At refineries	173,093	171,664	[2] 195,213	[2] 190,584
At plants	65	50	58	38
Total stocks	173,158	171,714	195,271	190,622
Imports	48,148	50,883	53,826	55,783
Exports	1,547	1,123	898	2,757
Domestic demand	874,539	900,262	927,211	971,320
Residual fuel oil:				
Production	275,814	265,906	257,510	274,684
Crude used directly as residual	4,272	4,334	4,317	4,565
Stocks end of year	65,359	58,395	53,994	59,681
Imports	409,928	461,611	557,845	577,525
Exports	20,013	16,891	19,785	13,218
Domestic demand	668,239	721,924	804,288	837,869

See footnotes at end of table.

Table 31.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1968	1969	1970	1971 p
Petrochemical feedstocks (excluding LRG): [3]				
Production	95,422	98,356	100,381	110,948
Stocks end of year	2,945	2,845	3,619	3,886
Imports: Naphtha—400°	--	40	5,352	5,109
Exports: Other	2,795	3,848	3,776	5,269
Domestic demand:				
Still gas	9,844	9,985	12,564	16,158
Naphtha—400°	55,618	57,569	57,279	56,821
Other	27,474	27,094	31,340	37,542
Total domestic demand	92,936	94,648	101,183	110,521
Special naphthas:				
Production:				
At refineries	27,643	28,397	30,196	28,255
At gas processing plants	473	492	384	329
Total production	28,116	28,889	30,580	28,584
Stocks end of year:				
At refineries	5,816	6,281	6,184	5,373
At plants	13	11	9	11
Total stocks	5,829	6,292	6,193	5,384
Imports	1,399	3,191	2,297	1,838
Exports	2,427	2,019	1,586	1,450
Domestic demand	27,007	29,598	31,390	29,781
Lubricants:				
Production	65,684	65,080	66,183	65,473
Stocks end of year	14,023	14,088	14,712	15,049
Imports	33	163	224	10
Exports:				
Grease	298	257	293	234
Oil	17,703	16,139	15,797	15,534
Total exports	18,001	16,396	16,090	15,768
Domestic demand	48,467	48,782	49,693	49,378
Wax (1 barrel = 280 pounds):				
Production	5,887	6,049	6,294	6,939
Stocks end of year	1,001	997	993	1,117
Imports	17	158	117	93
Exports	1,588	1,623	1,808	1,654
Domestic demand	4,360	4,588	4,607	5,254
Coke (5 barrels = 1 short ton):				
Production:				
Marketable coke	45,823	52,006	59,107	62,313
Catalyst coke	49,367	50,862	48,764	46,801
Total production	95,190	102,868	107,871	109,114
Stocks end of year	6,195	5,198	5,297	7,445
Exports	19,497	23,035	30,557	26,992
Domestic demand	76,319	80,830	77,215	79,974
Asphalt (5.5 barrels = 1 short ton):				
Production	135,460	135,691	146,658	157,039
Stocks end of year	20,055	16,753	15,779	21,202
Imports	6,236	4,761	6,201	7,216
Exports	429	464	356	304
Domestic demand	141,151	143,290	153,477	158,528
Road oil:				
Production	6,826	9,086	9,393	8,755
Stocks end of year	550	880	632	900
Domestic demand	7,080	8,756	9,641	8,487
Still gas for fuel: Production	149,796	160,363	163,905	156,967
Miscellaneous products:				
Production:				
At refineries	15,711	17,139	14,746	14,271
At gas processing plants	3,385	805	924	1,156
Total production	19,096	17,944	15,670	15,427
Stocks end of year:				
At refineries	1,931	2,345	2,105	1,593
At plants	25	19	15	11
Total stocks	1,956	2,364	2,120	1,604
Exports	1,049	919	1,071	1,023
Domestic demand	17,842	16,617	14,843	14,920

See footnotes at end of table.

Table 31.—Salient statistics of the major refined petroleum products in the United States—Continued

Product	1968	1969	1970	1971
Unfinished oils (net):				
Input (+) Output (−)	+26,152	+34,346	+38,091	+43,608
Stocks end of year	93,399	97,819	98,989	100,574
Imports	29,350	38,766	39,261	45,193

p Preliminary. NA Not available.

[1] Includes underground stocks at plants and refineries, in thousands of barrels. At plants: ethane, 1970, 810; 1971, 2,431; propane, 1970, 31,924; 1971, 49,721; butane, 1970, 10,902; 1971, 11,178; butane-propane mixture, 1970, 291; 1971, 271; and isobutane, 1970, 4,317; 1971, 8,403. At refineries (includes LRG): propane, 1970, 2,153; 1971, 5,235; butane, 1970, 1,679; 1971, 2,528; butane-propane mixture, 1970, 127; 1971, 370; and isobutane, 1970, 766; 1971, 1,218.

[2] Includes No. 4 fuel oil, in thousands of barrels: 1970, 4,276; 1971, 5,160. Data for previous years are not available.

[3] Produced at petroleum refineries. Data for LRG for petrochemical feedstocks are included with those for "Liquefied gases."

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 32.—Stocks of refined petroleum products (including unfinished oils) in the United States at end of month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1970												
Gasoline:												
Motor	225,564	232,916	235,189	230,370	221,338	210,152	196,863	191,722	194,622	189,906	198,925	209,255
Aviation	6,251	5,887	5,604	5,354	5,058	4,745	5,081	4,654	4,703	4,559	5,040	5,093
Total	231,815	238,803	240,793	235,724	226,396	214,897	201,944	196,376	199,325	194,465	203,965	214,348
Jet fuel:												
Naphtha type	8,221	7,962	7,361	7,321	7,625	7,749	7,522	7,881	7,771	7,409	7,838	6,621
Kerosine type	18,877	18,471	19,839	21,908	21,731	21,834	22,480	22,726	22,444	23,386	22,288	20,989
Total	27,098	26,433	27,200	29,229	29,356	29,583	30,002	30,607	30,215	30,795	30,126	27,610
Ethane (including ethylene)	2,110	1,998	2,117	2,265	2,249	2,303	2,355	2,179	1,925	1,516	1,360	1,319
Liquefied gases [1]	40,273	34,962	35,514	41,217	52,380	60,883	67,637	74,176	78,712	78,285	73,286	65,724
Kerosine	20,398	17,956	18,499	20,785	22,851	26,254	27,749	29,592	30,295	31,012	31,517	27,848
Distillate fuel oil	130,726	111,523	100,983	102,061	115,846	137,506	163,469	188,169	205,674	216,386	218,138	195,271
Residual fuel oil	49,544	46,068	40,320	42,791	44,664	46,036	47,886	48,141	53,954	57,130	58,823	53,994
Petrochemical feedstocks	3,516	3,435	3,489	3,424	3,539	3,359	3,610	3,694	3,542	3,695	3,733	3,619
Special naphthas	6,372	6,243	6,518	6,193	6,302	6,042	5,915	5,631	5,325	5,430	5,888	6,193
Lubricants	14,292	14,456	14,105	13,809	14,127	13,640	13,274	13,710	14,014	13,644	14,237	14,712
Wax	998	976	939	1,014	1,041	1,072	1,052	1,087	1,070	955	1,013	993
Coke	5,937	5,865	5,385	5,661	4,831	4,830	5,192	5,256	5,469	5,407	5,180	5,297
Asphalt	19,516	21,587	24,779	25,758	24,912	21,338	17,290	13,962	11,643	11,141	13,175	15,779
Road oil	769	890	1,196	1,377	1,580	1,517	1,283	1,077	772	557	554	632
Miscellaneous	2,018	1,981	1,831	1,545	1,679	1,928	1,730	1,893	1,743	1,884	1,995	2,120
Unfinished oils	99,739	98,488	101,720	106,009	107,854	108,058	106,050	105,414	99,322	100,751	102,081	98,989
Total 1970	655,121	631,664	625,388	638,862	659,607	679,246	696,438	720,964	743,000	753,053	765,071	734,448
1971												
Gasoline:												
Motor	232,079	245,310	245,659	230,349	221,714	209,595	203,010	204,225	207,885	208,525	208,959	219,352
Aviation	4,943	5,206	4,906	4,641	4,518	4,376	4,177	4,149	4,430	4,372	4,604	4,419
Total	237,022	250,516	250,565	234,990	226,232	213,971	207,187	208,374	212,315	212,897	213,563	223,771
Jet fuel:												
Naphtha type	6,910	7,040	6,917	6,606	6,692	6,934	7,202	6,681	6,645	6,795	7,005	6,990
Kerosine type	20,680	19,992	20,214	20,658	21,822	21,819	21,645	21,015	21,437	20,364	20,934	20,747
Total	27,590	27,032	27,131	27,264	28,514	28,753	28,847	27,696	28,082	27,159	27,939	27,737
Ethane (including ethylene)	1,331	1,511	1,844	2,066	2,083	2,034	2,110	2,372	2,310	2,739	3,076	3,365
Liquefied gases [1]	53,394	46,454	49,166	58,220	70,813	81,840	93,021	101,603	105,836	106,644	100,516	91,348
Kerosine	23,921	19,662	19,231	19,539	21,610	23,602	26,392	28,030	27,806	28,218	26,765	24,438
Distillate fuel oil	158,740	128,706	112,872	113,693	125,815	145,790	172,373	196,973	210,136	222,969	214,780	190,622
Residual fuel oil	53,878	48,900	49,425	50,623	55,371	58,735	63,716	65,904	66,519	68,547	59,934	59,681
Petrochemical feedstocks	3,104	3,260	3,160	3,343	3,297	3,471	3,503	3,290	3,318	3,199	3,246	3,886
Special naphthas	6,213	6,029	5,682	5,727	5,448	5,308	5,208	5,279	4,997	5,212	5,463	5,384
Lubricants	15,152	15,172	15,463	15,167	15,446	15,375	15,148	14,805	15,044	14,874	14,913	15,049
Wax	1,071	1,088	1,037	1,041	1,070	1,095	1,104	1,070	1,070	1,066	1,120	1,117

Coke	5,443	5,636	5,850	5,753	6,242	5,959	6,596	7,693	9,499	8,967	7,919	7,445
Asphalt	19,667	22,732	25,500	27,743	28,282	25,243	23,840	20,159	18,077	16,512	17,593	21,202
Road oil	1,039	1,303	1,751	1,970	2,070	1,777	1,659	1,333	1,056	944	879	900
Miscellaneous	1,872	1,804	1,732	1,707	1,835	1,756	1,653	1,683	1,747	1,787	1,685	1,604
Unfinished oils	94,379	90,562	90,492	98,636	100,648	102,891	103,625	100,322	99,378	103,355	103,921	100,574
Total 1971	703,816	670,367	660,901	667,482	694,776	717,600	755,982	786,586	807,190	825,089	803,312	778,123

[1] Includes LRG used for petrochemical feedstocks.

Table 33.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1967	1968	1969	1970	1971 p
INPUT					
Crude petroleum:					
Domestic	3,174,004	3,308,044	3,363,602	3,485,332	3,481,543
Foreign	408,590	[1] 466,316	[1] 516,003	[1] 482,171	[1] 606,266
Total crude petroleum	3,582,594	3,774,360	3,879,605	3,967,503	4,087,809
Unfinished oils rerun (net)	34,237	26,152	34,346	38,091	43,608
Total crude and unfinished oils rerun	3,616,831	3,800,512	3,913,951	4,005,594	4,131,417
Natural gas liquids:					
Liquefied petroleum gases	68,675	72,652	72,764	80,307	79,695
Natural gasoline	138,521	148,132	157,492	163,976	166,222
Plant condensate	37,524	38,552	34,332	34,051	39,020
Total natural gas liquids	244,720	259,336	264,588	278,334	284,937
Other hydrocarbons and hydrogen [2]	87	3,377	4,213	6,238	6,074
OUTPUT					
Gasoline:					
Motor gasoline [3]	1,801,448	1,902,264	1,995,947	2,080,199	2,179,093
Aviation gasoline	37,074	31,563	26,460	19,712	18,457
Total gasoline [3]	1,838,522	1,933,827	2,022,407	2,099,911	2,197,550
Jet fuel:					
Naphtha type [3]	109,650	121,165	104,748	84,060	85,317
Kerosine type	163,535	193,486	216,952	217,832	219,348
Total jet fuel [3]	273,185	314,651	321,700	301,892	304,665
Ethane (including ethylene)	7,028	9,446	9,159	9,460	9,266
Liquefied refinery gas:					
For fuel use	67,589	71,102	75,659	80,870	88,648
For chemical use	36,900	37,539	38,703	35,657	32,304
Total liquefied refinery gas	104,489	108,641	114,362	116,527	120,952
Kerosine [3]	99,061	100,545	101,738	94,635	86,256
Distillate fuel oil [3]	804,429	839,373	846,863	895,656	910,727
Residual fuel oil	275,956	275,814	265,906	257,510	274,684
Petrochemical feedstocks:					
Still gas	9,500	9,844	9,985	12,564	16,158
Naphtha—400°	50,573	55,077	57,389	54,154	54,096
Other	27,355	30,501	30,982	33,663	40,694
Total petrochemical feedstocks	87,428	95,422	98,356	100,381	110,948
Special naphthas [3]	26,912	27,643	28,397	30,196	28,255
Lubricants	64,870	65,684	65,080	66,183	65,473
Wax [4]	5,719	5,887	6,049	6,294	6,939
Coke [4]	90,933	95,190	102,868	107,871	109,114
Asphalt [4]	127,767	135,460	135,691	146,658	157,039
Road oil	6,978	6,826	9,086	9,393	8,755
Still gas for fuel	140,034	149,796	160,363	163,905	156,967
Miscellaneous [3]	14,919	15,711	17,139	14,746	14,271
Processing gain (−) or loss (+)	−106,592	−116,691	−122,412	−131,052	−139,433

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Benzol included for 1967 only. "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 natural gasoline 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 34.—Input and output at refineries in the United States, by month

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
INPUT 1970													
Crude petroleum:													
Domestic	292,385	259,432	291,919	281,533	288,280	286,741	294,960	304,018	290,538	298,766	292,569	304,191	3,485,332
Foreign	44,537	45,348	43,955	36,839	35,697	39,425	40,522	37,684	39,755	37,875	38,059	42,475	[1] 482,171
Total crude petroleum	336,922	304,780	335,874	318,372	323,977	326,166	335,482	341,702	330,293	336,641	330,628	346,666	3,967,503
Unfinished oils rerun (net)	1,969	4,484	743	−1,374	1,434	2,675	4,951	3,112	9,095	1,174	1,450	8,378	38,091
Total crude and unfinished oils rerun	338,891	309,264	336,617	316,998	325,411	328,841	340,433	344,814	339,388	337,815	332,078	355,044	4,005,594
Natural gas liquids:													
Liquefied petroleum gases	7,711	6,706	6,357	5,561	5,105	5,283	5,821	5,602	6,107	7,799	8,399	9,856	80,307
Natural gasoline	13,184	12,309	13,216	13,092	13,428	13,760	14,495	14,617	13,866	14,605	13,458	13,946	163,976
Plant condensate	2,831	2,654	3,058	2,756	2,896	2,976	2,668	2,815	2,781	2,870	2,941	2,805	34,051
Total natural gas liquids	23,726	21,669	22,631	21,409	21,429	22,019	22,984	23,034	22,754	25,274	24,798	26,607	278,334
Other hydrocarbons	403	450	469	350	358	437	540	956	468	583	745	479	6,238
OUTPUT 1970													
Gasoline:													
Motor gasoline [2]	174,626	155,296	171,404	162,272	170,382	171,992	178,072	180,639	178,516	175,670	173,331	187,999	2,080,199
Aviation gasoline	1,442	1,252	1,574	1,585	1,631	1,335	2,034	1,894	1,880	1,577	1,828	1,680	19,712
Total gasoline [2]	176,068	156,548	172,978	163,857	172,013	173,327	180,106	182,533	180,396	177,247	175,159	189,679	2,099,911
Jet fuel:													
Naphtha type [2]	6,128	6,677	6,633	6,558	6,627	6,362	8,523	7,809	7,496	7,100	7,426	6,721	84,060
Kerosine type	17,733	17,358	19,718	17,932	17,076	18,515	18,339	18,802	18,447	18,921	17,168	17,823	217,832
Total jet fuel [2]	23,861	24,035	26,351	24,490	23,703	24,877	26,862	26,611	25,943	26,021	24,594	24,544	301,892
Ethane (including ethylene)	904	798	895	758	763	817	820	727	800	774	674	730	9,460
Liquefied gases:													
LRG for fuel use	6,781	6,506	6,635	6,557	6,938	6,690	7,221	7,076	6,626	6,238	6,568	7,034	80,870
LRG for chemical use	3,038	2,951	3,048	3,140	3,149	3,049	3,206	2,658	2,703	3,059	2,879	2,777	35,657
Total liquefied gases	9,819	9,457	9,683	9,697	10,087	9,739	10,427	9,734	9,329	9,297	9,447	9,811	116,527
Kerosine [2]	10,134	9,052	9,372	7,429	6,966	7,344	6,160	6,436	6,143	8,063	9,127	8,409	94,635
Distillate fuel oil [2]	79,353	71,762	77,541	70,674	70,658	72,165	73,391	74,704	73,270	76,586	75,145	80,407	895,656
Residual fuel oil	25,963	23,947	23,639	19,829	17,676	17,020	17,688	20,670	19,868	20,044	22,230	28,936	257,510
Petrochemical feedstocks:													
Still gas	850	825	875	1,062	1,309	1,250	1,019	1,052	929	1,131	968	1,294	12,564
Naphtha—400°	4,844	5,053	4,829	3,515	4,795	3,950	4,762	4,144	4,544	4,432	4,361	4,925	54,154
Other	2,623	2,617	3,238	2,940	2,804	2,657	2,862	2,850	2,765	2,742	2,724	2,841	33,663
Total petrochcmieal feedstocks	8,317	8,495	8,942	7,517	8,908	7,857	8,643	8,046	8,238	8,305	8,053	9,060	100,381

See footnotes at end of table.

Table 34.—Input and output at refineries in the United States, by month—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Special naphthas [2]	2,210	2,183	2,407	2,621	2,609	2,427	2,511	2,605	2,405	2,810	2,627	2,781	30,196
Lubricants:													
Bright stock	563	575	713	672	556	605	608	722	594	738	611	590	7,547
Neutral	2,416	1,966	2,271	2,354	2,424	2,298	2,444	2,615	2,431	2,453	2,517	2,584	28,773
Other grades	2,503	2,195	2,473	2,423	2,620	2,439	2,424	2,345	2,604	2,415	2,675	2,747	29,863
Total lubricants	5,482	4,736	5,457	5,449	5,600	5,342	5,476	5,682	5,629	5,606	5,803	5,921	66,183
Wax:													
Microcrystalline	89	103	104	100	100	103	103	109	77	113	93	97	1,191
Crystalline-fully refined	206	203	227	252	236	276	235	236	310	194	223	262	2,860
Crystalline-other	158	150	171	263	182	214	168	164	195	183	195	200	2,243
Total wax [3]	453	456	502	615	518	593	506	509	582	490	511	559	6,294
Coke [3]	9,278	8,215	8,482	9,170	8,638	9,643	9,643	9,091	8,997	8,777	8,714	9,223	107,871
Asphalt [3]	6,790	6,695	9,303	10,824	12,996	14,452	16,071	16,546	15,573	14,981	12,292	10,135	146,658
Road oil	130	228	498	581	1,113	1,246	1,645	1,533	1,024	719	426	250	9,393
Still gas for fuel	14,283	13,742	13,284	13,739	13,218	13,548	14,259	14,527	13,917	12,823	13,004	13,561	163,905
Miscellaneous products [2]	1,277	1,123	1,306	1,094	1,261	1,238	1,087	1,146	1,243	1,183	1,317	1,471	14,746
Processing gain (−) or loss (+)	−11,302	−10,089	−10,923	−9,587	−9,529	−10,338	−11,338	−12,296	−10,747	−10,054	−11,502	−13,347	−131,052
INPUT 1971 p													
Crude petroleum:													
Domestic	305,620	276,397	304,104	292,953	287,682	293,854	302,703	294,498	276,284	288,419	270,829	288,200	3,481,543
Foreign	39,316	35,869	40,974	43,269	45,117	50,651	52,304	57,907	57,750	57,097	62,732	63,280	[1] 606,266
Total crude petroleum	344,936	312,266	345,078	336,222	332,799	344,505	355,007	352,405	334,034	345,516	333,561	351,480	4,087,809
Unfinished oils rerun (net)	+7,629	+6,408	+2,744	−4,876	+1,008	+1,284	+3,686	+7,989	+5,311	+381	+3,318	+8,726	+43,608
Total crude and unfinished oils rerun	352,565	318,674	347,822	331,346	333,807	345,789	358,693	360,394	339,345	345,897	336,879	360,206	4,131,417
Natural gas liquids:													
Liquefied petroleum gases	8,269	7,129	6,208	5,224	5,030	5,053	5,382	5,439	6,134	7,708	8,663	9,456	79,695
Natural gasoline	14,103	12,881	14,088	12,991	14,322	14,340	14,330	14,543	13,697	13,641	13,272	14,014	166,222
Plant condensate	2,858	2,697	3,151	2,944	2,772	3,505	3,440	3,328	3,746	3,703	2,967	3,909	39,020
Total natural gas liquids	25,230	22,707	23,447	21,159	22,124	22,898	23,152	23,310	23,577	25,052	24,902	27,379	284,937
Other hydrocarbons	448	343	449	478	430	532	552	443	439	732	563	665	6,074
OUTPUT 1971 p													
Gasoline:													
Motor gasoline [2]	183,378	164,880	178,914	168,447	172,357	179,508	190,748	194,323	183,649	186,145	181,268	195,476	2,179,093
Aviation gasoline	1,387	1,686	1,372	1,509	1,467	1,457	1,486	1,853	2,093	1,587	1,490	1,070	18,457
Total gasoline [2]	184,765	166,566	180,286	169,956	173,824	180,965	192,234	196,176	185,742	187,732	182,758	196,546	2,197,550
Jet fuel:													
Naphtha type [2]	6,787	6,472	7,087	7,098	7,176	7,061	6,880	6,627	7,553	7,390	7,645	7,541	85,317
Kerosine type	19,111	17,209	19,236	18,021	18,581	18,269	17,512	18,246	17,490	18,878	18,490	18,305	219,348
Total jet fuel [2]	25,898	23,681	26,323	25,119	25,757	25,330	24,392	24,873	25,043	26,268	26,135	25,846	304,665

Ethane (including ethylene)	797	727	761	777	682	840	745	772	679	765	853	868	9,266
Liquefied gases:													
LRG for fuel use	7,113	6,967	7,916	7,566	7,665	7,759	7,849	8,402	6,811	6,872	6,315	7,413	88,648
LRG for chemical use	2,445	2,386	2,763	2,649	2,688	2,819	2,866	2,641	2,589	2,805	2,799	2,854	32,304
Total liquefied gases	9,558	9,353	10,679	10,215	10,353	10,578	10,715	11,043	9,400	9,677	9,114	10,267	120,952
Kerosine [2]	9,352	8,332	8,228	6,577	5,839	6,443	7,082	5,993	5,496	7,095	7,011	8,808	86,256
Distillate fuel oil [2]	80,811	72,178	77,898	76,551	74,935	76,679	77,671	77,831	71,215	74,644	72,078	78,236	910,727
Residual fuel oil	31,321	27,099	26,533	22,238	18,978	20,042	19,964	19,176	19,742	19,719	22,295	27,577	274,684
Petrochemical feedstocks:													
Still gas	1,135	1,575	1,242	1,433	1,131	1,372	1,509	1,966	1,688	1,158	984	965	16,158
Naphtha—400°	4,372	4,549	4,864	4,801	4,378	4,442	3,898	4,204	4,128	5,014	4,210	5,236	54,096
Other	2,230	2,134	2,757	3,686	3,535	3,497	3,573	3,315	4,055	3,875	3,845	4,192	40,694
Total petrochemical feedstocks	7,737	8,258	8,863	9,920	9,044	9,311	8,980	9,485	9,871	10,047	9,039	10,393	110,948
Special naphthas [2]	2,370	1,979	2,651	2,314	2,253	2,270	2,495	2,185	2,309	2,746	2,371	2,312	28,255
Lubricants:													
Bright stock	526	613	534	631	675	653	526	478	610	619	652	590	7,107
Neutral	2,412	2,163	2,507	2,352	2,590	2,392	2,548	2,773	2,274	2,366	2,508	2,426	29,311
Other grades	2,324	2,165	2,750	2,680	2,438	2,716	2,647	2,351	2,322	2,522	1,979	2,161	29,055
Total lubricants	5,262	4,941	5,791	5,663	5,703	5,761	5,721	5,602	5,206	5,507	5,139	5,177	65,473
Wax:													
Microcrystalline	92	87	109	109	89	96	93	96	209	82	111	71	1,244
Crystalline-fully refined	253	217	268	234	275	245	223	249	241	255	320	292	3,072
Crystalline-other	180	249	267	266	252	287	191	224	166	172	182	187	2,623
Total wax [3]	525	553	644	609	616	628	507	569	616	509	613	550	6,939
Coke [3]	9,013	8,259	9,267	9,159	9,015	9,106	9,173	9,749	8,933	9,263	8,914	9,263	109,114
Asphalt [3]	8,219	7,732	10,084	12,087	14,053	16,308	17,375	17,396	16,206	15,045	12,772	9,762	157,039
Road oil	529	345	594	519	792	975	1,361	1,367	897	665	434	277	8,755
Still gas for fuel	13,616	11,433	13,129	12,664	13,326	13,505	14,002	13,639	12,748	12,860	12,464	13,581	156,967
Miscellaneous products [2]	1,263	1,169	1,239	1,368	1,130	1,133	1,163	1,266	1,050	1,149	1,082	1,259	14,271
Processing gain (−) or loss(+)	−12,793	−10,881	−11,252	−12,753	−9,939	−10,655	−11,183	−12,975	−11,792	−12,010	−10,728	−12,472	−139,433

[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 35.—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., Wis., etc.	Okla., Kans., etc.	Total
INPUT 1970								
Crude petroleum:								
Domestic	237,178	20,462	257,640	21,183	666,357	23,573	326,930	1,038,043
Foreign	181,481	31,771	213,252	786	[1] 61,911	49,467	1,049	[1] 113,213
Total crude petroleum	418,659	52,233	470,892	21,969	728,268	73,040	327,979	1,151,256
Unfinished oils rerun (net)	+55,255	+674	+55,929	+172	−381	+14	−552	−747
Total crude and unfinished oils rerun	473,914	52,907	526,821	22,141	727,887	73,054	327,427	1,150,509
Natural gas liquids:								
Liquefied petroleum gases	2,155	12	2,167	60	10,838	3,038	11,808	25,744
Natural gasoline	2,428	3	2,431	--	9,459	857	11,196	21,512
Plant condensate	688	21	709	--	291	2,579	--	2,870
Total natural gas liquids	5,271	36	5,307	60	20,588	6,474	23,004	50,126
Other hydrocarbons	218	--	218	--	--	--	225	225
OUTPUT 1970								
Gasoline:								
Motor gasoline [2]	219,511	21,554	241,065	11,367	394,565	40,521	193,171	639,624
Aviation gasoline	530	--	530	--	1,705	--	439	2,144
Total gasoline [2]	220,041	21,554	241,595	11,367	396,270	40,521	193,610	641,768
Jet fuel:								
Naphtha type [2]	2,606	756	3,362	--	6,285	764	7,914	14,963
Kerosine type	11,108	894	12,002	8	31,706	1,028	11,840	44,582
Total jet fuel [2]	13,714	1,650	15,364	8	37,991	1,792	19,754	59,545
Ethane (including ethylene)	--	--	--	--	--	--	316	316
Liquefied gases:								
For fuel use	11,964	1,091	13,055	331	12,636	1,386	8,400	22,753
For chemical use	3,830	--	3,830	--	2,983	--	751	3,734
Total liquefied gases	15,794	1,091	16,885	331	15,619	1,386	9,151	26,487
Kerosine [2]	11,273	1,143	12,416	879	17,488	1,779	3,419	23,565
Distillate fuel oil [2]	127,280	12,938	140,218	5,523	152,920	18,630	77,962	255,035
Residual fuel oil	30,650	4,409	35,059	1,868	47,586	7,023	6,362	62,839
Petrochemical feedstocks:								
Still gas	1,764	--	1,764	--	1,660	--	50	1,710
Naphtha—400°	2,249	--	2,249	--	4,129	--	2,204	6,333
Other	610	737	1,347	--	2,935	--	507	3,442
Total petrochemical feedstocks	4,623	737	5,360	--	8,724	--	2,761	11,485
Special naphthas [2]	709	331	1,040	253	3,080	--	1,311	4,644
Lubricants:								
Bright stock	608	1,168	1,776	--	553	--	891	1,444
Neutral	3,393	1,976	5,369	17	2,390	--	3,642	6,049
Other grades	3,464	673	4,137	--	3,405	--	1,244	4,649
Total lubricants	7,465	3,817	11,282	17	6,348	--	5,777	12,142
Wax:								
Microcrystalline	333	198	531	--	27	--	257	284
Crystalline-fully refined	979	87	1,066	14	280	--	257	551
Crystalline-other	564	289	853	--	125	--	99	224
Total wax [3]	1,876	574	2,450	14	432	--	613	1,059
Coke [3]	11,986	151	12,137	39	18,500	3,072	9,181	30,792
Asphalt [3]	29,853	2,048	31,901	1,521	30,549	4,461	14,679	51,210
Road oil	--	669	669	--	4,069	246	1,013	5,328
Still gas for fuel	18,292	2,123	20,415	736	30,666	2,460	12,672	46,534
Miscellaneous products [2]	1,688	118	1,806	18	1,189	122	1,239	2,568
Processing gain (−) or loss (+)	−15,841	−410	−16,251	−373	−22,956	−1,964	−9,164	−34,457
INPUT 1971 p								
Crude petroleum:								
Domestic	217,562	19,325	236,887	19,538	671,712	23,195	327,016	1,041,461
Foreign	213,316	35,507	248,823	457	[1] 78,081	56,172	2,866	137,576
Total crude petroleum	430,878	54,832	485,710	19,995	749,793	79,367	329,882	1,179,037

See footnotes at end of table.

in the United States, by district

barrels)

PAD district III						PAD district IV	PAD district V	United States
Texas Inland	Texas Gulf	La. Gulf	Ark., La. Inland, etc.	N. Mex.	Total	Other Rocky Mt.	West Coast	
144,317	894,181	480,866	56,040	14,784	1,590,188	126,164	473,297	3,485,332
--	--	--	--	--	--	17,162	138,544	[1] 482,171
144,317	894,181	480,866	56,040	14,784	1,590,188	143,326	611,841	3,967,503
−242	−27,251	+1,416	+773	+59	−25,245	−280	+8,434	+38,091
144,075	866,930	482,282	56,813	14,843	1,564,943	143,046	620,275	4,005,594
8,638	20,981	11,796	804	717	42,936	3,562	5,898	80,307
14,962	84,731	25,487	820	345	126,345	1,830	11,858	163,976
--	24,974	2,212	2,749	--	29,935	59	478	34,051
23,600	130,686	39,495	4,373	1,062	199,216	5,451	18,234	278,334
91	93	465	--	--	649	135	5,011	6,238
91,206	463,284	244,268	26,986	8,141	833,885	73,680	291,945	2,080,199
2,058	5,574	3,672	--	--	11,304	443	5,291	19,712
93,264	468,858	247,940	26,986	8,141	845,189	74,123	297,236	2,099,911
8,648	13,539	8,372	1,654	1,863	34,076	3,932	27,727	84,060
9,180	49,646	39,033	--	158	98,017	3,943	59,288	217,832
17,828	63,185	47,405	1,654	2,021	132,093	7,875	87,015	301,892
102	5,283	3,130	--	--	8,515	--	629	9,460
3,372	15,525	13,310	1,091	534	33,832	2,291	8,939	80,870
277	16,160	7,346	257	--	24,040	--	4,053	35,657
3,649	31,685	20,656	1,348	534	57,872	2,291	12,992	116,527
1,501	32,097	19,756	1,361	110	54,825	2,042	1,787	94,635
25,787	228,836	120,587	14,239	2,897	392,346	34,587	73,470	895,656
4,308	36,925	15,599	3,101	409	60,342	9,100	90,170	257,510
--	7,855	--	--	--	7,855	135	1,100	12,564
1,471	38,567	1,709	5	--	41,752	--	3,820	54,154
2,984	6,599	17,051	234	--	26,868	214	1,792	33,663
4,455	53,021	18,760	239	--	76,475	349	6,712	100,381
1,061	16,835	550	1,036	--	19,482	145	4,885	30,196
--	1,837	694	--	--	2,531	48	1,748	7,547
--	7,653	6,386	1,053	--	15,092	191	2,072	28,773
137	17,345	963	840	--	19,285	136	1,656	29,863
137	26,835	8,043	1,893	--	36,908	375	5,476	66,183
89	185	96	--	--	370	6	--	1,191
--	512	361	--	--	873	47	323	2,860
--	614	279	--	--	893	31	242	2,243
89	1,311	736	--	--	2,136	84	565	6,294
2,325	18,599	13,122	2,213	117	36,376	3,385	25,181	107,871
7,204	9,037	12,138	6,629	980	35,988	8,840	18,719	146,658
135	53	--	--	--	188	1,849	1,359	9,393
6,236	34,239	15,521	2,066	564	58,626	5,134	33,196	163,905
1,146	5,508	1,339	19	--	8,012	81	2,279	14,746
−1,461	−34,598	−23,040	−1,598	+132	−60,565	−1,628	−18,151	−131,052
146,330	904,134	499,694	54,073	15,480	1,619,711	131,307	452,177	3,481,543
--	16,963	2,741	--	--	19,704	16,576	183,587	[1] 606,266
146,330	921,097	502,435	54,073	15,480	1,639,415	147,883	635,764	4,087,809

Table 35.—Input and output at refineries in

(Thousand

Item	PAD district I			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wis., etc.	Okla., Kans., etc.	Total
INPUT 1971 p—Continued								
Unfinished oils rerun (net)	+56,004	+97	+56,101	+63	−1,774	+65	−218	−1,864
Total crude and unfinished oils rerun	486,882	54,929	541,811	20,058	748,019	79,432	329,664	1,177,173
Natural gas liquids:								
Liquefied petroleum gases	954	24	978	--	11,230	3,179	10,222	24,631
Natural gasoline	2,035	6	2,041	--	7,231	977	11,508	19,716
Plant condensate	662	562	1,224	145	3,396	3,211	--	6,752
Total natural gas liquids	3,651	592	4,243	145	21,857	7,367	21,730	51,099
Other hydrocarbons	--	--	--	--	227	--	198	425
OUTPUT 1971 p								
Gasoline:								
Motor gasoline [2]	230,558	23,369	253,927	10,296	412,635	44,243	196,090	663,264
Aviation gasoline	471	--	471	--	1,874	--	478	2,352
Total gasoline [2]	231,029	23,369	254,398	10,296	414,509	44,243	196,568	665,616
Jet fuel:								
Naphtha type [2]	2,167	735	2,902	--	7,836	1,234	8,196	17,266
Kerosine type	11,409	740	12,149	--	34,289	1,496	10,962	46,747
Total jet fuel [2]	13,576	1,475	15,051	--	42,125	2,730	19,158	64,013
Ethane (including ethylene)	217	--	217	--	--	--	612	612
Liquefied gases:								
LRG for fuel use	11,578	1,212	12,790	367	14,097	1,460	7,524	23,448
LRG for chemical use	5,088	--	5,088	--	2,630	12	1,017	3,659
Total liquefied gases	16,666	1,212	17,878	367	16,727	1,472	8,541	27,107
Kerosine [2]	8,683	1,333	10,016	791	14,959	1,326	2,987	20,063
Distillate fuel oil [2]	123,809	12,995	136,804	5,520	157,394	20,673	77,598	261,185
Residual fuel oil	31,566	5,559	37,125	1,402	45,728	6,435	5,325	58,890
Petrochemical feedstocks:								
Still gas	1,355	18	1,373	--	1,769	118	61	1,948
Naphtha—400°	3,056	--	3,056	--	3,926	--	1,915	5,841
Other	103	456	559	--	2,307	14	428	2,749
Total petrochemical feedstocks	4,514	474	4,988	--	8,002	132	2,404	10,538
Special naphthas [2]	532	345	877	264	3,373	--	1,375	5,012
Lubricants:								
Bright stock	535	1,303	1,838	--	654	--	800	1,454
Neutral	3,786	2,235	6,021	8	2,644	--	3,187	5,839
Other grades	3,902	545	4,447	--	2,197	--	1,475	3,672
Total lubricants	8,223	4,083	12,306	8	5,495	--	5,462	10,965
Wax:								
Microcrystalline	371	200	571	--	127	--	235	362
Crystalline—fully refined	1,083	95	1,178	14	248	--	225	487
Crystalline-other	546	328	874	--	153	--	94	247
Total wax [3]	2,000	623	2,623	14	528	--	554	1,096
Coke [3]	11,785	150	11,935	--	18,045	3,104	9,900	31,049
Asphalt [3]	31,414	1,667	33,081	1,272	32,784	6,044	15,916	56,016
Still gas fuel	18,506	1,993	20,499	656	30,480	2,187	11,895	45,218
Road oil	28	662	690	--	3,383	216	935	4,534
Miscellaneous products [2]	1,961	128	2,089	18	1,468	133	1,004	2,623
Processing gain (−) or loss (+)	−13,976	−547	−14,523	−405	−24,897	−1,896	−8,642	−35,840

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.

the United States, by district—Continued

barrels)

PAD district III						PAD district IV	PAD district V	United States
Texas Inland	Texas Gulf	La. Gulf	Ark., La. Inland, etc.	N. Mex.	Total	Other Rocky Mt.	West Coast	
−1,302	−20,108	−237	+527	+62	−21,058	+137	+10,292	+43,608
145,028	900,989	502,198	54,600	15,542	1,618,357	148,020	646,056	4,131,417
8,397	17,416	15,205	753	757	42,528	3,306	8,252	79,695
15,569	88,498	25,929	797	379	131,172	1,619	11,674	166,222
--	17,301	2,468	2,421	--	22,190	4,718	4,136	39,020
23,966	123,215	43,602	3,971	1,136	195,890	9,643	24,062	284,937
327	227	2,004	--	--	2,558	204	2,887	6,074
95,814	494,765	263,308	24,378	8,594	886,859	77,577	297,466	2,179,093
1,719	6,117	2,896	--	--	10,732	474	4,428	18,457
97,533	500,882	266,204	24,378	8,594	897,591	78,051	301,894	2,197,550
8,388	13,156	10,070	1,755	1,980	35,349	3,929	25,871	85,317
8,474	48,280	40,297	12	52	97,115	4,413	58,924	219,348
16,862	61,436	50,367	1,767	2,032	132,464	8,342	84,795	304,665
97	4,395	3,334	--	--	7,826	--	611	9,266
3,436	19,283	14,313	1,076	520	38,628	2,347	11,435	88,648
167	12,535	5,992	318	--	19,012	26	4,519	32,304
3,603	31,818	20,305	1,394	520	57,640	2,373	15,954	120,952
1,495	33,450	16,448	885	94	52,372	2,104	1,701	86,256
26,251	224,300	121,334	13,767	3,091	388,743	38,054	85,941	910,727
3,020	37,494	16,585	3,246	549	60,894	9,886	107,889	274,684
8	7,796	--	--	--	7,804	145	4,888	16,158
1,487	37,125	1,443	--	--	40,055	--	5,144	54,096
2,871	13,392	19,444	129	--	35,836	227	1,323	40,694
4,366	58,313	20,887	129	--	83,695	372	11,355	110,948
1,057	14,367	404	1,126	1	16,955	205	5,206	28,255
--	1,767	685	--	--	2,452	45	1,318	7,107
--	8,297	5,971	773	--	15,041	204	2,206	29,311
87	16,584	1,221	1,185	--	19,077	163	1,696	29,055
87	26,648	7,877	1,958	--	36,570	412	5,220	65,473
75	176	49	--	--	300	11	--	1,244
--	553	396	--	--	949	59	399	3,072
--	795	492	--	--	1,287	22	193	2,623
75	1,524	937	--	--	2,536	92	592	6,939
2,405	20,342	13,041	2,065	111	37,964	3,046	25,120	109,114
6,757	9,556	14,548	7,207	932	39,000	9,914	19,028	157,039
180	7	--	--	--	187	1,878	1,466	8,755
4,959	35,530	17,495	1,929	547	60,460	4,963	25,827	156,967
2,138	4,317	711	18	--	7,184	88	2,287	14,271
−1,564	−39,948	−22,673	−1,298	+207	−65,276	−1,913	−21,881	−139,433

Table 36.—Percentage yields of refined petroleum products from crude oil in the United States [1]

Finished products	1967	1968	1969	1970	1971 p
Gasoline	44.0	43.9	44.8	45.3	46.2
Jet fuel	7.5	8.3	8.2	7.5	7.4
Ethane (including ethylene)	(2)	(2)	.2	.2	.2
Liquefied gases	3.1	3.1	2.9	3.0	2.9
Kerosine	2.7	2.7	2.6	2.3	2.1
Distillate fuel oil	22.2	22.1	21.7	22.4	22.0
Residual fuel oil	7.7	7.2	6.8	6.4	6.6
Petrochemical feedstocks	2.4	2.5	2.5	2.5	2.7
Special naphthas	.8	.7	.7	.8	.7
Lubricants	1.8	1.7	1.7	1.6	1.6
Wax	.2	.2	.2	.2	.2
Coke	2.5	2.5	2.6	2.7	2.6
Asphalt	3.5	3.6	3.5	3.6	3.8
Road oil	.2	.1	.2	.3	.2
Still gas	3.9	4.0	4.1	4.1	3.8
Miscellaneous	.4	.4	.4	.3	.4
Shortage	−2.9	−3.0	−3.1	−3.2	−3.4
Total	100.0	100.0	100.0	100.0	100.0

p Preliminary.
[1] Other unfinished oils added to crude in computing yields.
[2] Included with liquefied gases.

Table 37.—Salient statistics of motor gasoline in the United States, by month and district

(Thousand barrels)

	1970						1971 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	174,626	432	1,936	24	225,564	162,605	183,378	479	2,158	18	232,079	163,173
February	155,296	404	1,240	36	232,916	149,552	164,880	438	1,309	27	245,310	153,369
March	171,404	426	2,146	31	235,189	171,672	178,914	465	1,991	18	245,659	181,003
April	162,272	400	2,086	51	230,370	169,526	168,447	433	1,893	135	230,349	185,948
May	170,382	453	1,873	28	221,338	181,712	172,357	456	1,566	40	221,714	182,974
June	171,992	447	2,200	39	210,152	185,786	179,508	406	1,541	31	209,595	193,543
July	178,072	473	1,862	45	196,863	193,651	190,748	429	1,652	21	203,010	199,393
August	180,639	459	1,949	45	191,722	188,143	194,323	429	1,676	29	204,225	195,184
September	178,516	443	2,008	33	194,622	178,034	183,649	381	1,718	21	207,885	182,067
October	175,670	451	2,317	40	189,906	183,114	186,145	422	1,115	10	208,525	187,032
November	173,331	469	2,349	45	198,925	167,085	181,268	303	2,304	27	208,959	183,414
December	187,999	490	2,354	44	209,255	180,469	195,476	382	2,735	21	219,352	188,179
Total	2,080,199	5,347	24,320	461	209,255	2,111,349	2,179,093	5,023	21,658	398	219,352	2,195,279
By refining district:												
East Coast	219,511	--			51,937		230,558	--			55,296	
Appalachian No. 1	21,554	--	24,006	3	6,031	725,638	23,369	--	21,425	6	6,097	740,617
Appalachian No. 2	11,367	--			3,183		10,296	--			3,385	
Indiana, Illinois, Kentucky, etc	394,565	--	65	74	34,666	737,223	412,635	--	--	3	35,702	763,630
Minnesota, Wisconsin, etc	40,521	--			7,341		44,243	--			7,515	
Oklahoma, Kansas, etc	193,171	26			18,314		196,090	1			18,675	
Texas Inland	91,206	864			9,187		95,814	829			9,254	
Texas Gulf Coast	463,284	212			24,249		494,765	170			29,751	
Louisiana Gulf Coast	244,268	1,728	--	164	14,084	270,537	263,308	1,658	--	145	13,642	301,105
Arkansas, Louisiana Inland, etc	26,986	2,517			8,799		24,378	2,365			7,757	
New Mexico	8,141	--			719		8,594	--			856	
Rocky Mountain	73,680	--	--	12	6,117	63,868	77,577	--	--	--	6,443	72,596
West Coast	291,945	--	249	208	24,628	314,083	297,466	--	233	244	24,979	317,331
Total	2,080,199	5,347	24,320	461	209,255	2,111,349	2,179,093	5,023	21,658	398	219,352	2,195,279

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[1] Includes stocks of gasoline at refineries, bulk terminals and pipelines, and gas processing plants.

Table 38.—Production (refinery output) and consumption of gasoline (excluding naphtha) in the United States, by State

(Thousand barrels)

	1969		1970		1971 p	
	Production	Consumption [1]	Production	Consumption [1]	Production	Consumption [1]
Alabama	(2)	36,042	(2)	38,155	(2)	40,336
Alaska	--	2,449	--	2,430	140	2,559
Arizona	--	20,527	--	22,649	--	24,008
Arkansas	14,515	22,092	15,257	23,019	13,580	24,565
California	[3] 281,936	210,903	[3] 297,236	219,693	[3] 301,754	227,060
Colorado	6,736	24,445	7,116	26,523	8,018	28,385
Connecticut	--	27,638	--	29,026	--	30,238
Delaware	(4)	6,024	(4)	6,305	(4)	6,485
District of Columbia	--	5,670	--	5,705	--	5,811
Florida	--	72,790	--	78,761	--	84,671
Georgia	--	52,149	--	55,206	--	59,182
Hawaii	(3)	5,254	(3)	5,439	(3)	5,908
Idaho	--	9,259	--	9,791	--	10,282
Illinois	132,838	103,067	152,576	105,323	168,937	109,818
Indiana	95,955	57,922	97,576	60,045	93,782	62,267
Iowa	--	36,182	--	36,350	--	38,523
Kansas	[5] 98,123	32,619	[5] 98,674	32,816	[5] 99,525	32,566
Kentucky	[6] 24,509	32,641	[6] 26,837	34,373	[6] 30,420	36,693
Louisiana	[r] 211,166	34,532	224,772	35,763	236,883	37,204
Maine	--	10,715	--	11,220	--	11,801
Maryland	--	35,238	--	37,626	--	39,874
Massachusetts	--	47,075	--	49,891	--	51,611
Michigan	26,560	95,956	26,804	99,619	27,399	102,688
Minnesota	25,719	43,776	25,788	45,412	29,552	47,808
Mississippi	[r 2] 33,116	23,905	[2] 34,897	24,952	[2] 40,119	26,352
Missouri	(5)	54,567	(5)	57,016	(5)	60,653
Montana	21,397	9,664	22,233	10,125	23,922	10,598
Nebraska	(5)	19,975	(5)	20,225	(5)	21,202
Nevada	--	7,054	--	7,693	--	8,141
New Hampshire	--	7,723	--	8,295	--	8,844
New Jersey	89,418	64,363	84,232	67,510	88,276	69,758
New Mexico	8,244	12,944	8,141	13,431	8,594	14,866
New York	13,686	150,120	14,396	149,777	15,281	156,761
North Carolina	--	55,183	--	57,650	--	60,702
North Dakota	[7] 13,853	9,109	[7] 14,733	9,060	[7] 14,691	9,311
Ohio	104,533	105,053	103,844	109,519	104,267	112,344
Oklahoma	91,460	35,398	94,936	37,490	97,043	38,232
Oregon	--	23,874	--	25,336	--	26,722
Pennsylvania	[4] 139,813	100,946	[4] 135,396	103,472	[4] 141,943	107,120
Rhode Island	--	7,942	--	8,240	--	9,512
South Carolina	--	27,346	--	29,066	--	31,511
South Dakota	--	9,899	--	10,143	--	10,594
Tennessee	(6)	41,806	(6)	43,359	(6)	46,378
Texas	534,286	149,737	562,122	152,226	598,415	159,997
Utah	21,526	14,021	22,158	14,372	22,678	15,391
Vermont	--	4,772	--	5,115	--	5,413
Virginia	(8)	48,020	(8)	50,862	(8)	53,992
Washington	(3)	35,595	(3)	36,721	(3)	37,671
West Virginia	[8] 9,624	15,603	[8] 7,571	16,526	[8] 8,898	17,134
Wisconsin	(7)	44,210	(7)	46,386	(7)	48,113
Wyoming	23,394	5,760	22,616	6,085	23,433	6,322
Total	2,022,407	2,109,554	2,099,911	2,191,692	2,197,550	2,293,977

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1 American Petroleum Institute.
2 Alabama included with Mississippi.
3 Washington and Hawaii included with California.
4 Delaware included with Pennsylvania.
5 Nebraska and Missouri included with Kansas.
6 Tennessee included with Kentucky.
7 Wisconsin included with North Dakota.
8 Virginia included with West Virginia.

Table 39.—Salient statistics of aviation gasoline in the United States, by month and refining district

(Thousand barrels)

	1970				1971 p			
	Production	Exports	Stocks (end of period)	Domestic demand	Production	Exports	Stocks (end of period)	Domestic demand
By month:								
January	1,442	41	6,251	1,343	1,387	115	4,943	1,422
February	1,252	194	5,887	1,422	1,686	227	5,206	1,196
March	1,574	101	5,604	1,756	1,372	65	4,906	1,607
April	1,585	69	5,354	1,766	1,509	79	4,641	1,695
May	1,631	75	5,058	1,852	1,467	63	4,518	1,527
June	1,335	52	4,745	1,596	1,457	73	4,376	1,526
July	2,034	112	5,081	1,586	1,486	109	4,177	1,576
August	1,894	32	4,654	2,289	1,853	66	4,149	1,815
September	1,880	56	4,703	1,775	2,093	236	4,430	1,576
October	1,577	76	4,559	1,645	1,587	35	4,372	1,610
November	1,828	38	5,040	1,309	1,490	76	4,604	1,182
December	1,680	63	5,093	1,564	1,070	98	4,419	1,157
Total	19,712	909	5,093	19,903	18,457	1,242	4,419	17,889
By refining districts:								
East Coast	530	29 (East Coast and Appalachian No. 1)	745	4,265 (East Coast and Appalachian No. 1)	471	47 (East Coast and Appalachian No. 1)	619	5,254 (East Coast and Appalachian No. 1)
Appalachian No. 1	--		74		--		49	
Appalachian No. 2	--		1		--		1	
Illinois, Indiana, Kentucky, etc.	1,705		643		1,874		548	
Minnesota, Wisconsin, North Dakota	--	32 (Appalachian No. 2 through Oklahoma, Kansas, etc.)	193	4,660 (Appalachian No. 2 through Oklahoma, Kansas, etc.)	--	75 (Appalachian No. 2 through Oklahoma, Kansas, etc.)	170	4,295 (Appalachian No. 2 through Oklahoma, Kansas, etc.)
Oklahoma, Kansas, etc.	439		192		478		259	
Texas Inland	2,058		403		1,719		264	
Texas Gulf Coast	5,574		797		6,117		927	
Louisiana Gulf Coast	3,672	529 (Texas Inland through New Mexico)	789	5,287 (Texas Inland through New Mexico)	2,896	1,012 (Texas Inland through New Mexico)	545	3,073 (Texas Inland through New Mexico)
Arkansas, Louisiana Inland, etc.	--		--		--		30	
New Mexico	--		4		--		3	
Rocky Mountain	443	--	79	710	474	--	68	697
West Coast	5,291	319	1,173	4,981	4,428	108	936	4,570
Total	19,712	909	5,093	19,903	18,457	1,242	4,419	17,889

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Table 40.—Shipments of aviation fuels

(Thousand barrels)

Product and use	Shipments to PAD districts I	II	III	IV	V	U.S. total
1970						
Aviation gasoline:						
For commercial use:						
Airlines	447	319	216	24	158	1,164
Factory	54	27	20	--	14	115
General aviation	2,248	2,557	1,604	399	1,817	8,625
Total	2,749	2,903	1,840	423	1,989	9,904
For military use	1,941	1,226	3,616	243	2,964	9,990
Jet fuel:						
For commercial use:						
Airlines	87,704	48,812	19,414	6,493	67,835	230,258
Factory	1,340	926	234	--	533	3,033
General aviation	3,058	2,449	1,681	758	1,925	9,871
Total	92,102	52,187	21,329	7,251	70,293	243,162
For military use:						
JP-4	[1] 20,840	15,290	15,254	2,516	32,745	86,645
JP-5	6,723	77	3,843	--	7,368	18,011
Other	232	65	540	30	461	1,328
Total [1]	27,795	15,432	19,637	2,546	40,574	105,984
1971						
Aviation gasoline:						
For commercial use:						
Airlines	376	97	118	25	146	762
Factory	34	29	18	--	14	95
General aviation	2,317	3,105	1,578	399	2,049	9,448
Total	2,727	3,231	1,714	424	2,209	10,305
For military use	2,560	1,065	1,350	258	2,356	7,585
Jet fuel:						
Kerosine-type:						
Airlines	89,813	53,334	19,558	6,001	68,435	237,141
Factory	349	211	131	--	528	1,219
General aviation	3,265	2,457	1,340	371	845	8,278
Total	93,427	56,002	21,029	6,372	69,808	246,638
For commercial use, total	97,244	56,449	21,743	6,372	71,862	253,670
For military use:						
JP-4	[2] 16,965	17,377	13,924	2,197	28,030	78,493
JP-5	10,160	1,687	1,177	31	9,924	22,979
Other	765	17	648	363	457	2,250
Total [2]	27,890	19,081	15,749	2,591	38,411	103,722

[1] Excludes direct imports by the military into PAD district I, 3,143,000 barrels; PAD district V, 960,000 barrels.
[2] Excludes direct imports by the military into PAD district I, 7,300,000 barrels; PAD district V, 1,946,000 barrels.

Definitions of terms used in this table:
Aviation gasoline—Any fuel in the gasoline-boiling range for use in a piston-type aviation engine.
Jet fuel—Any fuel for use in an aviation turbine engine.
Airline—Sales to U.S. certificated air carriers including air freight carriers, to international air carriers (if delivery is made in the United States), and to such other air carriers as supplemental or nonschedule carriers, air taxi, etc.
Factory—Direct sales to airframe and engine manufacturers.
General aviation—Primarily sales to distributors and airport dealers.
Military—Sales to Defense Fuel Supply Center and to other military agencies of the Government.

Table 41.—Salient statistics of kerosine in the United States, by month and district

(Thousand barrels unless otherwise stated)

	1970							1971 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	10,134	3.0	86	25	3	20,398	16,624	9,352	2.6	110	1	24	23,921	13,366
February	9,052	2.9	71	183	16	17,956	11,732	8,332	2.6	100	--	20	19,662	12,671
March	9,372	2.8	80	48	20	18,499	8,937	8,228	2.4	116	1	15	19,231	8,761
April	7,429	2.3	72	160	12	20,785	5,363	6,577	2.0	94	--	24	19,539	6,339
May	6,966	2.1	77	78	10	22,851	5,045	5,839	1.7	113	--	5	21,619	3,876
June	7,344	2.2	79	299	8	26,254	4,311	6,443	1.9	96	--	27	23,602	4,520
July	6,160	1.8	111	264	17	27,749	5,023	7,082	2.0	111	--	25	26,392	4,378
August	6,436	1.9	100	161	6	29,592	4,848	5,993	1.7	124	--	4	28,030	4,475
September	6,143	1.8	97	3	5	30,295	5,535	5,496	1.6	107	48	7	27,806	5,868
October	8,063	2.4	105	41	11	31,012	7,481	7,095	2.1	105	23	11	28,218	6,800
November	9,127	2.7	101	14	9	31,517	8,728	7,011	2.1	74	9	11	26,765	8,536
December	8,409	2.4	98	175	4	27,848	12,347	8,808	2.4	93	107	8	24,438	11,327
Total	94,635	2.3	1,077	1,451	121	27,848	95,974	86,256	2.1	1,243	189	181	24,438	90,917
By refining districts:														
East Coast	11,273	2.4	--	1,349	10	11,223	45,802	8,683	1.8	--	187	11	9,983	47,374
Appalachian No. 1	1,143	2.2	--			628		1,333	2.4	--			693	
Appalachian No. 2	879	4.0	--			385		791	3.9	--			497	
Indiana, Illinois, Kentucky, etc	17,488	2.4	--	--	5	4,866	30,545	14,959	2.0	--	2	5	4,435	28,065
Minnesota, Wisconsin, etc	1,779	2.4	--			1,046		1,326	1.7	--			1,084	
Oklahoma, Kansas, etc	3,419	1.1	--			776		2,987	.9	--			1,016	
Texas Inland	1,501	1.1	223			242		1,495	1.0	330			266	
Texas Gulf Coast	32,097	3.7	47			4,045		33,450	3.7	36			2,381	
Louisiana Gulf Coast	19,756	4.1	183	--	68	2,612	15,780	16,448	3.3	281	--	140	2,287	11,851
Arkansas, Louisiana Inland, etc	1,361	2.4	592			1,195		885	1.6	560			846	
New Mexico	110	.7	32			26		94	.6	36			13	
Rocky Mountain	2,042	1.4	--	--	--	380	2,019	2,104	1.4	--	--	--	547	1,905
West Coast	1,787	.3	--	102	38	424	1,828	1,701	.3	--	--	25	390	1,722
Total	94,635	2.3	1,077	1,451	121	27,848	95,974	86,256	2.1	1,243	189	181	24,438	90,917

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Table 42.—Salient statistics of distillate fuel oil in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1970								1971 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	79,353	23.4	133	59	6,686	29	130,726	127,190	80,811	22.9	119	52	6,484	273	158,740	123,724
February	71,762	23.2	117	55	5,707	70	111,523	96,774	72,178	22.6	114	51	5,200	241	128,706	107,336
March	77,541	23.0	121	67	7,581	33	100,983	95,817	77,898	22.4	129	67	5,585	376	112,872	99,137
April	70,674	22.3	117	61	4,550	131	102,061	74,193	76,551	23.1	127	125	3,237	166	113,693	79,053
May	70,658	21.7	127	55	3,384	105	115,846	60,334	74,935	22.4	129	124	2,874	230	125,815	65,710
June	72,165	21.9	130	85	1,872	20	137,506	52,572	76,679	22.2	124	166	3,509	411	145,790	60,092
July	73,391	21.6	130	46	2,840	177	163,469	50,267	77,671	21.7	111	166	3,327	334	172,373	54,358
August	74,704	21.7	114	57	2,762	46	188,169	52,891	77,831	21.6	103	184	2,841	261	196,973	56,098
September	73,270	21.6	105	65	2,777	67	205,674	58,645	71,215	21.0	84	159	2,963	91	210,136	61,167
October	76,586	22.7	107	67	3,986	112	216,386	69,922	74,644	21.6	113	142	3,679	133	222,969	65,612
November	75,145	22.6	116	68	5,018	36	218,138	78,559	72,078	21.4	101	131	5,098	163	214,780	85,434
December	80,407	22.6	124	58	6,663	72	[2]195,271	110,047	78,236	21.7	116	181	10,986	78	[2]190,622	113,599
Total	895,656	22.4	1,441	743	53,826	898	[2]195,271	927,211	910,727	22.0	1,370	1,548	55,783	2,757	[2]190,622	971,320
By refining district:																
East Coast	127,280	26.9	--	--	49,333	24	84,356	475,109	123,809	25.4	--	--	53,373	34	73,968	481,443
Appalachian No. 1	12,938	24.4	--				3,886		12,995	23.7	--				3,882	
Appalachian No. 2	5,523	25.0	--				2,448		5,520	27.5	--				2,968	
Indiana, Illinois, Kentucky, etc.	152,920	21.0	--	475	2,223	5	30,817	271,926	157,394	21.0	--	499	258	388	29,851	288,178
Minnesota, Wisconsin, etc.	18,630	25.5	--				8,926		20,673	26.0	--				9,516	
Oklahoma, Kansas, etc.	77,962	23.8	--				15,187		77,598	23.5	--				14,517	
Texas Inland	25,787	17.9	163				1,724		26,251	18.1	127				2,317	
Texas Gulf Coast	228,836	26.4	117				20,183		224,300	24.9	98				21,765	
Louisiana Gulf Coast	120,587	25.0	409	197	1,192	103	8,409	69,608	121,334	24.2	447	191	1,079	835	11,190	75,216
Arkansas, Louisiana Inland, etc.	14,239	25.1	752				3,458		13,767	25.2	698				5,641	
New Mexico	2,897	19.5	--				375		3,091	19.9	--				198	
Rocky Mountain	34,587	24.2	--	71	--	2	2,631	25,790	38,054	25.7	--	69	--	--	2,808	29,892
West Coast	73,470	11.9	--	--	1,078	764	12,871	84,778	85,941	13.3	--	789	1,073	1,500	12,001	96,591
Total	895,656	22.4	1,441	743	53,826	898	[2]195,271	927,211	910,727	22.0	1,370	1,548	55,783	2,757	[2]190,622	971,320

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[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, 1970, 3,855; 1971, 4,021; PAD district II, 1970, 145; 1971, 328; PAD district III, 1970, 273; 1971, 654; PAD district IV, 1970, 3; 1971, 6; PAD district V, 1971, 151.

Table 43.—Salient statistics of residual fuel oil in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1970							1971 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	25,963	7.7	378	55,998	1,474	49,544	89,716	31,321	8.9	328	55,193	494	53,878	86,464
February	23,947	7.7	333	56,529	2,116	46,068	82,169	27,099	8.5	371	49,635	1,355	48,900	80,728
March	23,639	7.0	479	58,488	1,102	40,320	87,252	26,533	7.6	479	57,598	1,521	49,425	82,564
April	19,829	6.3	355	47,304	1,375	42,791	63,642	22,238	6.7	337	47,229	1,749	50,623	66,857
May	17,676	5.4	442	36,825	1,794	44,664	51,276	18,978	5.7	325	46,634	1,167	55,371	60,022
June	17,020	5.2	341	43,581	1,349	46,036	58,221	20,042	5.8	376	43,538	1,091	58,735	59,501
July	17,688	5.2	372	44,686	1,730	47,886	59,166	19,964	5.6	367	45,231	991	63,716	59,590
August	20,670	6.0	375	41,659	1,223	48,141	61,226	19,176	5.3	380	39,733	1,376	65,904	55,725
September	19,868	5.9	292	39,119	2,812	53,954	50,654	19,742	5.8	373	43,545	868	66,519	62,177
October	20,044	5.9	315	42,927	1,246	57,130	58,864	19,719	5.7	472	42,581	910	68,547	59,834
November	22,230	6.7	344	41,777	952	58,823	61,706	22,295	6.6	354	47,100	1,200	59,934	77,162
December	28,936	8.1	291	48,952	2,612	53,994	80,396	27,577	7.7	403	59,508	496	59,681	87,245
Total	257,510	6.4	4,317	557,845	19,785	53,994	804,288	274,684	6.6	4,565	577,525	13,218	59,681	837,869
By refining district:														
East Coast	30,650	6.5	--	536,968	872	23,666	598,045	31,566	6.5	--	558,769	606	26,653	624,848
Appalachian No. 1	4,409	8.4				470		5,559	10.1				580	
Appalachian No. 2	1,868	8.4				44		1,402	7.0				414	
Indiana, Illinois, Kentucky, etc	47,586	6.6	579	4,207	316	6,520	71,376	45,728	6.1	576	3,953	316	7,215	67,270
Minnesota, Wisconsin, etc	7,023	9.7				980		6,435	8.1				903	
Oklahoma, Kansas, etc	6,362	1,9				1,262		5,325	1.6				839	
Texas Inland	4,308	3.0				200		3,020	2.1				187	
Texas Gulf Coast	36,925	4.3				4,086		37,494	4.2				4,937	
Louisiana Gulf Coast	15,599	3.3	1,785	11,029	4,211	1,619	31,688	16,585	3.3	1,783	6,553	3,168	2,006	27,617
Arkansas, Louisiana Inland, etc	3,101	5.5				210		3,246	5.9				110	
New Mexico	409	2.8				4		549	3.5				4	
Rocky Mountain	9,100	6.3	252	52		515	9,194	9,886	6.7	252	41	3	919	9,347
West Coast	90,170	14.5	1,701	5,589	14,386	14,418	93,985	107,889	16.7	1,954	8,209	9,125	14,914	108,787
Total	257,510	6.4	4,317	557,845	19,785	53,994	804,288	274,684	6.6	4,565	577,525	13,218	59,681	837,869

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[1] Represents crude oil used as fuel on leases and for general industrial purposes.

Table 44.—Salient statistics of jet fuel in the United States, by month and refining district

(Thousand barrels)

	Production			Imports			Exports			Total stocks, end of period			Domestic demand		
	Naphtha type [1]	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type	Kerosine type	Total
1970															
By month:															
January	6,131	17,733	23,864	531	3,754	4,285	279	--	279	8,221	18,877	27,098	6,718	22,127	28,845
February	6,678	17,358	24,036	417	3,768	4,185	201	--	201	7,962	18,471	26,433	7,153	21,532	28,685
March	6,635	19,718	26,353	89	2,732	2,821	172	--	172	7,361	19,839	27,200	7,153	21,082	28,235
April	6,560	17,932	24,492	323	4,567	4,890	194	--	194	7,321	21,908	29,229	6,729	20,430	27,159
May	6,629	17,076	23,705	1,343	2,957	4,300	165	--	165	7,625	21,731	29,356	7,503	20,210	27,713
June	6,364	18,515	24,879	914	3,988	4,902	94	--	94	7,749	21,834	29,583	7,060	22,400	29,460
July	8,524	18,339	26,863	419	4,546	4,965	259	--	259	7,522	22,480	30,002	8,911	22,239	31,150
August	7,811	18,802	26,613	587	4,522	5,109	102	--	102	7,881	22,726	30,607	7,937	23,078	31,015
September	7,499	18,447	25,946	430	4,607	5,037	149	--	149	7,771	22,444	30,215	7,890	23,336	31,226
October	7,103	18,921	26,024	1,225	3,690	4,915	166	--	166	7,409	23,386	30,795	8,524	21,669	30,193
November	7,426	17,168	24,594	457	3,131	3,588	85	--	85	7,838	22,288	30,126	7,369	21,397	28,766
December	6,721	17,823	24,544	270	3,429	3,699	228	--	228	6,621	20,989	27,610	7,980	22,551	30,531
Total	84,081	217,832	301,913	7,005	45,691	52,696	2,094	--	2,094	6,621	20,989	27,610	90,927	262,051	352,978
By refining district:															
East Coast	2,606	11,108	13,714	4,438	25,382	29,820	5	--	5	294	4,370	4,664	24,423	103,358	127,781
Appalachian No. 1	756	894	1,650							40	318	358			
Appalachian No. 2	--	8	8							44	138	182			
Indiana, Illinois, Kentucky, etc.	6,285	31,706	37,991							613	3,536	4,149			
Minnesota, Wisconsin, North and South Dakota	764	1,028	1,792	--	2,687	2,687	1	--	1	156	731	887	15,413	55,508	70,921
Oklahoma, Kansas, Missouri, etc.	7,914	11,840	19,754							799	927	1,726			
Texas Inland	8,648	9,180	17,828							421	914	1,335			
Texas Gulf Coast	13,539	49,646	63,185							877	2,683	3,560			
Louisiana Gulf Coast	8,372	39,033	47,405	--	2,429	2,429	2	--	2	642	903	1,545	15,590	18,583	34,173
Arkansas, Louisiana Inland, etc.	[2] 1,675	--	1,675							286	205	491			
New Mexico	1,863	158	2,021							154	131	285			
Rocky Mountain	3,932	3,943	7,875	--	--	--	--	--	--	260	285	545	1,265	7,090	8,355
West Coast	27,727	59,288	87,015	2,567	15,193	17,760	2,086	--	2,086	2,035	5,848	7,883	34,236	77,512	111,748
Total	84,081	217,832	310,913	7,005	45,691	52,696	2,094	--	2,094	6,621	20,989	27,610	90,927	262,051	352,978

1971 p																
By month:																
January	6,787	19,111	25,898	684	2,828	3,512	112	--	112	6,910	20,680	27,590	7,070	22,248	29,318
February	6,472	17,209	23,681	903	4,621	5,524	86	89	175	7,040	19,992	27,032	7,159	22,429	29,588
March	7,087	19,236	26,323	565	4,101	4,666	125	21	146	6,917	20,214	27,131	7,650	23,094	30,744
April	7,100	18,021	25,121	462	3,560	4,022	233	40	273	6,606	20,658	27,264	7,640	21,097	28,737
May	7,179	18,581	25,760	637	4,376	5,013	114	23	137	6,692	21,822	28,514	7,616	21,770	29,386
June	7,064	18,269	25,333	1,401	4,778	6,179	120	--	120	6,934	21,819	28,753	8,103	23,050	31,153
July	6,881	17,512	24,393	1,086	5,157	6,243	91	--	91	7,202	21,645	28,847	7,608	22,843	30,451
August	6,627	18,246	24,873	1,413	4,688	6,101	116	--	116	6,681	21,015	27,696	8,445	23,564	32,009
September	7,553	17,490	25,043	1,245	4,536	5,781	108	46	154	6,645	21,437	28,082	8,726	21,558	30,284
October	7,390	18,878	26,268	916	4,127	5,043	15	--	15	6,795	20,364	27,159	8,141	24,078	32,219
November	7,645	18,490	26,135	870	4,352	5,222	99	--	99	7,005	20,934	27,939	8,206	22,272	30,478
December	7,541	18,305	25,846	910	5,398	6,308	97	--	97	6,990	20,747	27,737	8,369	23,890	32,259
Total	85,326	219,348	304,674	11,092	52,522	63,614	1,316	219	1,535	6,990	20,747	27,737	94,733	271,893	366,626
By refining districts:																
East Coast	2,167	11,409	13,576	8,549	28,409	33,953	--	--	--	255	3,905	4,160	28,094	109,358	137,452
Appalachian No. 1	735	740	1,475							123	278	401			
Appalachian No. 2	--	--	--							67	163	230			
Indiana, Illinois, Kentucky, etc	7,836	34,289	42,125							657	3,061	3,718			
Minnesota, Wisconsin, North and South Dakota	1,234	1,496	2,730	--	3,043	3,043	1	--	1	136	720	856	17,825	57,730	75,555
Oklahoma, Kansas, Missouri, etc	8,196	10,962	19,158							824	908	1,732			
Texas Inland	8,388	8,474	16,862							397	1,022	1,419			
Texas Gulf Coast	13,156	48,280	61,436							917	2,374	3,291			
Louisiana Gulf Coast	10,070	40,297	50,367	--	2,959	2,508	1	--	1	934	1,361	2,295	14,616	17,845	32,461
Arkansas, Louisiana Inland, etc	1,764	12	1,776							397	548	945			
New Mexico	1,980	52	2,032							237	94	331			
Rocky Mountain	3,929	4,413	8,342	--	--	--	--	--	--	230	340	570	2,199	6,766	8,965
West Coast	25,871	58,924	84,795	2,543	18,111	19,388	1,314	219	1,533	1,816	5,973	7,789	31,999	80,194	112,193
Total	85,326	219,348	304,674	11,092	52,522	58,892	1,316	219	1,535	6,990	20,747	27,737	94,733	271,893	366,626

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[1] Includes naphtha-type jet fuel produced at natural gas processing plants: Arkansas, Louisiana inland, etc., 1970, 21; 1971, 9.
[2] Includes naphtha-type jet fuel stored at natural gas processing plants: Arkansas, Louisiana inland, etc., 1970, 3; 1971, 2.

Table 45.—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	
1970												
By month:												
January	563	2,416	2,503	5,482	1.6	48	1,272	1,408	4,684	8,200	14,292	4,054
February	575	1,966	2,195	4,736	1.5	2	1,150	1,492	4,561	8,403	14,456	3,424
March	713	2,271	2,473	5,457	1.6	1	1,725	1,426	4,423	8,256	14,105	4,084
April	672	2,354	2,423	5,449	1.7	1	1,315	1,494	4,479	7,836	13,809	4,431
May	556	2,424	2,620	5,600	1.7	1	1,312	1,629	4,530	7,968	14,127	3,971
June	605	2,298	2,439	5,342	1.6	1	1,169	1,597	4,370	7,673	13,640	4,661
July	608	2,444	2,424	5,476	1.6	88	1,730	1,422	4,131	7,721	13,274	4,200
August	722	2,615	2,345	5,682	1.6	--	1,200	1,471	4,422	7,817	13,710	4,046
September	594	2,431	2,604	5,629	1.6	37	1,117	1,474	4,382	8,158	14,014	4,245
October	738	2,453	2,415	5,606	1.7	44	1,562	1,467	4,254	7,923	13,644	4,458
November	611	2,517	2,675	5,803	1.7	1	1,142	1,194	4,545	8,498	14,237	4,069
December	590	2,584	2,747	5,921	1.7	--	1,396	1,233	4,555	8,924	14,712	4,050
Total	7,547	28,773	29,863	66,183	1.6	224	16,090	1,233	4,555	8,924	14,712	49,693
By refining districts:												
East Coast	608	3,393	3,464	7,465	1.6			155	599	2,652	3,406	
Appalachian No. 1	1,168	1,976	673	3,817	7.2	15	3,983	156	272	538	966	19,298
Appalachian No. 2	--	17	--	17	.1			--	45	81	126	
Indiana, Illinois, Kentucky,												
etc	553	2,390	3,405	6,348	.9	3	539	96	638	1,049	1,783	13,879
Minnesota, Wisconsin, etc	--	--	--	--	--			--	--	45	45	
Oklahoma, Kansas, etc	891	3,642	1,244	5,777	1.7			187	608	185	980	
Texas Inland	--	--	137	137	.1			--	--	52	52	
Texas Gulf Coast	1,837	7,653	17,345	26,835	3.1			315	1,238	2,748	4,301	
Louisiana Gulf Coast	694	6,386	963	8,043	1.6	206	10,531	38	680	290	1,008	11,171
Arkansas, Louisiana Inland, etc	--	1,053	840	1,893	3.3			--	111	192	303	
New Mexico	--	--	--	--	--			--	--	4	4	
Rocky Mountain	48	191	136	375	.2	--	7	12	39	45	96	468
West Coast	1,748	2,072	1,656	5,476	.9	--	1,030	274	325	1,043	1,642	4,877
Total	7,547	28,773	29,863	66,183	1.6	224	16,090	1,233	4,555	8,924	14,712	49,693

1971 p												
By month:												
January	526	2,412	2,324	5,262	1.5	1	1,248	1,383	4,853	8,916	15,152	3,575
February	613	2,163	2,165	4,941	1.5	2	1,270	1,500	4,801	8,871	15,172	3,653
March	534	2,507	2,750	5,791	1.6	1	1,364	1,573	4,986	8,904	15,463	4,137
April	631	2,352	2,680	5,663	1.7	1	1,491	1,387	4,825	8,955	15,167	4,469
May	675	2,590	2,438	5,703	1.7	--	1,383	1,433	4,807	9,206	15,446	4,041
June	653	2,392	2,716	5,761	1.7	1	1,015	1,512	4,912	8,951	15,375	4,818
July	526	2,548	2,647	5,721	1.6	--	1,398	1,397	4,876	8,875	15,148	4,550
August	478	2,773	2,351	5,602	1.6	--	1,648	1,240	4,894	8,671	14,805	4,297
September	610	2,274	2,322	5,206	1.5	2	1,342	1,245	4,926	8,873	15,044	3,627
October	619	2,366	2,522	5,507	1.6	--	1,128	1,296	4,669	8,909	14,874	4,549
November	652	2,508	1,979	5,139	1.5	1	1,316	1,461	4,694	8,758	14,913	3,785
December	590	2,426	2,161	5,177	1.4	1	1,165	1,404	4,910	8,735	15,049	3,877
Total	7,107	29,311	29,055	65,473	1.6	10	15,768	1,404	4,910	8,735	15,049	49,378
By refining districts:												
East Coast	535	3,786	3,902	8,223	1.7	6	3,679	200	592	2,645	3,437	20,539
Appalachian No. 1	1,303	2,235	545	4,083	7.4			129	285	633	1,047	
Appalachian No. 2	--	8	--	8	.1			--	22	76	98	
Indiana, Illinois, Kentucky, etc	654	2,644	2,197	5,495	.7	2	658	106	494	999	1,599	13,234
Minnesota, Wisconsin, etc	--	--	--	--	--			--	--	36	36	
Oklahoma, Kansas, etc	800	3,187	1,475	5,462	1.7			223	544	192	959	
Texas Inland	--	--	87	87	.1			--	--	39	39	
Texas Gulf Coast	1,767	8,297	16,584	26,648	3.0			293	1,433	2,667	4,393	
Louisiana Gulf Coast	685	5,971	1,221	7,877	1.6	--	10,452	105	972	203	1,280	9,946
Arkansas, Louisiana Inland, etc	--	773	1,185	1,958	3.6			--	75	291	366	
New Mexico	--	--	--	--	--			--	--	7	7	
Rocky Mountain	45	204	163	412	.3	--	11	14	70	15	99	334
West Coast	1,318	2,206	1,696	5,220	.8	2	968	334	423	932	1,689	5,325
Total	7,107	29,311	29,055	65,473	1.6	10	15,768	1,404	4,910	8,735	15,049	49,378

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Table 46.—Salient statistics of liquefied gases (excluding ethane) in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1970								1971 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	9,819	2.9	27,952	1,704	1,089	7,711	40,273	47,822	9,558	2.7	28,738	3,046	798	8,269	53,394	44,605
February	9,457	3.1	26,099	1,719	722	6,706	34,962	35,158	9,353	2.9	26,381	2,399	749	7,129	46,454	37,195
March	9,683	2.9	28,568	1,564	1,080	6,357	35,514	31,826	10,679	3.1	28,679	1,735	814	6,208	49,166	31,359
April	9,697	3.1	27,100	1,034	1,098	5,561	41,217	25,469	10,215	3.1	27,688	1,639	801	5,224	58,220	24,463
May	10,087	3.1	27,939	934	690	5,105	52,380	22,002	10,353	3.1	28,366	1,570	658	5,030	70,813	22,008
June	9,739	2.9	26,250	767	711	5,283	60,883	22,259	10,578	3.0	26,599	1,562	707	5,053	81,840	21,952
July	10,427	3.0	26,106	854	831	5,821	67,637	23,981	10,715	3.0	27,144	1,479	778	5,382	93,021	21,997
August	9,734	2.9	26,163	1,124	770	5,602	74,176	24,110	11,043	3.0	28,046	1,409	754	5,439	101,603	25,723
September	9,329	2.8	25,910	1,320	726	6,107	78,712	25,190	9,400	2.7	27,686	1,691	743	6,134	105,863	27,667
October	9,297	2.8	27,467	2,125	766	7,799	78,285	30,751	9,677	2.8	28,525	2,953	823	7,708	106,644	31,816
November	9,447	2.9	27,604	2,523	716	8,399	73,286	35,458	9,114	2.8	27,963	2,852	828	8,663	100,516	36,566
December	9,811	2.8	29,019	3,253	756	9,856	65,724	39,033	10,267	2.9	31,295	3,320	938	9,456	91,348	43,656
Total	116,527	3.0	326,177	18,921	9,955	80,307	65,724	363,059	120,952	2.9	337,110	25,655	9,391	79,695	91,348	369,007
By refining district:																
East Coast	15,794	3.3	4,774	1,884	13	2,155	5,616	45,243	16,666	3.4	4,325	4,775	20	954	6,159	51,321
Appalachian No. 1	1,091	2.1				12			1,212	2.2				24		
Appalachian No. 2	331	1.4				60			367	1.8				--		
Indiana, Illinois, Kentucky, etc.	15,619	2.1	55,632	8,383	263	10,838	21,712	103,049	16,727	2.2	56,037	10,859	85	11,230	30,169	96,967
Minnesota, Wisconsin, etc.	1,386	1.9				3,038			1,472	1.8				3,179		
Oklahoma, Kansas, etc.	9,151	2.8				11,808			8,541	2.6				10,222		
Texas Inland	3,649	2.5				8,638			3,603	2.5				8,397		
Texas Gulf Coast	31,685	3.7				20,981			31,818	3.5				17,416		
Louisiana Gulf Coast	20,656	4.2	250,429	412	8,278	11,796	37,311	185,038	20,305	4.0	260,652	794	7,895	15,205	53,773	187,877
Arkansas, Louisiana Inland, etc.	1,348	2.3				804			1,394	2.6				753		
New Mexico	534	3.6				717			520	3.3				757		
Rocky Mountain	2,291	1.6	8,291	3,130	--	3,562	372	5,635	2,373	1.6	9,276	3,060	--	3,306	442	10,131
West Coast	12,992	2.0	7,051	5,112	1,401	5,898	713	24,094	15,954	2.5	6,820	6,167	1,391	8,252	805	22,711
Total	116,527	3.0	326,177	18,921	9,955	80,307	65,724	363,059	120,952	2.9	337,110	25,655	9,391	79,695	91,348	369,007

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Table 47.—Salient statistics of ethane (including ethylene) in the United States, by month and refining district

(Thousand barrels)

	1970					1971 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	5,953	904	6,857	2,110	6,929	6,190	797	6,987	1,331	6,975
February	5,510	798	6,308	1,998	6,420	5,989	727	6,716	1,511	6,536
March	6,186	895	7,081	2,117	6,962	6,427	761	7,188	1,844	6,855
April	5,757	758	6,515	2,265	6,367	6,310	777	7,087	2,066	6,865
May	6,138	763	6,901	2,249	6,917	6,488	682	7,170	2,083	7,153
June	5,797	817	6,614	2,303	6,560	6,473	840	7,313	2,034	7,362
July	6,151	820	6,971	2,355	6,919	6,898	745	7,643	2,110	7,567
August	6,165	727	6,892	2,179	7,068	7,228	772	8,000	2,372	7,738
September	6,085	800	6,885	1,925	7,139	6,632	679	7,311	2,310	7,373
October	6,551	774	7,325	1,516	7,734	7,232	765	7,997	2,739	7,568
November	6,457	674	7,131	1,360	7,287	7,119	853	7,972	3,076	7,635
December	6,684	730	7,414	1,319	7,455	7,538	868	8,406	3,365	8,117
Total	73,434	9,460	82,894	1,319	83,757	80,524	9,266	89,790	3,365	87,744
By refining district:										
East Coast	--	--	--			--	217	217		
Appalachian No. 1	1,931	--	1,931	--	1,931	1,665	--	1,665	--	1,882
Appalachian No. 2	--	--	--			--	--	--		
Indiana, Illinois, Kentucky, etc	7,761	--	7,761	582	9,793	7,064	--	7,064		
Minnesota, Wisconsin, etc	--	--	--			--	--	--	935	10,396
Oklahoma, Kansas, etc	1,881	316	2,197			3,073	612	3,685		
Texas Inland	23,518	102	23,620			26,494	97	26,591		
Texas Gulf Coast	14,365	5,283	19,648			14,837	4,395	19,232		
Louisiana Gulf Coast	20,276	3,130	23,406	737	71,403	23,358	3,334	26,692	2,429	74,836
Arkansas, Louisiana Inland, etc	1,484	--	1,484			1,253	--	1,253		
New Mexico	2,218	--	2,218			2,760	--	2,760		
Rocky Mountain	--	--	--	--	1	20	--	20	1	19
West Coast	--	629	629	--	629	--	611	611	--	611
Total	73,434	9,460	82,894	1,319	83,757	80,524	9,266	89,790	3,365	87,744

p Preliminary.

Table 48.—Salient statistics on petrochemical feedstocks [1] in the United States, by month and refining district

(Thousand barrels)

	Production				Imports (naphtha 400°)	Exports (other)	Stocks, end of period			Domestic demand (all types)
	Still gas	Naphtha 400°	Other	Total			Naphtha 400°	Other	Total	
1970										
By month:										
January	850	4,844	2,623	8,317	365	297	1,892	1,624	3,516	7,715
February	825	5,053	2,617	8,495	415	191	1,820	1,615	3,435	8,799
March	875	4,829	3,238	8,942	242	173	1,672	1,817	3,489	8,957
April	1,062	3,515	2,940	7,517	304	555	1,735	1,689	3,424	7,331
May	1,309	4,795	2,804	8,908	340	380	1,818	1,721	3,539	8,751
June	1,250	3,950	2,657	7,857	402	307	1,681	1,678	3,359	8,132
July	1,019	4,762	2,862	8,643	553	221	1,933	1,677	3,610	8,723
August	1,052	4,144	2,850	8,046	828	362	1,818	1,876	3,694	8,428
September	929	4,544	2,765	8,238	221	420	1,875	1,667	3,542	8,194
October	1,131	4,432	2,742	8,305	559	255	1,801	1,894	3,695	8,455
November	968	4,361	2,724	8,053	565	259	1,901	1,832	3,733	8,322
December	1,294	4,925	2,841	9,060	558	356	1,856	1,763	3,619	9,376
Total	12,564	54,154	33,663	100,381	5,352	3,776	1,856	1,763	3,619	101,183
By refining district:										
East Coast	1,764	2,249	610	4,623	--	767	--	1	1	8,695
Appalachian No. 1	--	--	737	737			--	65	65	
Appalachian No. 2	--	--	--	--			--	--	--	
Indiana, Illinois, Kentucky, etc	1,660	4,129	2,935	8,724	--	64	229	195	424	12,567
Minnesota, Wisconsin, etc	--	--	--	--			--	--	--	
Oklahoma, Kansas, etc	50	2,204	507	2,761			62	125	187	
Texas Inland	--	1,471	2,984	4,455			5	455	460	
Texas Gulf Coast	7,855	38,567	6,599	53,021			1,078	568	1,646	
Louisiana Gulf Coast	--	1,709	17,051	18,760	5,352	1,022	--	310	310	74,839
Arkansas, Louisiana Inland, etc	--	5	234	239			--	5	5	
New Mexico	--	--	--	--			--	--	--	
Rocky Mountain	135	--	214	349	--	10	--	4	4	340
West Coast	1,100	3,820	1,792	6,712	--	1,913	482	35	517	4,742
Total	12,564	54,154	33,663	100,381	5,352	3,776	1,856	1,763	3,619	101,183
1971 p										
By month:										
January	1,135	4,372	2,230	7,737	620	495	1,349	1,755	3,104	8,377
February	1,575	4,549	2,134	8,258	385	277	1,682	1,578	3,260	8,210
March	1,242	4,864	2,757	8,863	125	594	1,477	1,683	3,160	8,494
April	1,433	4,801	3,686	9,920	47	506	1,605	1,738	3,343	9,278
May	1,131	4,378	3,535	9,044	532	309	1,519	1,778	3,297	9,313
June	1,372	4,442	3,497	9,311	592	663	1,641	1,830	3,471	9,066
July	1,509	3,898	3,573	8,980	362	159	1,514	1,989	3,503	9,151
August	1,966	4,204	3,315	9,485	789	752	1,452	1,838	3,290	9,735
September	1,688	4,128	4,055	9,871	616	266	1,391	1,927	3,318	10,193

October	1,158	5,014	3,875	10,047	203	660	1,402	1,797	3,199	9,709
November	984	4,210	3,845	9,039	290	358	1,335	1,911	3,246	8,924
December	965	5,236	4,192	10,393	548	230	1,732	2,154	3,886	10,071
Total	16,158	54,096	40,694	110,948	5,109	5,269	1,732	2,154	3,886	110,521
By refining district:										
East Coast	1,355	3,056	103	4,514	--	766	--	--	--	
Appalachian No. 1	18	--	456	474			--	13	13	7,536
Appalachian No. 2	--	--	--	--			--	--	--	
Indiana, Illinois, Kentucky, etc	1,769	3,926	2,307	8,002	--	58	333	159	492	11,708
Minnesota, Wisconsin, etc	118	--	14	132			--	--	--	
Oklahoma, Kansas, etc	61	1,915	428	2,404			101	137	238	
Texas Inland	8	1,487	2,871	4,366			2	341	343	
Texas Gulf Coast	7,796	37,125	13,392	58,313			1,110	591	1,701	
Louisiana Gulf Coast	--	1,443	19,444	20,887	5,109	1,894	--	533	533	81,972
Arkansas, Louisiana Inland, etc	--	--	129	129			--	4	4	
New Mexico	--	--	--	--			--	--	--	
Rocky Mountain	145	--	227	372	--	9	--	10	10	373
West Coast	4,888	5,144	1,323	11,355	--	2,542	186	366	552	8,932
Total	16,158	54,096	40,694	110,948	5,109	5,269	1,732	2,154	3,886	110,521

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[1] Produced at petroleum refineries (excluding ethane and liquefied gases).

Table 49.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons) [1]

	1967	1968	1969	1970	1971 p
Petroleum asphalt:					
Production	23,230	24,629	24,671	26,665	28,553
Imports (including natural)	1,172	1,134	866	1,127	1,312
Exports	77	78	84	65	55
Stocks (end of period)	3,265	3,646	3,046	2,869	3,855
Apparent domestic consumption	23,847	25,664	26,053	27,905	28,823
Petroleum asphalt shipments:					
Paving	18,867	20,690	21,333	23,594	24,450
Roofing	3,967	4,767	4,080	4,248	4,422
All other	2,969	2,922	2,743	1,870	1,855
Total	25,803	28,379	28,156	29,712	30,727
Road oil:					
Production	1,269	1,241	1,652	1,708	1,592
Stocks (end of period)	146	100	160	115	164
Apparent domestic consumption	1,290	1,287	1,592	1,753	1,543
Road oil shipments	1,033	1,025	1,116	1,753	1,543

p Preliminary.

[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 50.—Salient statistics of petroleum asphalt in the United States, by month and refining district

(Thousand short tons) [1]

	1970					1971 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	1,235	69	3	3,548	798	1,494	97	6	3,576	878
February	1,217	23	4	3,925	859	1,406	40	4	4,133	884
March	1,691	29	4	4,505	1,136	1,833	145	5	4,636	1,470
April	1,968	38	9	4,683	1,819	2,198	98	3	5,044	1,884
May	2,363	82	5	4,529	2,594	2,555	100	4	5,142	2,554
June	2,628	142	5	3,880	3,415	2,965	106	5	4,590	3,619
July	2,922	223	5	3,144	3,876	3,159	124	4	4,335	3,534
August	3,008	137	4	2,539	3,747	3,163	153	6	3,665	3,979
September	2,831	164	7	2,117	3,411	2,947	186	5	3,287	3,506
October	2,724	85	9	2,026	2,891	2,736	104	5	3,002	3,120
November	2,235	76	5	2,395	1,936	2,322	104	3	3,199	2,226
December	1,843	59	5	2,869	1,423	1,775	55	5	3,855	1,169
Total	26,665	1,127	65	2,869	27,905	28,553	1,312	55	3,855	28,823
By refining districts:										
East Coast	5,428	1,092	18	663	8,174	5,712	1,161	10	944	7,824
Appalachian No. 1	372			85		303			81	
Appalachian No. 2	277			73		231			107	
Illinois, Indiana, Kentucky, etc	5,554	35	4	473	9,490	5,961	29	6	643	10,302
Minnesota, Wisconsin, North Dakota	811			149		1,099			204	
Oklahoma, Kansas, etc	2,669			275		2,894			475	
Texas Inland	1,310			97		1,229			134	
Texas Gulf Coast	1,643			77		1,737			146	
Louisiana Gulf Coast	2,207	--	14	184	5,252	2,645	122	12	163	5,613
Arkansas, Louisiana Inland, etc	1,205			119		1,310			134	
New Mexico	178			40		169			40	
Rocky Mountain	1,607	--	2	222	1,669	1,803	--	2	392	1,677
West Coast	3,404	--	27	412	3,320	3,460	--	25	392	3,407
Total	26,665	1,127	65	2,869	27,905	28,553	1,312	55	3,855	28,823

p Preliminary.
[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 51.—Salient statistics of road oil in the United States, by months and refining districts

(Short tons) [1]

	1970			1971 p		
	Production	Stocks (end of period)	Domestic demand	Production	Stocks (end of period)	Domestic demand
By month:						
January	23,636	139,818	43,818	96,181	188,909	22,182
February	41,455	161,818	19,455	62,727	236,909	14,727
March	90,545	217,454	34,909	108,000	318,364	26,545
April	105,636	250,363	72,727	94,364	358,182	54,546
May	202,364	287,273	165,454	144,000	376,364	125,818
June	226,545	275,818	238,000	177,273	323,091	230,546
July	299,091	233,273	341,636	247,455	301,636	268,909
August	278,727	195,818	316,182	248,545	242,364	307,818
September	186,182	140,364	241,636	163,091	192,000	213,455
October	130,727	101,273	169,818	120,909	171,636	141,273
November	77,454	100,727	78,000	78,909	159,818	90,727
December	45,455	114,909	31,273	50,364	163,636	46,545
Total	1,707,817	114,909	1,752,908	1,591,818	163,636	1,543,091
By refining district:						
East Coast	--	--	123,454	5,091	--	122,545
Appalachian No. 1	121,636	1,091		120,364	4,000	
Appalachian No. 2	--	--		--	--	
Indiana, Illinois, Kentucky, etc	739,818	31,091		615,091	60,909	
Minnesota, Wisconsin, North Dakota	44,727	182	996,182	39,273	--	791,091
Oklahoma, Kansas, etc	184,182	4,727		170,000	8,364	
Texas Inland	24,545	727		32,727	1,636	
Texas Gulf Coast	9,636	--		1,273	--	
Louisiana Gulf Coast	--	--	34,182	--	--	33,091
Arkansas, Louisiana Inland, etc	--	--		--	--	
New Mexico	--	--		--	--	
Rocky Mountain	336,182	23,273	340,727	341,454	52,364	313,818
West Coast	247,091	53,818	258,363	266,545	36,363	282,546
Total	1,707,817	114,909	1,752,908	1,591,818	163,636	1,543,091

p Preliminary.
[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 52.—Salient statistics of special naphthas in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1970							1971 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	2,210	0.7	33	169	114	6,372	2,218	2,370	0.7	30	124	103	6,213	2,401
February	2,183	.7	32	217	158	6,243	2,403	1,979	.6	24	430	233	6,029	2,384
March	2,407	.7	37	6	106	6,518	2,069	2,651	.7	27	34	113	5,682	2,946
April	2,621	.8	34	130	158	6,193	2,952	2,314	.7	25	2	136	5,727	2,160
May	2,609	.8	31	6	210	6,302	2,327	2,253	.7	27	57	112	5,448	2,504
June	2,427	.7	31	100	136	6,042	2,682	2,270	.7	24	46	108	5,308	2,372
July	2,511	.7	35	16	106	5,915	2,583	2,495	.7	27	2	123	5,208	2,501
August	2,605	.8	32	--	99	5,631	2,822	2,185	.6	25	259	122	5,279	2,276
September	2,405	.7	32	153	111	5,325	2,785	2,309	.7	24	141	70	4,997	2,686
October	2,810	.8	30	677	150	5,430	3,262	2,746	.8	23	141	169	5,212	2,526
November	2,627	.8	27	420	118	5,888	2,498	2,371	.7	24	340	78	5,463	2,406
December	2,781	.8	30	403	120	6,193	2,789	2,312	.6	49	262	83	5,384	2,619
Total	30,196	.8	384	2,297	1,586	6,193	31,390	28,255	.7	329	1,838	1,450	5,384	29,781
By refining district:														
East Coast	709	.2	--	1,739	369	1,471	6,945	532	1	--	1,594	357	1,351	6,910
Appalachian No. 1	331	.7	--			86		345	.6	--			80	
Appalachian No. 2	253	1.1	--			28		264	1.3	--			25	
Indiana, Illinois, Kentucky, etc	3,080	.4	--	3	155	941	6,708	3,373	.5	--	61	85	763	7,452
Minnesota, Wisconsin, etc	--	--	--			78		--	--	--			84	
Oklahoma, Kansas, etc	1,311	.4	28			161		1,375	.4	20			168	
Texas Inland	1,061	.7	40			145		1,057	.7	4			133	
Texas Gulf Coast	16,835	1.9	--			2,248		14,367	1.6	--			1,861	
Louisiana Gulf Coast	550	.1	--	455	909	115	12,776	404	.1	--	170	901	33	10,020
Arkansas, Louisiana Inland, etc	1,036	1.8	316			136		1,126	2.1	305			165	
New Mexico	--	--	--			--		1	--	--			--	
Rocky Mountain	145	.1	--	10	--	20	164	205	.1	--	13	--	34	222
West Coast	4,885	.8	--	90	153	764	4,797	5,206	.8	--	--	107	687	5,177
Total	30,196	.8	384	2,297	1,586	6,193	31,390	28,255	.7	329	1,838	1,450	5,384	29,781

p Preliminary.

[1] Includes inventories at natural gas processing plants: Arkansas, Louisiana Inland, etc., 1970, 9; 1971, 11.

Table 53.—Salient statistics of wax in the United States, by type, month, and refining district

(Thousand barrels) [1]

	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Micro-crystal-line	Crystal-line fully-refined	Crystal-line other	Total			Micro-crystal-line	Crystal-line fully-refined	Crystal-line other	Total	
1970											
By month:											
January	89	206	158	453	26	130	164	380	454	998	348
February	103	203	150	456	13	154	159	343	474	976	337
March	104	227	171	502	13	147	165	321	453	939	405
April	100	252	263	615	19	162	157	313	544	1,014	397
May	100	236	182	518	--	172	175	336	530	1,041	319
June	103	276	214	593	6	161	176	349	547	1,072	407
July	103	235	168	506	--	149	177	351	524	1,052	377
August	109	236	164	509	13	133	191	378	518	1,087	354
September	77	310	195	582	--	156	170	385	515	1,070	443
October	113	194	183	490	13	169	184	340	431	955	449
November	93	223	195	511	--	105	198	340	475	1,013	348
December	97	262	200	559	14	170	192	325	476	993	423
Total	1,191	2,860	2,243	6,294	117	1,808	192	325	476	993	4,607
By refining district:											
East Coast	333	979	564	1,876			27	138	50	215	
Appalachian No. 1	198	87	289	574	1	729	32	1	121	154	2,122
Appalachian No. 2	--	14	--	14			--	2	--	2	
Indiana, Illinois, Kentucky, etc	27	280	125	432			2	14	115	131	
Minnesota, Wisconsin, etc	--	--	--	--	--	31					1,043
Oklahoma, Kansas, etc	257	257	99	613			58	20	8	86	
Texas Inland	89	--	--	89			22	--	--	22	
Texas Gulf Coast	185	512	614	1,311			21	33	109	163	
Louisiana Gulf Coast	96	361	279	736	116	974	28	60	58	146	865
Arkansas, Louisiana Inland, etc	--	--	--	--			--	--	--	--	
New Mexico	--	--	--	--			--	--	--	--	
Rocky Mountain	6	47	31	84	--	--	2	16	15	33	64
West Coast	--	323	242	565	--	74	--	41	--	41	513
Total	1,191	2,860	2,243	6,294	117	1,808	192	325	476	993	4,607

1971 [p]											
By month:											
January	92	253	180	525	8	140	209	399	463	1,071	315
February	87	217	249	553	8	154	200	388	500	1,088	390
March	109	268	267	644	--	175	207	356	474	1,037	520
April	109	234	266	609	14	163	227	316	498	1,041	456
May	89	275	252	616	13	143	215	377	478	1,070	457
June	96	245	287	628	13	141	222	396	477	1,095	475
July	93	223	191	507	--	151	208	404	492	1,104	347
August	96	249	224	569	12	137	191	387	492	1,070	478
September	209	241	166	616	12	143	208	406	456	1,070	485
October	82	255	172	509	--	95	204	404	458	1,066	418
November	111	320	182	613	13	60	235	452	433	1,120	512
December	71	292	187	550	--	152	228	439	450	1,117	401
Total	1,244	3,072	2,623	6,939	93	1,654	228	439	450	1,117	5,254
By refining district:											
East Coast	371	1,083	546	2,000	2	662	54	211	71	336	2,697
Appalachian No. 1	200	95	328	623			43	22	104	169	
Appalachian No. 2	--	14	--	14			--	--	--	--	
Indiana, Illinois, Kentucky, etc	127	248	153	528	--	39	3	18	87	108	1,094
Minnesota, Wisconsin, etc	--	--	--	--			--	--	--	--	
Oklahoma, Kansas, etc	235	225	94	554			47	13	14	74	
Texas Inland	75	--	--	75			21	--	--	21	
Texas Gulf Coast	176	553	795	1,524			29	51	90	170	
Louisiana Gulf Coast	49	396	492	937	91	882	26	59	54	139	866
Arkansas, Louisiana Inland, etc	--	--	--	--			--	--	--	--	
New Mexico	--	--	--	--			--	--	--	--	
Rocky Mountain	11	59	22	92	--	--	5	24	18	47	88
West Coast	--	399	193	592	--	71	--	41	12	53	509
Total	1,244	3,072	2,623	6,939	93	1,654	228	439	450	1,117	5,254

[p] Preliminary.
[1] Conversion factor: 280 pounds to the barrel.

Table 54.—Salient statistics of petroleum coke in the United States, by month and refining district

(Thousand barrels [1] unless otherwise stated)

	1970							1971 p						
	Marketable	Production catalyst	Total	Yield (percent)	Exports	Stocks (end of period)	Domestic demand	Marketable	Production catalyst	Total	Yield (percent)	Exports	Stocks (end of period)	Domestic demand
By month:														
January	4,999	4,279	9,278	2.7	1,855	5,937	6,684	4,787	4,226	9,013	2.6	2,190	5,443	6,677
February	4,380	3,835	8,215	2.7	2,194	5,865	6,093	4,657	3,602	8,259	2.6	1,914	5,636	6,152
March	4,508	3,974	8,482	2.5	2,376	5,385	6,586	5,465	3,802	9,267	2.6	2,390	5,850	6,663
April	5,346	3,824	9,170	2.9	2,445	5,661	6,449	5,447	3,712	9,159	2.8	2,405	5,753	6,851
May	4,681	3,957	8,638	2.7	2,756	4,831	6,712	5,341	3,674	9,015	2.7	2,534	6,242	5,992
June	5,590	4,053	9,643	2.9	3,247	4,830	6,397	5,192	3,914	9,106	2.6	2,654	5,959	6,735
July	5,284	4,359	9,643	2.8	2,817	5,192	6,464	5,083	4,090	9,173	2.5	1,235	6,596	7,301
August	4,859	4,232	9,091	2.6	2,296	5,256	6,731	5,389	4,360	9,749	2.7	1,313	7,693	7,339
September	4,807	4,190	8,997	2.7	2,360	5,469	6,424	5,089	3,844	8,933	2.6	1,572	9,499	5,555
October	4,869	3,908	8,777	2.6	3,023	5,407	5,816	5,312	3,951	9,263	2.7	1,818	8,967	7,977
November	4,699	4,015	8,714	2.6	2,706	5,180	6,235	5,087	3,827	8,914	2.6	3,823	7,919	6,139
December	5,085	4,138	9,223	2.6	2,482	5,297	6,624	5,464	3,799	9,263	2.6	3,144	7,445	6,593
Total	59,107	48,764	107,871	2.7	30,557	5,297	77,215	62,313	46,801	109,114	2.6	26,992	7,445	79,974
By refining district:														
East Coast	5,029	6,957	11,986	2.6	524	908	11,487	4,702	7,083	11,785	2.4	291	1,127	11,425
Appalachian No. 1	--	151	151	.3		--		--	150	150	.3		--	
Appalachian No. 2	--	39	39	.2		--		--	--	--	--		--	
Indiana, Illinois, Kentucky, etc	8,458	10,042	18,500	2.6		380		8,461	9,584	18,045	2.4		328	
Minnesota, Wisconsin, etc	2,041	1,031	3,072	4.2	2,516	166	28,161	2,095	1,009	3,104	3.9	2,095	363	28,895
Oklahoma, Kansas, etc	5,067	4,114	9,181	2.8		255		6,648	3,252	9,900	3.0		169	
Texas Inland	519	1,806	2,325	1.6		1		515	1,890	2,405	1.7		1	
Texas Gulf Coast	6,525	12,074	18,599	2.1		306		8,061	12,281	20,342	2.3		277	
Louisiana Gulf Coast	7,111	6,011	13,122	2.7	8,146	299	28,183	7,307	5,734	13,041	2.5	9,804	303	28,116
Arkansas, Louisiana Inland, etc	1,468	745	2,213	3.9		264		1,365	700	2,065	3.8		333	
New Mexico	--	117	117	.8		--		--	111	111	.7		--	
Rocky Mountain	1,321	2,064	3,385	2.4	1	1,703	3,239	1,149	1,897	3,046	2.0	--	1,805	2,956
West Coast	21,568	3,613	25,181	4.0	19,370	1,015	6,145	22,010	3,110	25,120	3.9	14,802	2,739	8,582
Total	59,107	48,764	107,871	2.7	30,557	5,297	77,215	62,313	46,801	109,114	2.6	26,992	7,445	79,974

p Preliminary.
[1] Conversion factor: 5.0 barrels to the short ton.

Table 55.—Production of miscellaneous finished oils at refineries and natural gas processing plants in the United States in 1971, by district and class

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils	Petrochemicals	Other products	Total
East Coast	--	--	1,391	429	141	1,961
Appalachian No. 1	10	82	29	7	--	128
Appalachian No. 2	--	--	11	7	--	18
Indiana, Illinois, Kentucky, etc	79	11	743	598	37	1,468
Minnesota, Wisconsin, North Dakota, and South Dakota	--	--	--	133	--	133
Oklahoma, Kansas, etc	81	204	584	--	208	1,077
Texas Inland	392	--	1,067	933	135	2,527
Texas Gulf	15	194	1,070	2,631	422	4,332
Louisiana Gulf	597	43	182	439	47	1,308
Arkansas, Louisiana Inland	80	--	7	11	--	98
Rocky Mountain, New Mexico	2	47	--	36	5	90
West Coast	23	7	1,296	727	234	2,287
Total:						
1971	1,279	588	[1] 6,380	5,951	1,229	15,427
1970	1,120	642	5,655	6,786	1,467	15,670

[1] Specialty oils include hydraulic, 186; insulating, 310; medicinal, 319; rust preventatives, 3; sand-frac, 1,067; spray oils, 356; and other, 4,139.

Table 56.—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
1970													
Crude petroleum	43,795	41,114	46,350	35,142	37,468	41,178	39,056	36,515	40,310	36,875	37,815	47,675	483,293
Petroleum products:													
Motor gasoline	1,936	1,240	2,146	2,086	1,873	2,200	1,862	1,949	2,008	2,317	2,349	2,354	24,320
Jet fuel:													
Naphtha type	531	417	89	323	1,343	914	419	587	430	1,225	457	270	7,005
Kerosine type	3,754	3,768	2,732	4,567	2,957	3,988	4,546	4,522	4,607	3,690	3,131	3,429	45,691
Total	4,285	4,185	2,821	4,890	4,300	4,902	4,965	5,109	5,037	4,915	3,588	3,699	52,696
Liquefied gases:													
Butane	920	729	716	488	503	454	472	703	690	1,210	1,028	1,541	9,454
Propane	784	990	848	546	431	313	382	421	630	915	1,495	1,712	9,467
Total	1,704	1,719	1,564	1,034	934	767	854	1,124	1,320	2,125	2,523	3,253	18,921
Kerosine	25	183	48	160	78	299	264	161	3	41	14	175	1,451
Distillate fuel oil	6,686	5,707	7,581	4,550	3,384	1,872	2,840	2,762	2,777	3,986	5,018	6,663	53,826
Residual fuel oil	55,998	56,529	58,488	47,304	36,825	43,581	44,686	41,659	39,119	42,927	41,777	48,952	557,845
Petrochemical feedstocks	365	415	242	304	340	402	553	828	221	559	565	558	5,352
Special naphthas	169	217	6	130	6	100	16	--	153	677	420	403	2,297
Lubricants	48	2	1	1	1	1	88	--	37	44	1	--	224
Wax	26	13	13	19	--	6	--	13	--	13	--	14	117
Asphalt	380	125	162	212	451	781	1,224	755	904	469	416	322	6,201
Plant condensate	--	176	208	172	280	210	208	169	204	189	235	207	2,258
Unfinished oils	3,889	3,233	3,975	2,915	3,279	2,879	2,943	2,476	3,003	2,603	2,780	5,286	39,261
Total petroleum products	75,511	73,744	77,255	63,777	51,751	58,000	60,503	57,005	54,786	60,865	59,686	71,886	764,769
Total crude and products	119,306	114,858	123,605	98,919	89,219	99,178	99,559	93,520	95,096	97,740	97,501	119,561	1,248,062
1971 p													
Crude petroleum	34,772	37,655	43,235	45,207	46,540	50,337	54,768	58,755	57,012	59,617	59,557	65,962	613,417
Petroleum products:													
Motor gasoline	2,158	1,309	1,991	1,893	1,566	1,541	1,652	1,676	1,718	1,115	2,304	2,735	21,658
Jet fuel:													
Naphtha type	684	903	565	462	637	1,401	1,086	1,413	1,245	916	870	910	11,092
Kerosine type	2,828	4,621	4,101	3,560	4,376	4,778	5,157	4,688	4,536	4,127	4,352	5,398	52,522
Total	3,512	5,524	4,666	4,022	5,013	6,179	6,243	6,101	5,781	5,043	5,222	6,308	63,614
Liquefied gases:													
Butane	1,290	981	657	934	1,069	901	1,033	955	1,024	2,013	1,566	1,626	14,049
Propane	1,756	1,418	1,078	705	501	661	446	454	667	940	1,286	1,694	11,606
Total	3,046	2,399	1,735	1,639	1,570	1,562	1,479	1,409	1,691	2,953	2,852	3,320	25,655

Kerosine	1	--	1	--	--	--	--	--	48	23	9	107	189
Distillate fuel oil	6,484	5,200	5,585	3,237	2,874	3,509	3,327	2,841	2,963	3,679	5,098	10,986	55,783
Residual fuel oil	55,193	49,635	57,598	47,229	46,634	43,538	45,231	39,733	43,545	42,581	47,100	59,508	577,525
Petrochemical feedstocks	620	385	125	47	532	592	362	789	616	203	290	548	5,109
Special naphthas	124	430	34	2	57	46	2	259	141	141	340	262	1,838
Lubricants	1	2	1	1	--	1	--	--	2	--	1	1	10
Wax	8	8	--	14	13	13	--	12	12	--	13	--	93
Asphalt	531	218	796	539	552	585	685	840	1,021	574	571	304	7,216
Plant condensate	203	368	514	502	557	1,576	1,594	1,528	1,857	1,638	1,126	1,858	13,321
Unfinished oils	3,019	2,591	2,674	3,268	3,020	3,527	4,420	4,686	4,367	4,358	3,884	5,379	45,193
Total petroleum products	74,900	68,069	75,720	62,393	62,388	62,669	64,995	59,874	63,762	62,308	68,810	91,316	817,204
Total crude and products	109,672	105,724	118,955	107,600	108,928	113,006	119,763	118,629	120,774	121,925	128,367	157,278	1,430,621

[p] Preliminary.
[1] Imports of crude oil, unfinished oils, and plant condensate reported to the U.S. Department of the Interior; imports of petroleum products compiled from records of the U.S. Department of Commerce.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district

(Thousands of barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [1 2]	No. 4 distillate fuel oil [3]	Residual fuel oil [1 2]	Military jet fuel [1]	Commercial jet fuel	Liquefied gases	Plant condensate	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
1970																	
North America:																	
Canada	245,258	610	22	135	4,941	510	7,683	45	45	17,872	2,258	858	--	5	1	--	279,733
Mexico	--	--	--	--	--	--	6,464	--	--	1	--	--	8,974	--	--	--	15,439
Total	245,258	610	22	135	4,941	510	14,147	45	45	17,873	2,258	858	8,974	5	1	--	295,172
Central America and Caribbean:																	
Bahamas	--	--	--	--	193	--	10,848	--	--	--	--	--	457	--	--	--	11,498
Honduras	--	--	--	--	50	--	--	--	--	--	--	--	--	--	--	--	50
Leeward and Windward Islands	--	--	--	181	--	--	548	--	--	--	--	--	--	--	--	--	729
Netherland Antilles	--	697	734	29	9,676	5,201	135,010	2,006	17,835	--	--	2,483	6,190	--	--	151	174,811
Panama	--	496	--	--	189	--	887	--	988	--	--	--	1,169	--	--	--	3,729
Puerto Rico	--	21,080	--	--	5,492	--	--	--	--	--	--	--	--	--	--	3,650	30,222
Trinidad and Tobago	265	31	--	--	3,903	3,730	61,553	2,550	8,755	--	--	8	272	212	--	1,551	79,100
Virgin Islands	--	1,235	--	953	4,390	369	52,453	--	--	--	--	--	9,833	--	--	--	68,864
Total	265	23,539	734	1,163	23,893	9,300	261,299	4,556	27,578	--	--	2,491	17,921	212	--	5,352	369,003
South America:																	
Argentina	--	--	--	--	--	--	156	--	--	--	--	--	--	--	--	--	156
Bolivia	534	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	534
Brazil	--	--	--	--	40	--	869	--	--	--	--	--	--	--	--	--	909
Colombia	7,313	--	--	--	264	--	8,587	--	--	--	--	--	460	--	--	--	16,624
Venezuela	97,996	168	1,265	73	21,156	13,611	211,230	2,276	13,723	902	--	2,769	9,481	--	116	--	361,155
Total	105,843	168	1,265	73	21,460	13,611	220,842	2,276	13,723	902	--	2,769	9,941	--	116	--	379,378
Europe:																	
Belgium	--	--	--	--	112	--	1,420	20	742	--	--	--	--	2	--	--	2,296
France	--	--	--	--	--	--	1,346	--	--	--	--	--	--	--	--	--	1,346
Germany, West	--	--	--	--	--	--	2	--	--	--	--	--	154	--	--	--	156
Italy	--	--	--	--	1,327	880	27,637	--	1,327	--	--	--	--	--	--	--	30,291
Netherlands	--	3	--	--	--	--	14,020	--	119	92	--	83	--	4	--	--	14,321
Romania	--	--	--	--	1,282	1,179	1,609	--	--	--	--	--	--	--	--	--	2,891
Spain	--	--	--	--	683	--	7,650	--	--	--	--	--	--	--	--	--	8,333
United Kingdom	--	--	186	80	--	--	3,486	--	198	--	--	--	--	1	--	--	3,951
U.S.S.R.	--	--	--	--	--	--	1,081	--	--	--	--	--	--	--	--	--	1,081
Total	--	3	186	80	3,404	2,059	58,251	20	2,386	92	--	83	154	7	--	--	64,666
Middle East:																	
Abu Dhabi	23,047	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23,047
Bahrain	--	--	--	--	--	--	786	86	921	--	--	--	--	--	--	--	1,793
Iran	12,184	--	90	--	--	--	303	20	898	--	--	--	540	--	--	--	14,035
Kuwait	12,123	--	--	--	--	--	--	--	--	--	--	--	1,075	--	--	--	13,198

Neutral Zone	8,398	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8,398
Saudi Arabia	6,140	--	--	--	--	--	465	--	--	54	--	--	--	--	--	--	6,659
Total	61,892	--	90	--	--	--	1,554	106	1,819	54	--	--	1,615	--	--	--	67,130
Africa:																	
Algeria	2,093	--	--	--	127	127	608	--	--	--	--	--	--	--	--	--	2,828
Ivory Coast	--	--	--	--	--	--	277	--	--	--	--	--	--	--	--	--	277
Libya	17,156	--	--	--	--	--	100	--	--	--	--	--	4	--	--	--	17,260
Nigeria	17,490	--	--	--	--	--	631	--	--	--	--	--	--	--	--	--	18,121
United Arab Republic	7,626	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7,626
Total	44,365	--	--	--	127	127	1,616	--	--	--	--	--	4	--	--	--	46,121
Asia:																	
India	--	--	--	--	--	--	133	--	--	--	--	--	--	--	--	--	133
Indonesia	25,670	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	25,670
Japan	--	--	--	--	1	--	--	2	--	--	--	--	652	--	--	--	655
Malaysia	--	--	--	--	--	--	--	--	140	--	--	--	--	--	--	--	140
Philippines	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--	3
Total	25,670	--	--	--	1	--	136	2	140	--	--	--	652	--	--	--	26,601
Total imports	483,293	24,320	2,297	1,451	53,826	25,607	557,845	7,005	45,691	18,921	2,258	6,201	39,261	224	117	5,352	1,248,062
Imports by PAD districts:																	
District I	211,403	24,006	1,739	1,349	49,333	25,607	536,968	4,438	25,382	1,884	--	6,008	30,221	15	1	--	892,747
District II	115,613	65	3	--	2,223	--	4,207	--	2,687	8,383	2,258	193	--	3	--	--	135,635
District III	--	--	455	--	1,192	--	11,029	--	2,429	412	--	--	913	206	116	5,352	22,104
District IV	17,573	--	10	--	--	--	52	--	--	3,130	--	--	--	--	--	--	20,765
District V	138,704	249	90	102	1,078	--	5,589	2,567	15,193	5,112	--	--	8,127	--	--	--	176,811
1971 p																	
North America:																	
Canada	263,294	203	647	42	470	212	12,505	--	45	21,710	13,288	500	103	4	14	--	312,825
Mexico	--	--	--	--	--	--	1,424	--	--	4	--	--	8,569	--	2	--	9,999
Total	263,294	203	647	42	470	212	13,929	--	45	21,714	13,288	500	8,672	4	16	--	322,824
Central America and Caribbean:																	
Bahamas	--	--	145	--	404	175	47,843	--	4,459	--	--	--	1,886	--	--	--	54,737
British West Indies	--	--	--	--	--	--	142	--	--	--	--	--	--	--	--	--	142
Netherland Antilles	--	117	94	--	10,969	6,973	116,412	150	19,252	230	--	3,151	5,991	--	13	--	156,379
Panama	--	--	141	--	305	--	336	--	906	--	--	--	526	--	--	--	2,214
Puerto Rico	--	20,442	--	--	8,369	--	--	--	--	--	--	--	4,294	--	--	1,680	34,785
Trinidad and Tobago	--	--	25	--	4,310	3,982	48,490	2,795	8,229	--	--	7	262	--	--	2,473	66,591
Virgin Islands	--	709	--	126	5,322	--	77,198	5,492	--	5	--	--	9,699	--	--	921	99,472
Total	--	21,268	405	126	29,679	11,130	290,421	8,437	32,846	235	--	3,158	22,658	--	13	5,074	414,320
South America:																	
Argentina	--	--	--	--	--	--	120	--	--	--	--	--	--	--	--	--	120
Bolivia	798	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	798
Brazil	--	--	--	--	--	--	1,184	--	--	--	--	--	--	--	--	--	1,184
Chile	261	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	261
Colombia	3,175	--	--	--	280	--	6,224	--	--	--	--	--	--	--	--	--	9,679
Venezuela	110,574	40	675	21	20,328	9,334	212,518	2,142	9,397	3,183	33	3,526	9,257	--	52	--	371,746
Total	114,808	40	675	21	20,608	9,334	220,046	2,142	9,397	3,183	33	3,526	9,257	--	52	--	383,788

See footnotes at end of table.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district—Continued

(Thousands of barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [1 2]	No. 4 distillate fuel oil [3]	Residual fuel oil [1 2]	Military jet fuel [1]	Commercial jet fuel	Liquefied gases	Plant condensate	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
Europe:																	
Belgium	--	--	--	--	--	--	1,715	--	255	--	--	--	--	--	--	--	1,970
France	--	--	--	--	--	--	1,777	--	--	--	--	--	--	1	--	35	1,813
Germany, West	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Italy	--	--	--	--	1,806	1,391	25,653	--	1,186	--	--	--	--	1	--	--	28,646
Netherlands	--	--	--	--	--	--	6,674	--	112	--	--	32	--	1	12	--	6,831
Norway	--	--	--	--	--	--	367	--	--	--	--	--	--	--	--	--	367
Romania	--	--	--	--	1,611	1,611	243	--	--	--	--	--	--	--	--	--	1,854
Spain	--	147	--	--	210	210	3,826	--	--	--	--	--	--	--	--	--	4,183
Sweden	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	3
United Kingdom	--	--	--	--	150	150	3,190	--	153	--	--	--	--	--	--	--	3,493
Total	--	147	--	--	3,777	3,362	43,445	--	1,706	3	--	32	--	3	12	35	49,160
Middle East:																	
Abu Dhabi	29,026	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	29,026
Bahrain	--	--	--	--	742	--	1,007	--	2,656	--	--	--	181	--	--	--	4,586
Iran	38,576	--	--	--	--	--	--	--	1,591	157	--	--	494	--	--	--	40,818
Iraq	3,932	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,932
Kuwait	10,650	--	111	--	--	--	--	--	--	--	--	--	2,411	--	--	--	13,172
Saudi Arabia	41,971	--	--	--	76	--	3,219	--	89	350	--	--	923	--	--	--	46,628
Southern Yemen	--	--	--	--	--	--	--	--	602	--	--	--	--	--	--	--	602
Total	124,155	--	111	--	818	--	4,226	--	4,938	507	--	--	4,009	--	--	--	138,764
Africa:																	
Algeria	4,685	--	--	--	--	--	870	--	--	--	--	--	--	--	--	--	5,555
Angola	1,301	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,301
Gabon	--	--	--	--	--	--	111	--	--	1	--	--	--	--	--	--	112
Guinea	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1
Ivory Coast	--	--	--	--	--	--	136	--	--	--	--	--	--	--	--	--	136
Libya	19,426	--	--	--	168	168	1,453	--	--	1	--	--	--	--	--	--	21,048
Nigeria	34,826	--	--	--	72	72	2,397	--	--	--	--	--	--	--	--	--	37,295
Sierra Leone	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	2
Tunisia	1,199	--	--	--	100	100	--	--	--	--	--	--	--	--	--	--	1,299
United Arab Republic	6,924	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,924
Total	68,361	--	--	--	340	340	4,967	--	--	5	--	--	--	--	--	--	73,673
Asia:																	
Australia	2,567	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,567
Guam	--	--	--	--	--	--	147	513	--	--	--	--	--	--	--	--	660
Indonesia	40,232	--	--	--	--	--	344	--	--	8	--	--	--	--	--	--	40,584

Japan	--	--	--	--	91	--	--	--	931	--	--	--	--	3	--	--	1,025
Malaysia	--	--	--	--	--	--	--	--	2,659	--	--	--	597	--	--	--	3,256
Total	42,799	--	--	--	91	--	491	513	3,590	8	--	--	597	3	--	--	48,092
Total imports	613,417	21,658	1,838	189	55,783	24,378	577,525	11,092	52,522	25,655	13,321	7,216	45,193	10	93	5,109	1,430,621
Imports by PAD districts:																	
District I	252,088	21,425	1,594	187	53,373	24,378	558,769	8,549	28,409	4,775	538	6,386	30,651	6	2	--	966,752
District II	137,064	--	61	2	258	--	3,953	--	3,043	10,859	4,580	160	--	2	--	--	159,982
District III	20,449	--	170	--	1,079	--	6,553	--	2,959	794	--	670	2,217	--	91	5,109	40,091
District IV	16,869	--	13	--	--	--	41	--	--	3,060	4,672	--	--	--	--	--	24,655
District V	186,947	233	--	--	1,073	--	8,209	2,543	18,111	6,167	3,531	--	12,325	2	--	--	239,141

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1 1970 imports of crude and unfinished oils reported to the Bureau of Mines. All other import figures are compiled from Department of Commerce data; 1971 imports of crude and unfinished oils reported to the Bureau of Mines and imports for on shore military jet fuel, distillate, and residual fuel oil, receipts from Puerto Rico, the Virgin Islands, and Guam are based on data reported to the U.S. Department of the Interior. All other 1971 import figures are compiled from U.S. Department of Commerce data.

2 Includes quantities imported duty free for supply of vessels and aircraft engaged in foreign trade.

3 Included in distillate fuel oil.

Table 58.—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
1970													
Crude petroleum	93	--	70	94	--	302	97	11	--	1,962	1,616	746	4,991
Refined products:													
Gasoline: [2]													
Motor	24	36	31	51	28	39	45	45	33	40	45	44	461
Aviation	41	194	101	69	75	52	112	32	56	76	38	63	909
Total gasoline	65	230	132	120	103	91	157	77	89	116	83	107	1,370
Jet fuel (naphtha-type)	279	201	172	194	165	94	259	102	149	166	85	228	2,094
Liquefied gases:													
Butane	75	94	106	176	114	89	209	182	159	165	146	140	1,655
Propane	463	105	384	330	102	163	91	107	106	105	89	120	2,165
Butane-propane mix	551	523	590	592	474	459	531	481	461	496	481	496	6,135
Total liquefied gases	1,089	722	1,080	1,098	690	711	831	770	726	766	716	756	9,955
Kerollsine	3	16	20	12	10	8	17	6	5	11	9	4	121
Distinate fuel oil	29	70	33	131	105	20	177	46	67	112	36	72	898
Residcal fuel oil	1,474	2,116	1,102	1,375	1,794	1,349	1,730	1,223	2,812	1,246	952	2,612	19,785
Petroemihcal feedstocks	296	192	173	555	382	307	222	362	417	256	258	356	3,776
Special naphthas	114	158	106	158	210	136	106	99	111	150	118	120	1,586
Lubricants	1,272	1,150	1,725	1,315	1,312	1,169	1,730	1,200	1,117	1,562	1,142	1,396	16,090
Wax	130	154	147	162	172	161	149	133	156	169	105	170	1,808
Coke	1,855	2,194	2,376	2,445	2,756	3,247	2,817	2,296	2,360	3,023	2,706	2,482	30,557
Asphalt	19	25	23	52	28	25	25	23	37	49	25	25	356
Miscellaneous	84	76	104	96	94	116	54	103	97	87	72	88	1,071
Total refined	6,709	7,304	7,193	7,713	7,821	7,434	8,274	6,440	8,143	7,713	6,307	8,416	89,467
Total crude and refined	6,802	7,304	7,263	7,807	7,821	7,736	8,371	6,451	8,143	9,675	7,923	9,162	94,458
1971 p													
Crude petroleum	--	2	1	313	8	--	--	--	143	36	--	--	503
Refined products:													
Gasoline: [2]													
Motor	18	27	18	135	40	31	21	29	21	10	27	21	398
Aviation	115	227	65	79	63	73	109	66	236	35	76	98	1,242
Total gasoline	133	254	83	214	103	104	130	95	257	45	103	119	1,640
Jet fuel:													
Naphtha-type	112	86	125	233	114	120	91	116	108	15	99	97	1,316
Kerosine-type	--	89	21	40	23	--	--	--	46	--	--	--	219
Total jet fuel	112	175	146	273	137	120	91	116	154	15	99	97	1,535

Liquefied gases:													
Butane	447	423	480	439	327	330	387	352	334	393	386	427	4,725
Propane	351	326	334	362	331	377	391	402	409	430	442	511	4,666
Total liquefied gases	798	749	814	801	658	707	778	754	743	823	828	938	9,391
Kerosine	24	20	15	24	5	27	25	4	7	11	11	8	181
Distillate fuel oil	273	241	376	166	230	411	334	261	91	133	163	78	2,757
Residual fuel oil	494	1,355	1,521	1,749	1,167	1,091	991	1,376	868	910	1,200	496	13,218
Petrochemical feedstocks	495	277	594	506	309	663	159	752	266	660	358	230	5,269
Special naphthas	103	233	113	136	112	108	123	122	70	169	78	83	1,450
Lubricants	1,248	1,270	1,364	1,491	1,383	1,015	1,398	1,648	1,342	1,128	1,316	1,165	15,768
Wax	140	154	175	163	143	141	151	137	143	95	60	152	1,654
Coke	2,190	1,914	2,390	2,405	2,534	2,654	1,235	1,313	1,572	1,818	3,823	3,144	26,992
Asphalt	32	24	28	19	21	28	23	33	26	25	16	29	304
Miscellaneous	70	76	105	78	81	111	73	113	121	45	78	72	1,023
Total refined	6,112	6,742	7,724	8,025	6,883	7,180	5,511	6,724	5,660	5,877	8,133	6,611	81,182
Total crude and refined	6,112	6,744	7,725	8,338	6,891	7,180	5,511	6,724	5,803	5,913	8,133	6,611	81,685

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1 Compiled from records of U.S. Department of Commerce.
2 Includes benzol, natural gasoline, and antiknock compounds.

Table 59.—Crude petroleum and products exported from the United States by countries of destination and shipments to and exports from territories and possessions

(Thousand barrels)

	Crude petroleum	Gasoline	Naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1970															
North America:															
Bahamas	1,355	9	3	--	(1)	8	875	26	5	79	(1)	1	1	(1)	2,362
Canada	328	291	296	5	15	589	3,978	1,364	48	300	93	3,092	619	165	11,183
Mexico	--	166	65	56	1	47	1,806	427	142	8,508	249	620	33	22	12,142
Trinidad and Tobago	2,909	(1)	(1)	(1)	--	--	--	39	(1)	--	4	(1)	2	(1)	2,954
Other	--	2	60	--	1	97	790	993	56	44	131	4	24	18	2,220
Total	4,592	468	424	61	17	741	7,449	2,849	251	8,931	477	3,717	679	205	30,861
South America:															
Argentina	--	2	9	--	(1)	--	(1)	309	2	119	2	(1)	7	3	453
Brazil	--	58	238	--	2	--	110	1,832	14	(1)	26	227	52	146	2,705
Chile	--	(1)	1	--	2	1	1	233	6	1	18	(1)	2	9	274
Colombia	--	(1)	1	1	(1)	--	172	92	1	--	119	--	4	22	412
Peru	--	1	(1)	--	--	2	(1)	81	1	(1)	11	--	1	3	100
Other	--	(1)	34	--	2	2	(1)	174	22	2	39	316	2	28	621
Total	--	61	283	1	6	5	283	2,721	46	122	215	543	68	211	4,565
Europe:															
Belgium-Luxembourg	--	(1)	50	--	(1)	1	207	545	1	31	14	845	46	16	1,756
France	--	2	89	--	(1)	(1)	5	107	47	31	49	670	786	17	1,803
Germany, West	--	9	55	--	25	42	(1)	r 265	2	1	366	2,876	159	35	r 3,835
Italy	--	3	12	--	1	21	878	472	2	3	100	1,734	268	53	3,547
Netherlands	--	378	180	--	2	463	194	508	1	(1)	30	3,082	564	28	5,430
Norway	--	(1)	(1)	--	--	--	--	20	(1)	--	1	1,060	1	4	1,086
Spain	--	(1)	5	--	--	--	274	93	9	--	42	701	r 318	6	r 1,448
Sweden	--	12	1	1	--	--	(1)	126	3	(1)	5	416	131	8	703
United Kingdom	176	13	346	--	21	136	1,337	848	1	293	95	832	217	46	4,361
Other	--	2	4	(1)	(1)	(1)	4	166	3	(1)	54	374	13	22	642
Total	176	419	742	1	49	663	2,899	r 3,150	69	359	756	12,590	r 2,503	235	r 24,611
Africa:															
Congo (Kinshasa)	--	--	2	--	(1)	--	--	24	1	(1)	2	--	1	2	32
South Africa, Republic	(1)	5	63	--	1	--	178	266	7	3	76	36	128	42	800
Other	(1)	3	6	--	5	(1)	2	351	8	(1)	45	180	13	30	643
Total	(1)	8	71	--	6	(1)	175	641	16	3	123	216	142	74	1,475
Asia:															
India	--	(1)	2	--	--	--	5	993	(1)	1	12	84	2	1	1,100
Indonesia	--	(1)	(1)	--	--	--	--	88	1	(1)	1	--	1	8	99
Japan	223	3	342	--	10	125	8,894	2,239	2	512	68	12,499	25	149	25,091

Philippines	--	1	22	--	--	--	(1)	367	1	--	13	--	11	25	440
Turkey	--	(1)	1	--	(1)	--	--	802	--	--	(1)	--	5	17	825
Other	--	1	87	(1)	3	5	3	r 1,561	9	(1)	58	180	44	54	r 2,005
Total	223	5	454	(1)	13	130	8,902	r 6,050	13	513	152	12,763	88	254	r 29,560
Oceania:															
Australia	--	(1)	45	--	2	(1)	3	252	1	1	49	686	350	37	1,426
French Pacific Islands	--	88	(1)	--	24	92	90	6	1	(1)	(1)	--	--	--	301
New Zealand	--	(1)	30	--	1	--	--	46	--	3	11	--	4	45	140
Other	--	--	3	--	--	--	--	2	2	(1)	--	--	--	(1)	7
Total	--	88	78	--	27	92	93	306	4	4	60	686	354	82	1,874
Grand total	4,991	1,049	2,052	63	118	1,631	19,801	r 15,717	399	9,932	1,783	30,515	r 3,834	1,061	r 92,946
Shipments from the United States to territories and possessions:															
Puerto Rico	--	2	18	--	1	2	--	350	5	16	23	42	21	12	492
Virgin Islands	--	83	3	(1)	--	9	--	20	7	9	(1)	--	1	(1)	132
Other [2]	--	234	--	2,030	5	423	--	10	--	--	3	--	--	--	2,705
Total	--	319	21	2,030	6	434	--	380	12	25	26	42	22	12	3,329
Exports from Puerto Rico to foreign countries	--	--	488	--	--	1,166	15	3	54	2	1	--	(1)	(1)	1,729
Total net shipments from United States	4,991	1,368	1,585	2,093	124	899	19,786	r 16,094	357	9,955	1,808	30,557	r 3,856	1,073	r 94,546
1971															
North America:															
Canada	60	435	217	2	10	793	3,331	1,539	68	97	116	2,703	581	154	10,106
Mexico	--	237	65	209	(1)	514	3,521	208	125	9,075	147	998	62	14	15,175
Trinidad and Tobago	--	--	10	--	--	--	--	40	1	--	5	--	1	1	58
Other	181	11	46	--	(1)	474	1,798	733	18	93	78	38	12	22	3,504
Total	241	683	338	211	10	1,781	8,650	2,520	212	9,265	346	3,739	656	191	28,843
South America:															
Argentina	--	(1)	10	--	(1)	--	(1)	1,032	(1)	(1)	2	--	9	(1)	1,053
Brazil	--	277	56	--	1	--	157	1,729	5	57	19	285	420	160	3,166
Chile	--	--	85	--	1	--	(1)	260	4	2	12	--	2	14	380
Colombia	(1)	(1)	1	--	(1)	--	(1)	29	1	--	78	--	2	5	116
Peru	--	(1)	31	--	--	143	162	90	2	1	18	--	1	4	452
Other	--	29	36	--	3	--	(1)	191	8	(1)	54	74	5	30	430
Total	(1)	306	219	--	5	143	319	3,331	20	60	183	359	439	213	5,597
Europe:															
Belgium-Luxembourg	--	40	55	--	--	(1)	(1)	741	8	--	51	1,626	29	12	2,562
France	--	2	130	--	(1)	1	(1)	114	8	--	43	691	703	4	1,696
Germany, West	--	38	48	--	34	18	1	264	3	(1)	426	3,256	200	35	4,323
Greece	--	(1)	(1)	--	--	--	6	19	(1)	(1)	(1)	386	(1)	(1)	411
Italy	(1)	2	51	--	1	26	681	522	1	(1)	58	1,512	180	52	3,086
Netherlands	--	291	209	--	2	266	92	700	(1)	(1)	30	2,411	378	52	4,431
Norway	--	(1)	(1)	--	--	--	--	17	1	--	(1)	821	1	2	842

See footnotes at end of table.

Table 59.—Crude petroleum and products exported from the United States by countries of destination and shipments to and exports from territories and possessions—Continued

(Thousand barrels)

	Crude petroleum	Gasoline	Naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
Spain	--	(1)	(1)	--	--	--	112	134	(1)	(1)	36	733	188	12	1,215
Sweden	--	(1)	1	--	--	--	(1)	134	1	--	4	366	279	4	789
United Kingdom	120	25	140	--	69	4	418	810	1	30	115	337	1,087	16	3,172
Other	--	3	5	--	--	(1)	23	135	4	4	23	198	11	11	417
Total	120	401	639	--	106	315	1,283	3,590	27	34	786	12,337	3,056	200	22,894
Africa:															
South Africa, Republic	--	(1)	43	--	2	(1)	226	359	5	1	76	23	137	56	928
Zaire	--	--	9	--	1	1	(1)	19	(1)	--	4	--	2	3	39
Other	2	6	7	--	9	--	--	298	8	--	49	318	13	30	740
Total	2	6	59	--	12	1	226	676	13	1	129	341	152	89	1,707
Asia:															
India	--	135	(1)	--	--	--	(1)	585	7	1	1	59	1	(1)	789
Indonesia	--	(1)	(1)	--	--	--	--	117	2	--	1	--	2	6	128
Japan	139	1	211	--	11	551	2,329	1,732	9	13	58	8,788	84	137	14,063
Philippines	--	(1)	18	--	1	--	222	362	2	--	14	(1)	4	16	639
Turkey	--	(1)	1	--	(1)	--	--	644	(1)	(1)	(1)	--	4	14	663
Other	1	158	33	--	2	2	1	1,393	9	(1)	65	273	53	45	2,035
Total	140	294	263	--	14	553	2,552	4,833	29	14	139	9,120	148	218	18,317
Oceania:															
Australia	--	3	56	--	6	--	2	238	3	2	47	693	789	69	1,908
French Pacific Islands	--	90	(1)	--	19	76	130	4	(1)	1	--	--	(1)	--	320
New Zealand	--	--	19	--	(1)	--	(1)	25	(1)	2	8	234	3	26	317
Other	--	(1)	(1)	--	--	--	--	1	(1)	--	--	--	--	--	1
Total	--	93	75	--	25	76	132	268	3	5	55	927	792	95	2,546
Grand total	503	1,783	1,593	211	172	2,869	13,162	15,218	304	9,379	1,638	26,823	5,243	1,006	79,904
Shipments from the United States to territories and possessions:															
Puerto Rico	--	(1)	43	(1)	(1)	16	2	579	3	9	23	246	103	21	1,045
Virgin Islands	4	721	1	--	--	183	--	24	1	5	(1)	--	1	(1)	940
Other [2]	--	96	4	1,325	7	459	22	5	--	--	--	--	--	--	1,918
Total	4	817	48	1,325	7	658	24	608	4	14	23	246	104	21	3,903
Exports from Puerto Rico to foreign countries	--	313	186	--	--	603	--	3	(1)	2	1	--	(1)	1	1,109
Total net shipments from United States	507	2,287	1,455	1,536	179	2,924	13,186	15,823	308	9,391	1,660	27,069	5,347	1,026	82,698

[r] Revised.
[2] Less than ½ unit.
[1] Data reported by shippers to the Bureau of Mines.

Table 60.—Crude petroleum: World production by country

(Thousand 42-gallon barrels)

Country	1969	1970	1971 [p]
North America:			
Canada	410,814	461,177	495,743
Cuba [e]	821	800	785
Mexico	149,661	156,530	155,912
Trinidad and Tobago	57,418	51,047	47,148
United States	3,371,751	3,517,450	3,453,914
South America:			
Argentina	130,086	143,428	154,514
Bolivia	14,759	8,820	13,446
Brazil	63,969	60,923	63,617
Chile	13,350	12,432	12,883
Colombia	76,776	79,594	78,635
Ecuador	1,567	1,444	1,354
Peru	26,330	26,272	22,588
Venezuela	1,311,832	1,353,420	1,295,406
Europe:			
Albania	8,767	9,995	8,674
Austria	19,236	19,515	17,549
Bulgaria	2,373	2,438	2,336
Czechoslovakia	1,424	1,424	1,356
France	18,207	16,825	13,651
Germany, East	365	438	435
Germany, West	56,886	54,427	53,597
Hungary	13,383	14,780	14,879
Italy	9,309	9,575	8,952
Netherlands	13,792	13,080	11,727
Norway	--	--	2,081
Poland	3,257	3,146	3,116
Romania	101,067	102,067	102,479
Spain	1,386	1,457	874
U.S.S.R.	2,412,899	2,594,550	2,778,300
United Kingdom	562	607	1,499
Yugoslavia	19,991	21,140	21,932
Africa:			
Algeria	345,436	371,767	279,627
Angola	17,456	36,499	41,228
Congo (Brazzaville)	173	137	130
Egypt, Arab Republic of	89,601	119,165	106,993
Gabon	36,421	39,292	41,911
Libya	[r] 1,135,684	1,209,314	1,007,687
Morocco	438	335	172
Nigeria	197,204	395,836	558,375
Tunisia	27,942	34,296	31,542
Asia:			
Bahrain	27,774	27,973	27,346
Brunei	45,624	50,233	47,482
Burma	[r] 6,050	6,388	6,652
China, People's Republic of [e]	106,000	146,000	186,000
India	[r] 51,724	52,596	52,596
Indonesia	271,001	311,628	325,673
Iran	1,232,155	1,397,460	1,661,901
Iraq	555,241	569,726	624,312
Israel [e] [1]	18,042	31,798	44,618
Japan	5,538	5,656	5,529
Kuwait [2]	1,021,615	1,090,040	1,166,938
Malaysia	3,278	6,299	25,071
Mongolia [e]	90	90	90
Oman	119,710	121,210	107,430
Pakistan	3,460	3,400	3,650
Qatar	129,746	132,456	156,882
Saudia Arabia [2]	1,173,896	1,387,266	1,741,541
Syrian Arab Republic	16,771	29,356	36,462
Taiwan	581	638	803
Thailand	16	70	95
Trucial States:			
Abu Dhabi	218,798	252,179	341,007
Dubai	3,800	31,321	45,648
Turkey	25,774	24,776	24,723
Oceania:			
Australia	15,805	65,149	112,914
New Zealand	3	467	804
Total	[r] 15,214,885	16,689,617	17,653,214

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Estimates of Israeli production from Sinai peninsula oilfields included with Israel rather than with Egypt, Arab Republic of.

[2] Data for both Kuwait and Saudi Arabia include those countries' share of production from former Kuwait-Saudi Arabia Neutral Zone.

Phosphate Rock

By Richard W. Lewis [1] and
William F. Stowasser [1]

A review of the data available indicates that world demand in 1971 exceeded world production of phosphate rock. This caused a much needed reduction in producers' stock inventories. Estimated total world sales for consumption in 1971 were nearly 5 percent greater than in 1970, whereas world production increased less than 2 percent.

Although the average value of domestic phosphate rock remained steady at $5.26 per ton for that sold or used, phosphatic fertilizers were much more in demand than in the previous 3 years. The demands for phosphoric acid and ammonium phosphates were especially good. However, because of rising costs and decreasing demand for industrial purposes, elemental phosphorus producers were not as fortunate as those producing for the fertilizer market.

Legislation and Government Programs.—Most legislation and Government actions during the year were related to environmental problems. Perhaps the most publicized legislation has been concerned with phosphorus in detergents. Federal legislation was introduced in Congress to ban phosphates in detergents, but by yearend none of the bills introduced had been enacted into law. Because newly developed substitutes for phosphates in detergents were stated to be health hazards by Federal officials, housewives were advised to continue to use phosphate detergents. This advice in September did not deter some States, counties, and cities from passing laws to limit or ban the use of phosphate detergents. Indiana was the first State to ban almost all phosphate detergents. The law, effective January 1, 1973, will outlaw the sale, use or disposal of any detergent "containing more than 3 percent phosphorus by weight." [2] A listing of other State and local legislation restricting the use of phosphate detergents and a discussion of the subject was published.[3]

On July 25, 1971, Florida Attorney General Robert Shevin filed suit in U.S. District Court, Washington, D.C., charging that the Secretary of the Interior, the Secretary of Agriculture, the Director of the Bureau of Land Management, and the Chief of the Forest Service had committed "unconstitutional and illegal action" by approving phosphate prospecting permits in the Osceola National Forest. The court was asked for an injunction to prevent the issuance of permits to mine in the Forest and to order the Federal agencies to undertake thorough ecological and economic studies of the effect of phosphate mining in the Osceola National Forest.

A public hearing was held July 27 and 28 in Ventura, Calif., concerning the environmental impact of mining phosphate in Los Padres National Forest. United States Gypsum Co. proposed developing a phosphate deposit on Pine Mountain in the national forest and applied for a preferential right lease to mine and process the mineral. An environmental statement, pursuant to Sec. 102(2)(c) (Public Law 90–190, 83 Stat. 852) was directed to be prepared by the Department of the Interior's Bureau of Land Management and the Department of Agriculture's Forest Service.

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[1] Physical scientist, Division of Nonmetallic Minerals.
[2] Wall Street Journal. Indiana Radically Limits Phosphate Detergents. V. 177, No. 70, Apr. 12, 1971, p. 23.
[3] Grundy, Richard D. Strategies for Control of Man-Made Eutrophication. Environmental Sci. & Technol., v. 5, No. 12, December 1971, pp. 1184–1190.

The environmental statement had not been completed at yearend.

The State of Florida enacted a mineral severance tax to become effective on July 1, 1971. It applies to "solid minerals" including phosphate rock. The law specifies a 3-percent tax on the mineral value at its point of severance during 1971–73, 4 percent during 1974–75, and 5 percent after June 30, 1975.

On December 11, 1971, the State of Florida filed a $20 million suit in Polk County Circuit Court, claiming that Cities Service Co. was negligent and responsible for the collapse of a slime retention dam on December 3, 1971. On December 22, the Circuit Court Judge ordered Cities Service to halt all mining activities at its Fort Meade phosphate operation until the court was convinced that there would not be a repeat of the December 3 dam failure.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Mine production	128,973	148,336	121,712	125,514	127,752
Marketable production	39,770	41,251	37,725	38,739	38,886
Value	$265,947	$250,692	$208,689	$203,218	$203,828
Average per ton	$6.69	$6.08	$5.53	$5.25	$5.24
Sold or used by producers	37,835	37,319	36,730	38,765	40,291
Value	$251,163	$228,347	$204,409	$203,810	$211,986
Average per ton	$6.64	$6.12	$5.57	$5.26	$5.26
Imports for consumption	139	116	140	136	84
Value	$3,261	$2,679	$3,554	$3,790	$2,478
Average per ton	$23.46	$23.09	$25.42	$27.87	$29.50
Exports [1]	10,072	12,099	11,336	11,738	12,587
P_2O_5 content	3,290	3,917	3,685	3,796	4,126
Value	$69,479	$75,653	$62,288	$59,980	$64,841
Average per ton	$6.90	$6.25	$5.49	[r] $5.11	$5.15
Consumption, apparent [2]	27,902	25,336	25,534	[r] 27,163	27,788
World: Production	85,914	92,577	90,598	94,083	96,469

[r] Revised.
[1] From table 6.
[2] Measured by sold or used plus imports minus exports.

DOMESTIC PRODUCTION

Production of marketable phosphate rock increased slightly in 1971, exceeding the 1970 quantity by about 150,000 tons. The 1971 production represented about 87 percent of the estimated total industry capacity of approximately 45 million tons. Florida and North Carolina accounted for approximately 83 percent of the total domestic production; the Western States, 11 percent; and Tennessee, 6 percent.

Florida, including North Carolina, increased production by 873,000 tons or about 3 percent above 1970 levels. Production declined in the Western States and in Tennessee. The Western States' decline was rather insignificant, but Tennessee's production was nearly 19 percent less than in 1970.

Two electric furnaces for phosphorus production were shut down; one by Hooker Chemical Corp. and the other by Monsanto Co. Five of 15 operating electric furnaces have been shut down during the last 2 years.

Phosphate rock was produced in seven States and Florida continued to produce more than the combined production of the others. Alabama and California did not report production as they had in 1970.

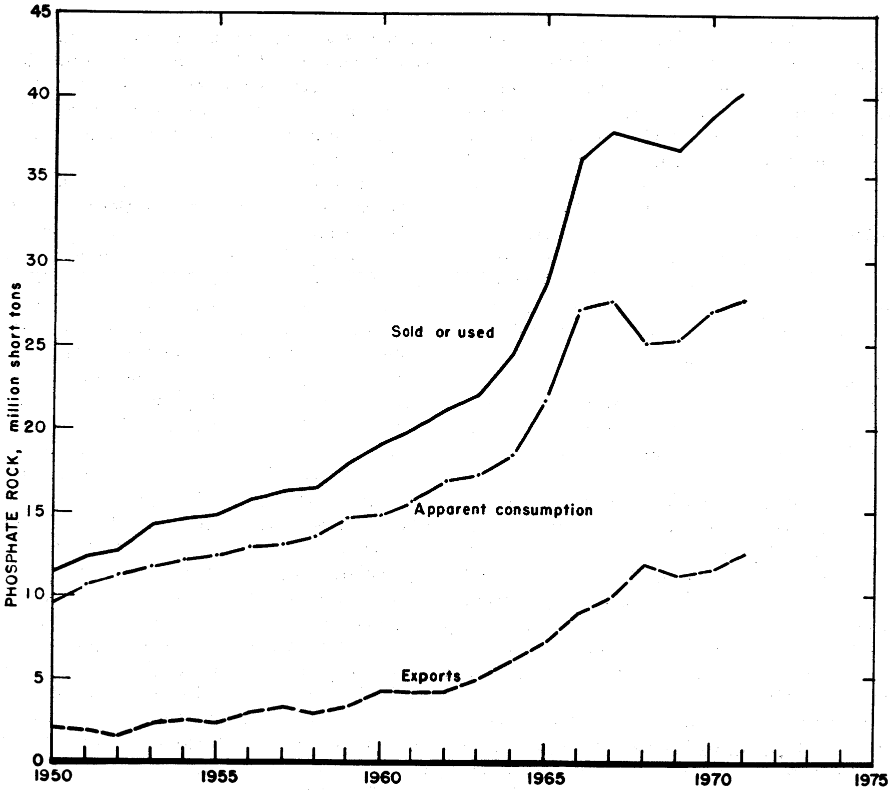

Figure 1.—Phosphate rock (sold or used), apparent consumption, and exports.

Table 2.—Production of phosphate rock in the United States, by State

(Thousand short tons and thousand dollars)

State	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
1970:									
Florida [1]	114,923	16,233	28	6	31,250	9,966	31,278	9,972	$158,972
Tennessee [2]	5,565	1,126	182	42	2,981	812	3,163	854	15,457
Western States [3]	5,026	1,275	3,282	849	1,015	323	4,297	1,172	28,789
Total [4]	125,514	18,634	3,492	896	35,247	11,101	38,739	11,998	203,218
1971:									
Florida [1]	118,130	16,659	16	3	32,136	10,308	32,151	10,311	167,753
Tennessee	4,750	1,002	W	W	W	W	2,571	684	12,151
Western States [3]	4,872	1,265	2,969	797	1,194	363	4,164	1,160	23,924
Total [5]	127,752	18,926	2,985	800	33,330	10,671	38,886	12,155	203,828

W Withheld to avoid disclosing individual company confidential data.
[1] Includes North Carolina.
[2] Includes Alabama.
[3] Includes California (1970), Idaho, Montana, Utah, and Wyoming.
[4] Data may not add to totals shown because of independent rounding.
[5] Totals are of listed figures only.

Land-pebble phosphate rock was produced in Florida by Agrico Chemical Co., American Cyanamid Co. (Brewster Phosphates), Borden Chemical Division of Borden, Inc., Cities Service Co., W. R. Grace & Co., International Minerals & Chemical Corp (IMC), Mobil Chemical Division of Mobil Oil Corp., Suwannee River Phosphate Division of Occidental Petroleum Corp., Swift Agricultural Chemical Corp., and U.S.S. Agri-Chemicals. Soft phosphate rock was produced in Florida by Howard Phosphate Co., Kellogg Co., Loncala Phosphate Co., Manko Co., Inc., and Sun Phosphate Co.

In Tennessee, the producers were Hooker Chemical Corp., Monsanto Co., Stauffer Chemical Co., and Tennessee Valley Authority.

In the Western States, Stauffer Chemical Co. produced phosphate rock in Idaho, Utah, and Wyoming; Monsanto Co. and J. R. Simplot Co. produced in Idaho, and Cominco American, Inc., produced in Montana.

Texas Gulf Sulphur Co. continued to be the only phosphate rock producer in North Carolina.

American Cyanamid Co. and Kerr-McGee Corp. formed a partnership, Brewster Phosphates, to mine and process phosphate rock. According to the published agreement, American Cyanamid retained the operation of the facility as well as 70 percent of the production. Brewster Phosphates operates American Cyanamid's Haynsworth mine near Bradley, Fla., and will, in the future, mine the adjoining extensive ore reserve that was held by Kerr-McGee. American Cyanamid closed its fertilizer plant at Bradley in April 1971, and arranged with Freeport Minerals Corp. to produce phosphoric acid from Brewster Phosphates' rock. One-half of Freeport's Uncle Sam, La., plant's capacity of 600,000 tons per year of P_2O_5 as phosphoric acid was made available to American Cyanamid. Brewster Phosphates purchased Monsanto Co.'s diammonium phosphate plant at Luling, La. Monsanto will continue to operate the plant for Brewster Phosphates.

CF Industries, Inc., of Chicago, Ill., acquired Central Phosphates, Inc., of Plant City, Fla., a privately owned fertilizer manufacturing firm that produces phosphoric acid, triple superphosphate, and ammonium phosphates. The phosphoric acid plant has an annual production capacity of approximately 200,000 tons. CF Industries, Inc., a cooperative organization, was formerly the Central Farmers Fertilizer Co. that manufactured and distributed chemical fertilizers.

Cities Service Co., at its Tampa, Fla., facility, started construction in December on a $4 million triple superphosphate plant, which was scheduled for completion in September 1972. In addition, a $3 million phosphoric acid concentration plant with facilities for the recovery of byproduct hydrofluosilicic acid was scheduled for completion in early 1972. On December 3, a Cities Service Co. settling pond dam failed southwest of Fort Meade, Fla. An estimated 1 to 2 billion gallons of waste slimes flowed down Widden Creek and into the Peace River. A large fish kill and other damage was reported. The State of Florida filed a $20 million damage suit against the company. On December 22, the Polk County Circuit Judge questioned the stability of other dams at the mine and issued a temporary injunction against the firm, suspending all mining operations until the court was satisfied that there was no danger of another dam failure. About 100 employees were furloughed during the closure. The injunction was lifted on January 28, 1972.

Farmland Industries, Inc., was completing a new phosphoric acid plant at its fertilizer facility near Bartow, Fla. The designed annual capacity of the new plant was reported to be 225,000 tons P_2O_5 equivalent.

Occidental Petroleum Corp. sold its fertilizer complex at Taft, La., to the Beker Chemical Co. The plant was formerly owned by Hooker Chemical Co. before its merger with Occidental.

Mobil Chemical Co. started a new mining operation near Nichols, Fla., and installed a new washer plant with an annual capacity of 1.5 million tons of product. An exchange of draglines took place between Mobil and IMC. IMC shut down its Achen washing plant.

Stauffer Chemical Co. announced a planned 25-percent increase in phosphate rock production at its Vernal, Utah, mine and plant. Annual production capacity will increase from 300,000 to 400,000 tons in 1972.

On December 10, 1971, following 6 years of negotiations, studies, and hearings, the

North Carolina State Board of Water and Air Resources granted Texas Gulf Sulphur Co. (TGS) a 20-year permit to mine phosphate in Beaufort County. The permit granted TGS the right to pump as much as 60 million gallons of water per day from a 400-acre mining area. After a 14-month study by the Board, it was concluded that the level of the fresh water table, which dropped when pumping started in 1965, had stabilized at an acceptable level.

It was reported in August 1971 that more than 600 acres of mined phosphate land had been reclaimed in Idaho by two firms. Monsanto Co. contoured and replanted about one-half of the 604 acres mined at the Ballard mine, and J. R. Simplot restored more than 300 acres at its Gay mine. Simplot stated its policy was to reclaim at least as much land as it disturbs annually.

CONSUMPTION AND USES

Apparent consumption of marketable phosphate rock continued to follow the upward trend that started in 1969; consumption was 2 percent greater than the revised quantity for 1970.

According to producers' reports, the quantity of phosphate rock sold or used for the production of phosphoric acid increased 28 percent. For all other uses, the quantity decreased. Triple superphosphate was down 25 percent, ordinary superphosphate decreased 17 percent, electric furnace phosphorus decreased 15 percent, and all other applications decreased 26 percent.

The total P_2O_5 sold or used for agricultural products, 6.95 million tons, was an increase of 6 percent over 1970. Of this quantity, an estimated 900,000 tons was exported as triple superphosphate, ammonium phosphates, and mixtures, TVA reported a preliminary quantity of 4.8 million tons of P_2O_5 actually consumed on the land.[4]

Reduction in the demand for phosphates in detergents significantly curtailed production of elemental phosphorus. Total industrial consumption was almost 14 percent less than in 1970.

[4] Harre, Edwin A. Fertilizer Trends—1971. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala., Bull. Y–40, December 1971. 5 pp.

Table 3.—Florida phosphate rock sold or used by producers, by kind

(Thousand short tons and thousand dollars)

Year	Land pebble [1]				Soft rock				Total [2]			
	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1967	29,796	9,646	$193,283	$6.49	36	7	$266	$7.42	29,832	9,654	$193,548	$6.49
1968	29,571	9,504	173,190	5.86	30	6	224	7.47	29,601	9,510	173,413	5.86
1969	28,835	9,307	155,197	5.38	30	6	221	7.34	28,865	9,313	155,418	5.38
1970	r31,111	r9,981	r157,652	5.07	24	5	168	7.10	r31,134	r9,986	r157,820	5.07
1971	33,176	10,621	173,950	5.24	20	4	141	7.19	33,195	10,625	174,091	5.24

r Revised.
[1] Includes North Carolina.
[2] Data may not add to totals shown because of independent rounding.

Table 4.—Tennessee phosphate rock sold or used by producers

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1967	3,032	808	$22,494	$7.42
1968	3,065	807	23,646	7.71
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

[1] Includes Alabama.

Table 5.—Phosphate rock sold or used by producers in the United States, by grade and State

(Thousand short tons)

Year and grade B.P.L. content [1] (percent)	Florida [2]		Tennessee [3]		Western States		Total [4] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1970								
Below 60	38	8	1,828	464	2,865	719	4,731	1,192
60–66	1,735	497	1,240	365	231	69	3,206	932
66–70	12,442	3,861	114	35	418	131	12,974	4,027
70–72	3,155	1,016	2	1	933	297	4,090	1,313
72–74	[r] 9,220	[r] 3,049	--	--	--	--	[r] 9,220	[r] 3,049
Plus 74	4,544	1,554	--	--	--	--	4,544	1,554
Total [4]	[r] 31,134	[r] 9,986	3,184	864	4,447	1,217	[r] 38,765	[r] 12,066
1971								
Below 60	33	8	1,877	479	2,590	671	4,500	1,157
60–66	1,676	489	W	W	W	W	2,292	668
66–70	14,334	4,449	W	W	W	W	15,297	4,716
70–72	4,533	1,472	--	--	1,049	332	5,582	1,804
72–74	8,734	2,887	--	--	--	--	8,734	2,887
Plus 74	3,885	1,321	--	--	--	--	3,885	1,321
Total [4]	33,195	10,625	2,596	687	4,500	1,241	40,291	12,553

[r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.
[2] Includes North Carolina.
[3] Includes Alabama in 1970.
[4] Data may not add to totals shown because of independent rounding.

Table 6.—Phosphate rock sold or used by producers, by use and State

(Thousand short tons)

Use	Florida [1]		Tennessee [2]		Western States		Total United States [3]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1970								
Domestic:								
Agricultural	19,511	6,232	30	9	1,021	318	20,562	6,559
Industrial	461	138	3,153	855	2,851	719	6,465	1,712
Total [3]	19,972	6,370	3,184	864	3,871	1,036	27,027	8,270
Exports	[r] 11,162	[r] 3,615	--	--	576	180	[r] 11,738	[r] 3,796
Total [3]	[r] 31,134	[r] 9,986	3,184	864	4,447	1,217	[r] 38,765	[r] 12,066
1971								
Domestic:								
Agricultural	20,879	6,585	--	--	1,254	366	22,132	6,951
Industrial	385	118	2,596	687	2,590	671	5,572	1,476
Total [3]	21,264	6,703	2,596	687	3,844	1,037	27,704	8,426
Exports	11,931	3,922	--	--	655	204	12,587	4,126
Total [3]	33,195	10,625	2,596	687	4,500	1,241	40,291	12,553

[r] Revised.
[1] Includes North Carolina.
[2] Includes Alabama in 1970.
[3] Data may not add to totals shown because of independent rounding.

Table 7.—Phosphate rock sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1970			1971		
	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
Domestic:						
Phosphoric acid (wet process)	11,992	3,772	$63,151	15,407	4,775	$84,542
Electric furnace phosphorus	6,456	1,709	34,097	5,516	1,457	24,845
Triple superphosphate	3,090	995	17,515	2,331	763	13,662
Ordinary superphosphate	4,154	1,366	20,877	3,463	1,114	17,586
Direct application to the soil	114	30	596	80	24	443
Nitraphosphate, Stock and poultry feed, Fertilizer filler, Other fertilizers, Other uses	1,222	399	7,595	907	294	6,067
Total	27,028	8,271	143,831	27,704	8,427	147,145
Exports	r 11,738	r 3,796	r 59,980	12,587	4,126	64,841
Grand total [1]	r 38,765	r 12,066	r 203,810	40,291	12,553	211,986

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

STOCKS

Yearend stocks of marketable phosphate rock showed a decrease of 10 percent from the 1970 level. This was a reduction of 1.4 million tons from the alltime high of 1970. Two more good selling years, without increased production, would reduce stock inventories to acceptable quantities.

Table 8.—Producer stocks of marketable phosphate rock, December 31

(Thousand short tons)

Source	1970		1971	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida [1]	12,995	4,071	11,951	3,722
Tennessee [2]	210	43	185	51
Western States	1,361	352	1,025	265
Total	14,566	4,466	13,161	4,038

[1] Includes North Carolina.
[2] Includes Alabama in 1970.

PRICES

Prices quoted by the Chemical Marketing Reporter for the various grades of Florida land-pebble phosphate rock are shown in table 9. Prices showed no change from the previous year and could only be used as a basis for negotiation between buyer and seller. There were no published prices for Tennessee and the Western States' phosphate rock because production from these States is not generally marketed, but is used by the producers.

Actual prices of Florida and North Carolina phosphate rock were subject to special discounts on contracts that were negotiated between buyer and seller. The average value reported by producers in 1971 was $5.24 per ton, an increase of $0.17 per ton over the alltime low of $5.07 per ton in 1970.

Table 9.—Prices of Florida land-pebble, unground, washed and dried phosphate rock, in bulk, carlots, at mine, in 1971

(Per short ton)

Grade, percent B.P.L.[1]	Price
66 to 68	$6.50
68 to 70	7.50
70 to 72	8.15
74 to 75	9.20
76 to 77	10.20

[1] 1.0 percent B.P.L. (bone phosphate of lime also known as tricalcium phosphate) = 0.458 percent P_2O_5.
Source: Chemical Marketing Reporter.

FOREIGN TRADE

The quantity of phosphate rock exported increased 8 percent over that of 1970, according to Bureau of Census reports. The average value per ton of Florida phosphate rock exported, calculated from total value reported by producers, was $5.15 f.o.b. plant, only a slight increase over the 1970 average of $5.11.

In addition to the exports of marketable phosphate rock (table 10) and superphosphates (table 11), the United States also exported 1,357,000 tons of ammonium phosphates valued at $72.4 million, and mixed fertilizers containing phosphates. Data on the latter are not available.

Only 83,814 tons of phosphate rock was imported and this was chiefly low-fluorine rock for animal feed supplements. This quantity was 38 percent less than was imported in 1970. The Netherlands Antilles supplied 68 percent of the imported rock, and Mexico supplied 32 percent.

Canada shipped 457,069 tons of ammonium phosphates into the United States, valued at $28 million, and 63,970 tons of other phosphatic fertilizer materials, valued at $4.8 million. About 60,000 tons of fertilizer materials valued at $5.3 million was imported from Mexico.

In addition, a total of 23,121 tons of dicalcium phosphate was imported, 3,590 tons from Canada and 19,531 tons from Belgium.

Table 10.—U.S. exports of phosphate rock, by grade and country

(Thousand short tons and thousand dollars)

Grade and destination	1970		1971	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Aden	--	--	29	$131
Austria	81	$579	117	817
Belgium-Luxembourg	396	2,516	673	4,037
Brazil	464	3,933	619	4,533
Canada	1,674	12,474	2,030	14,392
Chile	44	339	15	119
Colombia	41	263	73	475
El Salvador	15	92	13	75
France	376	2,518	536	3,814
Germany, West	1,430	9,060	1,273	7,660
India	494	3,212	407	2,610
Iran	89	652	128	979
Italy	1,407	9,840	1,227	8,878
Japan	2,083	17,696	2,171	18,598
Korea, Republic of (South)	537	3,707	573	4,021
Mexico	794	4,603	803	4,728
Netherlands	507	3,428	557	3,709
New Zealand	13	95	--	--
Norway	--	--	3	28
Peru	9	74	13	136
Philippines	113	744	174	1,282
Spain	133	950	135	974
Sweden	--	--	49	298
Switzerland	--	--	24	162
Taiwan	132	1,029	107	768
United Kingdom	34	321	64	454
Uruguay	26	262	23	216
Yugoslavia	22	982	--	--
Other	9	111	33	295
Total	10,923	79,480	11,869	84,189
Other phosphate rock: [1]				
Belgium-Luxembourg	1	56	--	--
Brazil	(2)	29	(2)	6
Canada	563	7,646	617	8,451
Colombia	1	67	3	177
Costa Rica	1	27	1	19
France	(2)	7	--	--
Germany, West	33	261	9	104
Iran	1	440	3	250
Japan	6	81	(2)	29
Mexico	108	843	129	1,098
Netherlands	4	27	--	--
Norway	89	641	51	352
Paraguay	3	180	--	--
Peru	(2)	1	3	25
Other	5	112	2	116
Total	815	10,418	818	10,627
Grand total	11,738	89,898	12,687	94,816

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.
[2] Less than ½ unit.

Table 11.—U.S. exports of superphosphates (acid phosphates), by country

(Thousand short tons and thousand dollars)

Destination	1970 Quantity	1970 Value	1971 Quantity	1971 Value
Algeria	--	--	65	$2,918
Argentina	15	$664	5	193
Australia	(1)	5	(1)	7
Belgium-Luxembourg	21	748	4	184
Brazil	192	6,993	253	9,840
Canada	90	4,177	73	3,682
Chile	132	4,313	82	2,715
Colombia	31	1,198	23	907
Costa Rica	5	176	10	431
Dominican Republic	5	189	7	250
Ecuador	4	183	6	234
El Salvador	(1)	21	6	335
France	23	676	53	1,934
Germany, West	2	93	1	42
Guyana	--	--	2	138
Hong Kong	2	115	1	100
Indonesia	1	55	--	--
Iran	12	414	45	1,574
Italy	13	427	41	1,541
Jamaica	5	267	5	230
Japan	50	1,549	18	813
Malaysia	(1)	1	--	--
Mexico	12	100	(1)	6
Netherlands	18	652	17	620
Nicaragua	1	20	1	28
Pakistan	39	1,838	--	--
Poland and Danzig	52	1,674	--	--
Singapore	3	158	(1)	1
Uruguay	--	--	6	304
Venezuela	3	103	1	46
Vietnam, South	24	1,156	10	593
Yugoslavia	--	--	6	281
Other	19	680	9	517
Total	774	28,645	750	30,464

[1] Less than ½ unit.

Table 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

(Thousand short tons and thousand dollars)

Fertilizer	1970 Quantity	1970 Value	1971 Quanity	1971 Value
Phosphates, crude and apatite	136	$3,790	84	$2,478
Phosphatic fertilizers and fertilizer materials	110	5,679	92	6,972
Ammonium phosphates, used as fertilizers	457	25,086	457	28,018
Bone ash, bone dust, bone meal and bones ground, crude or steamed	7	451	5	430
Manures, including guano	(1)	3	--	--
Dicalcium phosphate	33	1,534	23	1,162

[1] Less than ½ unit.

WORLD REVIEW

Algeria.—The State-owned Société du Djebel Onk was constructing a fertilizer manufacturing plant at Annaba to produce triple superphosphate and diammonium phosphate. The Djebel Onk mining operation was to be expanded to produce an additional 800,000 tons per year of 63- to 65-percent bone phosphate of lime (B.P.L.) concentrate by air separation to supply the Annaba fertilizer plant.[5]

Angola.—The phosphate rock deposit in the Cabinda District, belonging to Companhia dos Fosfatos de Angola (jointly owned by United States and Portuguese interests) was reported to contain at least 100 million tons of high-grade ore. Authorization to construct a 3-mile-long pier over the shallow coastal shelf for loading phosphate rock directly into bulk ore carriers was expected by yearend.

Australia.—Broken Hill South, Ltd., continued exploration and testing its extensive phosphate reserves in Northwest Queensland during the year in preparation for eventual exploitation. Because of the transportation problem of moving the rock to the Gulf of Carpentaria, the construction of port facilities and other problems, it seems unlikely that production from this area can be expected before 1980.

[5] Industrial Minerals. Algeria, Djebel Onk Phosphate: A Correction. No. 50, November 1971, p. 23.

Table 13.—Phosphate rock: World production by country

(Thousand short tons)

Country [1]	1969	1970	1971 [p]
North America:			
United States	37,725	38,739	38,886
Mexico	36	55	64
Netherlands Antilles	[2]125	[e] 120	[e] 120
South America:			
Argentina (guano)	1	--	--
Brazil:			
Apatite [e]	660	660	660
Phosphate rock	[r] 176	194	[e] 220
Chile (guano)	19	16	14
Colombia	[r] 11	13	[e] 13
Peru (guano)	22	55	24
Venezuela	[r] 45	34	54
Europe:			
France (phosphatic chalk)	[r] 29	29	[e] 30
Poland [e]	110	110	110
U.S.S.R.:			
Apatite (marketable concentrate, 39 percent P_2O_5)	[r] 11,574	12,456	12,842
Sedimentary rock (marketable concentrate, 19–25 percent P_2O_5)	[r] 9,645	10,472	11,023
Africa:			
Algeria	463	542	[e] 550
Arab Republic of Egypt (formerly United Arab Republic)	728	644	[e] 820
Morocco	11,753	12,566	13,237
Senegal:			
Aluminum phosphate	181	144	162
Calcium phosphate	1,141	1,100	1,541
Seychelles Islands (guano)	[2]12	[e] 12	[e] 12
South Africa, Republic of	[r] 1,850	1,857	1,906
Togo	1,624	1,662	1,891
Tunisia	2,960	3,325	3,485
Uganda (apatite)	[r] 15	18	14
Asia:			
China, People's Republic of [e]	1,200	1,300	1,300
Christmas Island (Indian Ocean)	[r] 1,268	1,182	[e] 1,200
India:			
Apatite	10	17	13
Phosphate rock	76	165	261
Israel	[r] 1,095	1,280	843
Jordan	[r] 1,297	927	717
Korea, North (apatite) [e]	330	330	330
Turkey	2	--	--
Vietnam, North:			
Apatite [e]	1,300	1,100	1,200
Phosphate rock [e]	55	55	60
Oceania:			
Australia	20	16	[e] 17
Nauru Island	[r] 2,417	2,330	[e] 2,300
Ocean Island	[r] 623	558	[e] 550
Total	[r] 90,598	94,083	96,469

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Belgium, Cambodia, Indonesia, Southern Rhodesia, and Tanzania produce phosphate rock, and the Philippines and South-West Africa produce guano, but information is inadequate to make reliable estimates of output levels.

[2] Exports.

Egypt, Arab Republic of.—A contract was signed with the U.S.S.R. to have Soviet experts prepare a technical and economic feasibility study to determine the potential of the phosphate deposits on the Abu Tartour plateau between the Kharga and Dukhla oases. The deposit, first discovered in 1958, was examined by Soviet geologists who reported probable reserves of 600 million tons that will require underground mining.[6] The Hamrawayn phosphate mines on the Red Sea were being developed and production at the rate of 300,000 tons per year is expected in January 1973. Production is scheduled to increase to 600,000 tons per year by the end of 1973.

The phosphate rock mining industry was described in a journal article.[7]

India.—The Geological Survey of India located new deposits of phosphate rock totaling 70 million tons in the Udaipur, Jaisalmer, and Kanswara Districts of Rajasthan. New phosphate rock discoveries totaling about 40 million tons were located at the Jhamar-Kotra mines, and 5 million tons was discovered at the Maton mines near Udaipur. In 1969, the State granted a 10-year concession to the Bikaner Gypsum Co., Ltd., of Bikaner, Rajasthan (50-percent State-owned) to mine the Jhamar-Kotra deposits. The company's goal to produce 1,000 tons per day was accomplished early in 1971. Expansion to 2,000 tons per day was the planned goal for early 1972. The new find at Maton mines was reportedly given to Hindusthan Zinc, Ltd. (a public-sector firm) for development.

Israel.—A new wet-process phosphoric acid plant was placed in production by Arad Chemical Industries Ltd., a joint venture of Madera Corp., United States and the Government of Israel. Full-capacity output of 230,000 tons per year (160,000 tons P_2O_5) is not expected before 1974.

Jordan.—A feasibility study of the establishment of a phosphate fertilizer plant to complement current phosphate mining operations at Al-Hasa was reportedly completed. The results of the study favored a plant to produce 200,000 tons per year of triple superphosphate. About 85 percent of the product would be designated for export.

Morocco.—Construction was started on a 300,000-ton-per-year washing plant at Meraa el-Arech. A 420,000-ton-per-year calcination and dry concentration plant was under construction at Beni Idir and scheduled for completion early in 1972. Another calcining plant with an annual capacity of 400,000 tons was scheduled for construction at Youssoufia. This project, when completed, is expected to concentrate 67-percent B.P.L. ore to 75-percent B.P.L. A new phosphoric acid plant and facilities for producing ammonium phosphate was planned to be completed in 1973. Annual production capacity of this facility was to be 1 million tons of products.

Production of phosphate rock in the first half of 1971 increased about 16 percent compared with the corresponding period in 1970.[8] A labor strike of the miners from September 20 to November 15 curtailed production during the last half of the year.

Peru.—Kaiser Aluminum & Chemical Corp. abandoned its interest in the Sechura phosphate project. Considering the many problems associated with the development of this deposit, commercial production is not expected before 1980.

Spanish Sahara.—An evaluation of the phosphate rock deposits at Bu-Craa indicated that the rock is of high quality and compares favorably with the Moroccan rock. A 1,500-metric-ton-per-month pilot plant was operated to produce test quantities of concentrates for prospective customers. Full production from this operation was scheduled for early 1973.[9]

Syria.—A phosphate rock processing plant near Palmyra was inaugurated. The annual capacity of the plant was stated to be 300,000 metric tons of 32-percent P_2O_5 phosphate rock concentrates. Another 600,000-ton-per-year plant was under construction. Temporary docks were constructed at the port of Tartous to load ships with phosphate rock. The implication is that Syria expects to export phosphate rock.

Tunisia.—Industries Chimiques Maghrébines was scheduled to produce 54-percent

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[6] Mining Journal, The (London). Egypt, Phosphates and Tantalum. V. 277, No. 7102, Oct. 1, 1971, p. 295.

[7] Phosphorus and Potassium (London). The Phosphate Rock Industry of the Arab Republic of Egypt. No. 56, November–December 1971, pp. 24–27.

[8] Bureau of Mines. Mineral Trade Notes. V. 69, No. 2, February 1972, pp. 18–20.

[9] Industrial Minerals. Spanish Sahara, Evaluation of Phosphate Deposits. No. 43, April 1971, p. 31.

P_2O_5 phosphoric acid at its new 120,000 ton-per-year plant at Gabes by the end of 1971. The entire output of the new facility will be exported.[10]

U.S.S.R.—The Kola apatite mine was only slightly improved in 1971. Emphasis was placed on increasing production from the Karu Tau mine and evaluation of new reserves. A new mine, Kok-Dzhon, with an annual capacity of 4.7 million tons, was activated. The Chulak Tau mine will be phased out of production and emphasis will be placed on expanding production at Aksai, Dzhanatass, Kok-Su and Kok-Dzhon. By 1975, planned production from the four mines will be 22 million tons, and the capacity of the Kola mine will be 12 to 14.5 million tons.[11]

TECHNOLOGY

Serrana SA de Mineração, a privately owned Brazilian company recently began mining and beneficiating low-grade apatite rock after the high-grade (18-22 percent P_2O_5) ore was completely depleted. The low-grade ore, averaging only 12 percent apatite (5 percent P_2O_5) and containing 80 percent calcite, is beneficiated to a 36- to 38-percent-P_2O_5 concentrate with a recovery of 80 or higher percent. A series of flotation circuits are used, followed by dewatering and a rotary oil-fired dryer. A general description of the mining and beneficiation methods was reported.[12]

N. Robinson of Fisons, Ltd. published an article citing the factors affecting the selection of phosphate rock for the manufacture of phosphoric acid. Among the factors discussed were reactivity with acid, foaming, reaction inhibition, P_2O_5 losses, filtration rates for the gypsum produced, and corrosion properties of the acid produced. Testing procedures used at the Research and Development Center of the Fertilizer Division of Fisons, Ltd., were described.[13]

A new process to produce phosphoric acid from low-grade phosphate rock was under development by Typpi Oy of Oulu, Finland. In the process, the phosphorus is leached from phosphate rock with nitric acid. Calcium and most other impurities remain in the tailings. The phosphoric acid and nitric acid solution is treated in an extractor with a tertiary amyl alcohol solvent. The solvent, after absorbing phosphoric acid and a part of the nitric acid, is washed with ammonium nitrate solution to remove carryover calcium and other impurities. The main advantage claimed for the process is a better quality product and production costs that are similar to conventional nitrophosphate processes.[14]

The Bureau of Mines Albany Metallurgy Research Center continued to study the separation of phosphate from carbonates of western ores. The objective is to remove acid-consuming carbonates from unaltered phosphate rock ores. A report of the research was being prepared for publication.

The Bureau of Mines Tuscaloosa Metallurgy Research Laboratory investigated new and improved beneficiation techniques for recovering phosphate concentrates from low-grade Tennessee siliceous and calcareous phosphate deposits. Phosphatic limestones from specific Alabama deposits were also examined.[15]

A method of dewatering phosphate slimes with an efficient but inexpensive flocculent and specially designed low-cost thickening equipment was developed.[16]

Bohna Engineering and Research Corp. developed two new processes for obtaining high-purity, high-analysis phosphoric acid. One process uses sulfuric acid, and the other uses anhydrous ammonium bisulfate. Both were reported to produce a relatively clean, concentrated (64 percent P_2O_5) acid. The processes were described in a published report.[17]

[10] Phosphorus and Potassium (London). Industries Chimiques Maghrébines. No. 56, November–December 1971, p. 21.

[11] Phosphorus and Potassium. World Phosphate Capacity in 1971. No. 55, September–October 1971, p. 17.

[12] Silvia, A. F., and P. A. Andery. Mining and Beneficiation of Apatite Rock, at the Jacupiranga Mine, Brazil. Phosphorus and Potassium, No. 57, January–February 1972, pp. 37–40.

[13] Robinson, N. The Assessment of Phosphate Rocks for Phosphoric Acid Ammonium Phosphate Manufacture. Phosphorus and Potassium, No. 57, January–February 1972, pp. 31–36.

[14] European Chemical News (London). Typpi Oy Hopes for NPK Feedstock Breakthrough. V. 20, No. 505, November 1971, p. 34.

[15] Lamont, W. E., C. E. Spruiell, Jr., D. R. Brooks, and I. L. Feld. Laboratory Flotation Studies of Tennessee Phosphates in the Presence of Slimes. BuMines Rept. of Inv. 7601, 1972, 17 pp.

[16] Stern, David R., and Ralph M. Foecking. Dewatering of Phosphate Slimes. Soc. Min. Eng., AIME, Mar. 3, 1971, 31 pp.

[17] Rubin, Allen G. Coming: New Superphosphates. Agr. Chem. & Commercial Fertilizer, v. 26, No. 11, November 1971, pp. 12–28.

Platinum-Group Metals

By Francis C. Mitko [1]

The market oversupply continued in 1971 with prices and consumption falling. Dealers' prices of all the platinum-group metals were below producers prices at yearend and throughout most of the year. Consumption of platinum-group metals, as measured by sales to consuming industries, declined 1 percent in the United States.

U.S. exports declined 2 percent; imports declined 8 percent. Refinery, importer, and dealer stocks increased 12 percent.

World production of the metals decreased 4 percent as production in the Republic of South Africa was cutback because of rising inventories and falling prices. U.S. mine production increased 4 percent, but the value of mine production fell 5 percent. U.S. refinery production of new metal increased 50 percent, but refinery production of secondary metal declined 21 percent, and toll refining decreased 16 percent.

Legislation and Government Programs.—At yearend, the national stockpile contained 507,314 ounces of palladium, an increase of 5,162 ounces over stocks at yearend 1970. The National stockpile of platinum increased 2,610 ounces to 402,646 ounces at yearend. The stockpile of iridium was reduced by 80 ounces to bring it more in line with the objective. (See table 2.)

[1] Economist, Division of Nonferrous Metals.

Table 1.—Salient platinum-group metals statistics
(Troy ounces)

	1967	1968	1969	1970	1971
United States:					
Mine production [1]	16,365	14,793	21,586	r 17,316	18,029
Value	$1,428,863	$1,500,603	$2,094,607	r $1,429,521	$1,359,675
Refinery production:					
New metal	29,663	12,305	17,875	21,395	32,102
Secondary metal	365,799	329,455	371,659	r 350,176	278,175
Exports (except manufactures)	279,852	395,157	501,064	413,766	404,610
Imports for consumption	1,321,278	1,773,984	1,225,851	r 1,410,786	1,302,740
Stocks Dec. 31: Refiner, importer, dealer	869,211	802,711	1,077,478	r 765,332	856,784
Consumption	1,334,296	1,367,911	r 1,358,469	r 1,388,510	1,375,792
World: Production	3,175,309	3,393,749	3,431,155	4,238,956	4,076,788

r Revised.
[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.

Table 2.—Government inventory of platinum-group metals, December 31, 1971
(Troy ounces)

Metal	National stockpile	Supplemental stockpile	Objective
Iridium	[1] 16,992	--	17,000
Palladium	507,314	747,680	1,300,000
Platinum	402,646	49,999	555,000

[1] Excludes 184 ounces nonstockpile grade.

DOMESTIC PRODUCTION

Mine production of new platinum-group metals increased 4 percent, but the value of production fell 5 percent owing to the decline in production of primary platinum from Alaska; the increase in quantity was mostly in lower priced byproduct palladium from copper refining. The placer dredging operation at Goodnews Bay, Alaska, is the only primary platinum operation in the United States, and the product assays about 64 to 76 percent platinum and 0.23 to 0.39 percent palladium. Byproduct production from copper and gold refining is mostly palladium.

Refinery production of new platinum-group metals increased 50 percent; all the metals except iridium contributed to the increase. However, secondary production declined 21 percent—platinum declined 13 percent and palladium, 23 percent.

Toll refining decreased 16 percent in 1971 to a total of 1,452,838 ounces. Used material accounted for 84 percent of the toll refining; the balance was virgin materials, mostly from overseas. The United States refines on toll a substantial part of the crude platinum or matte from Colombia, Canada, and the Republic of South Africa. The toll-refined material is returned to the producing company, but not necessarily to the same branch of the company or even to a branch in the producing country.

The total amounts in troy ounces treated on toll in 1971 were as follows, with the corresponding 1970 amounts in parentheses: Platinum, 782,248 (1,079,736); palladium, 593,842 (569,711); rhodium, 51,291 (56,746); iridium, 12,063 (5,659); osmium, 4,169 (958); and ruthenium, 9,225 (9,060).

Table 3.—New platinum-group metals recovered by refiners in the United States by source

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1967	20,296	8,262	754	151	189	11	29,663
1968	6,302	5,358	454	95	90	6	12,305
1969	8,702	8,387	570	135	70	11	17,875
1970:							
From domestic sources: Crude platinum; gold and copper refining	8,036	11,851	1,261	149	64	10	21,371
From foreign crude platinum	--	24	--	--	--	--	24
Total	8,036	11,875	1,261	149	64	10	21,395
1971:							
From domestic sources: Crude platinum; gold and copper refining	10,198	20,951	498	208	83	164	32,102
From foreign crude platinum	--	--	--	--	--	--	--
Total	10,198	20,951	498	208	83	164	32,102

Table 4.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1967	126,377	215,162	7,748	2,377	11,505	2,630	365,799
1968	115,587	195,620	2,127	672	12,176	3,273	329,455
1969	126,822	227,763	2,250	208	11,743	2,873	371,659
1970	r 118,298	r 208,555	1,927	121	13,394	7,881	r 350,176
1971	103,429	161,099	2,186	352	8,837	2,272	278,175

r Revised.

CONSUMPTION AND USES

Overall sales of platinum-group metals to consuming industries decreased 1 percent in 1971, to 1,375,792 ounces. Sales of platinum and rhodium fell 4 percent and 30 percent, respectively, but sales of the other metals rose by the following percentages: Palladium, 3; iridium, 42; osmium, 25; and ruthenium, 6. The chemical, petroleum, and electrical industries accounted for 83 percent of total sales, compared with 82 percent in 1970.

Platinum sales decreased slightly, to 541,164 ounces, despite the 25-percent increase in sales to the petroleum industry and gains in sales for dental, medical, and miscellaneous uses. The increase in sales to the petroleum industry was for new reforming units to produce nonleaded gasoline. The bulk of platinum sales in 1971 was distributed among petroleum refiners (46.5 percent), manufacturers of organic and inorganic chemicals (25.0 percent), and electrical and electronic equipment manufacturers (9.6 percent).

Palladium sales increased 3 percent despite sizable declines in sales to the glass industry. Sales to manufacturers of chemicals and electrical equipment increased 18 and 1 percent, respectively, and accounted for 29 and 57 percent, respectively, of all palladium sales.

Iridium sales increased 42 percent; the bulk of the material went to chemical manufacturers (54 percent) and electrical and electronic equipment manufacturers (17 percent). Sales of osmium increased 419 ounces to 2,126 ounces, most of which went to the chemical industry. Rhodium sales declined 14,531 ounces, to 34,366; most of the drop occurred in the chemical industry, the biggest user, with 14,910 ounces purchased, or 43 percent of the total. Ruthenium increased only slightly; most of the increase came in electrical and jewelry uses.

In the chemical industry, one of the major uses for platinum (alloyed with 10 percent rhodium) is as a catalyst in producing nitric acid by the oxidation of ammonia (*see* Technology). Platinum and the other platinum-group metals also are used as catalysts in a great variety of other chemical processes as shown in table 6. Monsanto has successfully operated a commercial plant for over a year at Texas City, Tex. to convert methanol and carbon monoxide to acetic acid. The system uses an iodide-promoted rhodium catalyst.[2] Engelhard Industries Division (Engelhard Minerals & Chemicals Corp.) announced a successful 1-year operation for its series EOS ethylene oxide synthesis catalyst at a U.S. commercial plant.[3]

[2] Chemical & Engineering News. Catalyst Behind New Route to Acetic Acid. V. 49, No. 35, Aug. 30, 1971, p. 19.

[3] American Metal Market. Engelhard Catalyst. V. 78, No. 133, July 13, 1971, p. 15.

Table 5.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1967	633,864	621,141	12,086	1,823	54,952	10,430	1,334,296
1968	580,155	721,479	9,443	1,612	44,776	10,446	1,367,911
1969	r 516,703	758,738	14,218	1,472	50,144	17,194	r 1,358,469
1970: r							
Chemical	148,289	184,618	5,551	992	26,445	13,825	379,720
Petroleum	202,015	15,494	--	--	59	156	217,724
Glass	46,687	21,147	408	--	7,138	--	75,380
Electrical	103,318	429,032	2,236	2	9,056	2,555	546,199
Dental and medical	18,302	47,583	757	661	51	185	67,539
Jewelry and decorative	29,203	17,329	1,717	--	5,343	3,061	56,653
Miscellaneous	18,555	24,140	236	52	805	1,507	45,295
Total	566,369	739,343	10,905	1,707	48,897	21,289	1,388,510
1971:							
Chemical	135,112	218,651	8,342	1,490	14,910	10,440	388,945
Petroleum	251,876	2,916	447	--	176	9	255,424
Glass	40,703	237	635	--	3,362	--	44,937
Electrical	51,940	431,505	2,619	--	9,084	4,351	499,499
Dental and medical	23,097	61,594	611	631	31	236	86,200
Jewelry and decorative	18,577	18,752	1,104	--	5,419	5,298	49,150
Miscellaneous	19,859	26,451	1,754	5	1,384	2,184	51,637
Total	541,164	760,106	15,512	2,126	34,366	22,518	1,375,792

r Revised.

Table 6.—Chemical processes using platinum-group metal catalysts

Process	Catalyst
Hydrogenation	Pt, Pd, Ir, Rh, Ru, Os.
Dehydrogenation	Pt, Pd, Ir, Ru, Pd-Ag.
Fragmentation	Pt, Pd.
Decomposition	Ir, Ru.
Hydrocracking	Pt, Ir.
Reforming	Pt, Ir, Rh, Pt-Ir.
Synthesis	Ir, Rh, Ru.
Polimerization	Ir–Ni, $RhCl_3$.
Isomerization	Pd, $IrCl_3$, Ir-Ni, Ir-V, $RhCl_3$, Pt-Ir, Pt-Rh, Pt-Ru, Pt–Os.
Oxidation	Pt, Rh, Ru, Pt-Ir, Pt-Rh.
Regenerable reagents	$PdCl_2$.
Homogeneous reactions	
Carbonylation	Ir, Ru, $PdCl_2$, $RhCl_3$, $Rh(NO_3)_3$.
Oxidation	Ir, Ru, $PdCl_2$.
Reductions	Ru, Pt-Ir, $RhCl_3$.

STOCKS

During the year, stocks of platinum-group metals held by refiners, importers, and dealers increased 12 percent, to 856,784 ounces. Increases in the stocks of individual metals were as follows, in percent: Platinum, 29; iridium, 23; rhodium, 8; and ruthenium, 15. Palladium and osmium stocks fell 5 percent and 68 percent, respectively.

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
1967	327,919	460,624	17,410	2,802	47,275	13,181	869,211
1968	322,932	393,882	15,127	2,402	55,097	13,271	802,711
1969	370,675	608,716	14,505	2,873	55,833	24,876	1,077,478
1970	r 346,852	r 332,726	r 13,366	1,868	r 47,767	r 22,753	r 765,332
1971 [1]	445,821	316,126	16,434	604	51,529	26,270	856,784

r Revised.

[1] Stocks of platinum and palladium in the Mercantile Exchange depositories as of December 31, 1971, were 18,900 troy ounces, and palladium, 21,600 troy ounces.

PRICES

The producers' price of platinum dropped from \$130–\$135 to \$120–\$125 per ounce in the first quarter of 1971 and remained unchanged to yearend. Rhodium dropped from \$205–\$210 to \$195–\$200 per ounce during the year. The producers' prices of the other metals began and ended the year at the following prices, in dollars per troy ounce: Palladium, 36–38; iridium, 150–155; osmium, 200–225; and ruthenium, 50–55.

The dealers' prices of all the metals were below producers' prices at yearend. Most of the metals fluctuated in price during the year, but ended the year at the following prices, in dollars per troy ounce (1970 yearend dealers' prices in parentheses): Platinum, 113–116 (122–125); palladium, 36–37 (35–35.50); iridium, 145–148 (145–148); rhodium, 195–198 (205–205); osmium, 175–200 (220–225); and ruthenium 45 (45).

FOREIGN TRADE

Despite an 18-percent increase in the quantity of platinum exported, the total of all platinum-group metals exported was down 2 percent in quantity and 22 percent in value. The average value per ounce of the platinum and other platinum-group metals decreased so that, in total, platinum export value declined 11 percent; while other platinum-group metals declined 60 percent in value. Platinum comprised 79 percent of the export quantity and 88 percent of the export value in 1971, compared with 65 percent of the quantity and 77 percent of the value in 1970. Exports to five countries accounted for 89 percent of the platinum exports in 1971 and 94 percent in 1970. Those five countries were France, Belgium-Luxembourg, West Germany, Japan, and the United Kingdom. West Germany, Japan, and Italy received most of the exports of the other platinum-group metals in both 1971 and 1970.

Table 8.—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	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1970:												
Argentina	--	--	--	--	--	--	--	--	673	$38	--	--
Australia	--	--	--	--	8	$2	--	--	2,146	86	--	--
Belgium-Luxembourg	5,871	$256	16,602	$800	--	--	--	--	2,345	77	--	--
Brazil	140	5	--	--	559	113	--	--	6,914	281	31	$1
Canada	--	--	--	--	320	64	480	$75	10,464	420	35	3
France	--	--	--	--	26,299	3,553	201	33	6,342	800	--	--
Germany, West	53	6	19,263	904	70,289	10,081	3,215	113	58,476	4,261	3,926	138
Hong Kong	--	--	--	--	12	3	99	12	46	3	--	--
Italy	--	--	--	--	4,874	646	--	--	11,896	794	--	--
Japan	600	39	737	81	46,989	6,651	2,049	237	20,351	1,690	85	4
Mexico	--	--	--	--	350	55	--	--	3,808	143	--	--
Netherlands	--	--	687	13	5,601	799	524	63	5,171	709	93	5
Switzerland	--	--	16	3	3,420	648	--	--	4,775	233	204	8
United Kingdom	1,706	251	38,205	4,223	21,230	3,220	16	3	2,908	260	147	7
Other	--	--	--	--	169	26	--	--	2,328	72	18	1
Total	8,370	557	75,510	6,024	180,120	25,861	6,584	536	138,643	9,867	4,539	167
1971:												
Argentina	--	--	--	--	353	43	--	--	702	30	--	--
Australia	--	--	--	--	510	58	--	--	1,422	51	--	--
Belgium-Luxembourg	3,472	100	31,708	1,220	--	--	--	--	5,024	171	--	--
Brazil	--	--	--	--	339	58	50	6	947	42	154	6
Canada	9,723	862	--	--	3,483	429	175	27	4,716	223	409	24
France	--	--	--	--	32,642	4,144	--	--	2,331	147	111	3
Germany, West	1,070	44	28,872	1,409	39,052	4,711	20	1	21,395	943	207	12
Hong Kong	--	--	--	--	--	--	901	104	33	2	81	4
Italy	--	--	--	--	223	30	--	--	9,374	492	1,337	21
Japan	631	44	--	--	58,199	6,612	14,562	1,660	15,800	922	5,073	183
Mexico	--	--	--	--	171	35	133	14	1,049	40	573	29
Netherlands	4	1	--	--	14,180	1,762	--	--	1,542	151	105	4
South Africa, Republic of	--	--	1,550	200	35	7	--	--	--	--	--	--
Switzerland	48	7	32	5	1,741	233	9	2	2,607	174	--	--
United Kingdom	--	--	73,063	5,184	1,882	222	44	9	3,454	159	1,758	52
Other	--	--	--	--	1,965	189	--	--	3,269	123	295	13
Total	14,948	1,058	135,225	8,018	154,775	18,533	15,894	1,823	73,665	3,670	10,103	351

Table 9.—U.S. imports for consumption of platinum-group metals

	Troy ounces	Value (thousands)
1969	1,225,851	$93,899
1970	r 1,410,786	r 104,823
1971	1,302,740	93,674

r Revised.

Table 10.—U.S. imports for consumption of platinum-group metals, by country

Year and country	Unwrought											
	Grains and nuggets (platinum)		Sponge (platinum)		Sweepings, waste and scrap		Iridium		Palladium		Rhodium	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1970:												
Australia	--	--	--	--	6,090	$551	3	$1	--	--	--	--
Belgium-Luxembourg	--	--	814	$133	12,038	1,515	--	--	24	$1	68	$15
Canada	318	$41	2,550	104	13,669	1,644	2,200	295	2,275	91	3,500	797
Colombia	20,963	2,654	--	--	1,224	178	--	--	--	--	4,160	517
Germany, West	r 428	r 66	1,655	222	128	16	--	--	r 2,409	r 66	959	r 161
Japan	1,141	198	7,639	1,094	r 10,166	r 1,463	--	--	502	18	--	--
Mexico	37	5	--	--	6,374	120	--	--	--	--	--	--
Netherlands	25	r 4	5,284	684	460	53	1,000	147	3,252	115	--	--
Norway	2,609	438	350	55	--	--	--	--	4,869	198	--	--
South Africa, Republic of	1,425	185	96,116	12,222	r 6,608	r 467	--	--	8,685	415	714	150
Switzerland	--	--	--	--	272	25	100	14	1	(1)	--	--
U.S.S.R.	--	--	--	--	--	--	--	--	67,175	2,351	7,694	1,565
United Kingdom	2,000	253	230,071	24,863	689	82	5,156	782	180,842	6,622	21,531	4,322
Other	119	17	1,590	208	6,479	r 427	--	--	--	--	--	--
Total	r 29,065	r 3,861	346,069	39,585	r 64,197	r 6,541	8,459	1,239	r 270,034	r 9,877	38,626	r 7,527
1971:												
Argentina	--	--	--	--	112	5	--	--	--	--	--	--
Australia	--	--	--	--	5,083	385	--	--	--	--	--	--
Austria	--	--	--	--	--	--	--	--	--	--	--	--
Belgium-Luxembourg	--	--	5,515	205	15,752	2,266	--	--	3,160	105	39	7
Brazil	--	--	--	--	2,547	64	--	--	--	--	--	--
Canada	--	--	1,404	189	27,752	2,786	3,250	416	16,200	528	--	--
Colombia	21,914	1,910	113	1	1,897	260	--	--	--	--	2,932	114
Denmark	--	--	--	--	--	--	--	--	--	--	--	--
Finland	--	--	--	--	788	25	--	--	--	--	--	--
France	--	--	5	(1)	--	--	--	--	--	--	--	--
Germany, West	--	--	7,961	848	101	20	--	--	--	--	242	33
Italy	--	--	1,240	149	--	--	--	--	--	--	--	--
Japan	--	--	13,962	1,822	4,198	591	--	--	--	--	--	--
Mexico	--	--	--	--	4,624	104	--	--	--	--	--	--
Netherlands	--	--	--	--	--	--	--	--	--	--	--	--
New Zealand	--	--	--	--	51	3	--	--	--	--	--	--
Norway	3,485	369	528	59	--	--	--	--	3,890	129	--	--
Panama	--	--	--	--	50	2	--	--	--	--	--	--
Peru	--	--	--	--	67	7	--	--	--	--	--	--
South Africa, Republic of	3,109	128	111,743	12,064	6,356	447	3,000	279	37,113	1,330	335	64
Surinam	--	--	--	--	49	6	--	--	--	--	--	--
Sweden	--	--	--	--	3,179	292	--	--	--	--	--	--
Switzerland	--	--	--	--	--	--	--	--	458	15	--	--
U.S.S.R.	--	--	1,539	54	--	--	--	--	11,215	491	4,835	946
United Kingdom	6,450	763	191,322	21,679	2,425	214	8,043	1,213	143,482	5,133	25,381	4,816
Total	34,958	3,170	335,332	37,070	75,031	7,477	14,293	1,908	215,518	7,731	33,764	5,980

Table 10.—U.S. imports for consumption of platinum-group metals, by country—Continued

Year and country	Unwrought: Ruthenium Troy ounces	Unwrought: Ruthenium Value (thousands)	Unwrought: Other platinum-group metals Troy ounces	Unwrought: Other platinum-group metals Value (thousands)	Semimanufactured: Platinum Troy ounces	Semimanufactured: Platinum Value (thousands)	Semimanufactured: Palladium Troy ounces	Semimanufactured: Palladium Value (thousands)	Semimanufactured: Rhodium Troy ounces	Semimanufactured: Rhodium Value (thousands)	Semimanufactured: Other platinum-group metals Troy ounces	Semimanufactured: Other platinum-group metals Value (thousands)	Total Troy ounces	Total Value (thousands)
1970:														
Australia	--	--	--	--	--	--	--	--	--	--	--	--	6,093	$552
Belgium-Luxembourg	--	--	1,050	$37	190	$33	--	--	--	--	--	--	14,184	1,734
Canada	--	--	144	20	89	12	--	--	--	--	--	--	24,745	3,004
Colombia	--	--	--	--	1,200	137	--	--	--	--	--	--	27,547	3,486
Germany, West	--	--	1,045	64	1,057	138	r 2,129	$73	506	$71	4	$4	r 10,320	r 881
Japan	--	--	--	--	r 4,060	627	--	--	r 1,320	233	800	104	r 25,628	r 3,737
Mexico	--	--	--	--	--	--	--	--	--	--	--	--	6,411	125
Netherlands	--	--	--	--	--	--	--	--	--	--	--	--	10,021	r 1,003
Norway	--	--	--	--	1,748	275	2,100	70	--	--	--	--	11,676	1,036
South Africa, Republic of	--	--	--	--	--	--	1,952	69	--	--	--	--	115,500	13,508
Switzerland	247	$10	7	(1)	1,017	153	27	1	--	--	(1)	(1)	1,671	203
U.S.S.R.	--	--	--	--	r 31,078	5,312	389,031	13,659	--	--	--	--	r 494,978	22,887
United Kingdom	20,569	974	6,996	374	74,634	9,636	106,615	3,627	560	113	2,232	334	651,895	51,982
Other	--	--	--	--	--	--	1,929	33	--	--	--	--	10,117	r 685
Total	20,816	984	9,242	495	r 115,073	16,323	r 503,783	17,532	r 2,386	r 417	3,036	442	r 1,410,786	r 104,823
1971:														
Argentina	--	--	--	--	--	--	--	--	--	--	--	--	112	5
Australia	--	--	--	--	--	--	--	--	--	--	16	2	5,099	387
Austria	--	--	--	--	--	--	1,612	55	--	--	--	--	1,612	55
Belgium-Luxembourg	--	--	--	--	--	--	--	--	--	--	--	--	24,466	2,583
Brazil	--	--	--	--	--	--	--	--	--	--	--	--	2,547	64
Canada	--	--	23	3	657	70	2,079	75	--	--	--	--	51,365	4,067
Colombia	--	--	--	--	--	--	--	--	--	--	--	--	26,856	2,285
Denmark	--	--	--	--	375	42	400	13	--	--	--	--	775	55
Finland	--	--	--	--	--	--	--	--	--	--	--	--	788	25
France	--	--	--	--	--	--	--	--	--	--	--	--	5	(1)
Germany, West	--	--	--	--	1,299	175	--	--	81	13	--	--	9,684	1,089
Italy	--	--	--	--	--	--	--	--	--	--	--	--	1,240	149
Japan	--	--	965	106	4,541	680	--	--	--	--	504	89	24,170	3,288
Mexico	--	--	--	--	--	--	--	--	--	--	--	--	4,624	104
Netherlands	--	--	--	--	150	16	631	21	--	--	--	--	781	37
New Zealand	--	--	--	--	--	--	--	--	--	--	--	--	51	8
Norway	--	--	--	--	2,700	263	1,950	64	--	--	--	--	12,553	884
Panama	--	--	--	--	--	--	--	--	--	--	--	--	50	2
Peru	--	--	--	--	--	--	--	--	--	--	--	--	67	7
South Africa, Republic of	--	--	--	--	1,966	230	2,050	72	--	--	--	--	165,672	14,614
Surinam	--	--	--	--	--	--	--	--	--	--	--	--	49	6
Sweden	--	--	--	--	--	--	888	176	--	--	--	--	4,067	468
Switzerland	--	--	--	--	12	(1)	--	--	--	--	--	--	470	15
U.S.S.R.	--	--	--	--	67,702	7,011	321,694	10,889	643	125	--	--	407,628	19,516
United Kingdom	28,063	1,222	14,049	1,958	26,404	2,988	111,161	3,833	174	31	1,055	116	558,009	43,966
Total	28,063	1,222	15,037	2,067	105,806	11,475	442,465	15,198	898	169	1,575	207	1,302,740	93,674

r Revised.
[1] Less than ½ unit.
Note: In addition, platinum content from materials n.e.s., 1970–120,377 troy ounces ($10,837,718); 1971–85,170 troy ounces ($7,350,966); and for 1970, platinum content from precious metal ores, 644 troy ounces ($87,103); and 1971, 133 troy ounces ($19,262).

U.S. imports of platinum-group metals decreased 11 percent in value and 8 percent in quantity in 1971. The United Kingdom was the source of 43 percent of the total imports, supplied some of all the platinum-group metals, and was in the top two countries for all import categories except sweepings and waste and scrap. The U.S.S.R. accounted for 31 percent of total platinum-group metal imports in 1971 and was the largest supplier of palladium. The third largest supplier was the Republic of South Africa.

WORLD REVIEW

Total world production of platinum-group metals declined 4 percent in 1971, reversing a 12-year advance. Although Western Platinum Ltd., in the Republic of South Africa, came on stream in 1971, production cutbacks by the larger producers, Rustenburg Platinum Mines Ltd. and Impala Platinum Ltd., caused a net decrease in South African production. Byproduct Canadian output declined with nickel production from the Sudbury district, Ontario. Also declining was production from Ethiopia, Finland, and Colombia. Mine output from the United States and the Philippines increased as did Japanese refinery production of platinum and palladium. Production from the U.S.S.R. was assumed to have increased.

Finland's production was in the form of byproduct metal from the copper refinery at Pori owned by Outokumpu Oy. Philippine production came from the nickel-cobalt concentrates of Acoje Mining Co. at Santa Cruz, Zambales Province, Luzon. The concentrate, which is 15 percent nickel-cobalt, assays 1.4 ounces of platinum and 2.8 ounces of palladium per ton of concentrate. The concentrator reportedly handles 400 tons of ore per day.

Canada.—The Canadian output of platinum-group metals decreased 3 percent, to 468,000 ounces. In 1971 nickel mines in the Sudbury district of Ontario were shut down, or production reduced, owing to falling copper and nickel prices. Since most of Canadian platinum is a byproduct of copper and nickel production in that area, production of platinum declined. In August 1971, International Nickel Co. of Canada Ltd. (INCO) announced a 7-percent cutback in nickel production to be accomplished by temporarily closing its Murray mine (Sudbury) and Soab mine (near Thompson, Manitoba). The reduction was apparently accomplished without layoffs but inventories continued to rise. In November, a further reduction was announced, and mines effected by early 1972 were the Pipe No. 1 (Manitoba), Creighton No. 3, Clarabelle, and Stobie (all in Sudbury). Falconbridge Nickel Mines Ltd., apparently did not reduce production, and in fact, continued its expansion program.

South Africa, Republic of.—After eight consecutive years of expanding output, South African platinum production decreased in 1971. Falling prices and sales due to recessions in the United States and other countries and to overexpansion of capacity resulted in South African inventories reaching a reported 1.2 to 1.5 million ounces of platinum. Although part of this inventory was intended to reassure U.S. automobile manufacturers that platinum was available to meet pollution control standards, the inventories became so high that production had to be drastically reduced. Rustenburg Platinum Mines Ltd. laid off about one-third of its labor force and cutback both production and planned capacity. Impala Platinum Ltd. apparently leveled off production below existing capacity and deferred further expansion. Both Rustenburg and Impala could increase production and capacity rapidly if demand for platinum in pollution control booms. Western Platinum Ltd. came on stream in 1971 on, or near, its schedule despite problems in obtaining sufficient electrical power. Atok Investments (Pty) Ltd. continued production at approximately its 1970 rate.

Table 11.—Platinum group metals: World production by country
(Troy ounces)

Country	1969	1970	1971 p
Canada: Platinum and other platinum-group metals	310,404	482,428	468,000
Colombia: Placer platinum	27,805	26,358	25,610
Ethiopia: Placer platinum	343	273	217
Finland: Platinum-group metals recovered from domestic copper ores by copper refinery	--	e 645	e 600
Japan:			
Palladium from refineries	3,877	4,610	5,381
Platinum from refineries	3,140	3,296	3,451
Philippines:			
Palladium metal	--	878	e 1,800
Platinum metal	--	352	e 900
South Africa, Republic of:			
Platinum-group metals from platinum ores e	950,000	1,500,000	1,250,000
Osmiridium from gold ores (sales) e	14,000	2,800	2,800
U.S.S.R.: Placer platinum and platinum-group metals recovered from platinum-nickel-copper ores	2,100,000	2,200,000	2,300,000
United States: Crude placer platinum and byproduct metals recovered largely from domestic gold and copper refining	21,586	17,316	18,029
Total	3,431,155	4,238,956	4,076,788

e Estimate. p Preliminary.

TECHNOLOGY

In June 1971, Ford Motor Co. and General Motors Corp. (GM) announced that they would use catalytic mufflers to meet the air pollution standards on some 1974 and all 1975 model automobiles. Ford announced its catalyst base would be platinum, but GM indicated its base would probably not be platinum, although they would continue testing platinum along with scores of other catalysts. At yearend, no decision on the exact catalyst had been announced by GM, and in fact, there was some speculation that Ford would not be able to use platinum mufflers in California since California's law requires the system to use the gasoline in common use, and the nonleaded gasoline required for platinum systems might not be in common use in California by 1974. Although no firm decisions were reached by yearend on the exact nature of the air pollution control systems to be used, enough data has been released to make reasonable comparisons between systems:

1. Platinum-based systems—Exhaust gases pass over a platinum catalyst in the muffler and the carbon monoxide (CO) and other hydrocarbons (HC) are converted to carbon dioxide and water. Oxides of nitrogen (NO_x), which also have ceilings under Environmental Protection Agency (EPA) guidelines, are not reduced by the platinum catalyst, but can be reduced by lower engine temperatures, engine modifications, or other catalysts in the system. The system must use nonleaded gasoline, because lead, even in small amounts, poisons the catalyst, making it inoperable. Around 0.1 ounce of platinum per muffler is the common estimate for this type of system with the mufflers costing $200 initially, but later dropping to around $50 when mass produced. Three firms have figured prominently in developing platinum systems: Engelhard Minerals & Chemicals Corp., Matthey Bishop, Inc., and Universal Oil Products (UOP). Because of the simplicity of operation, minimum engine modifications required, and extensive testing indicating long-term reliability, it is expected that a platinum system will be adopted by many of the automobile manufacturers worldwide.

2. Nonplatinum catalyst systems—Essentially the same system as above, but using a cheaper nonplatinum catalyst that is resistant to lead poisoning and hence can use currently available gasoline. Some catalysts that have been, or are being considered, for this type of system are oxides of vanadium, chromium, manganese, iron, cobalt, nickel, copper, molybdenum, tungsten, and the rare-earth elements. Although few details have been released on the performance of these systems, they apparently have not been tested as extensively as the platinum systems, yet still show less long-term reliability. Prominent among firms developing this type of system are Britain's Imperial Chemical Industries and a working partnership between Ethyl Corp. and Demark's Jensen & Co. of Co-

penhagen. Ethyl Corp. and PPG Industries also have devised filter systems to trap lead particles, making leaded gasoline use potentially compatible with platinum systems.

3. Thermal reactors—Use an afterburner to convert CO and HC to carbon dioxide and water, in coordination with engine modifications and exhaust gas recirculation to reduce NO_x. While these systems approach the emission standards for the life of the car (versus platinum systems 25,000 to 50,000 mile reliability), they reportedly reduce gas mileage and "driveability" considerably. Nonetheless, this type of system is being strongly considered by at least one American automobile manufacturer in view of the systems ability to handle No_x, the most difficult of the emissions to control. E. I. du Pont de Nemours & Co., Inc., is one maker of a thermal reactor system.

4. Radical engine designs—Experimental automobiles are being tested with inherently pollution-free engines. Some of these are steam-driven cars, battery-run electric cars, turbine-engine cars, and even cars with large flywheels for power. Although the design changes and lack of proved reliability and other characteristics make these cars unlikely candidates for 1975 production by major manufacturers, these engines may be adopted as long-run solutions to the pollution problem in the 1980's. Also in contention are the Wankel engine, which uses a figure-eight-shaped cylinder and a triangular rotary piston, and the Warren engine and other stratified-charge engines. The Wankel engine is already being produced and sold in this country by Mazda Corp. of Japan and NSU of West Germany. GM and Ford among other U.S. firms have purchased rights to produce the Wankel engine and may produce some in the 1970's. Although the Wankel engine produces emissions near the level common in reciprocal-type engines, its smaller size leaves room for more extensive pollution control equipment than would be acceptable on today's cars.

Elsewhere in platinum technology, in 1971 Matthey Bishop, Inc., of Malvern, Pa. introduced a new support system for a platinum gauze catalyst used in nitric acid plants. The new system called PGS (for platinum gauze support) was said to yield higher conversion of ammonia (up to 98 percent) with less loss of noble metal. Two other systems were introduced in 1970 for nitric acid production: Engelhard Minerals and Chemicals Division's Random Pack and C & I Girdler's nonnoble metal catalyst system.[4] Work by the National Aeronautics and Space Agency reports that carburized nickel-silver, in a 3:1 ratio, showed considerable anodic oxidation catalysis activity, although not as high as does uncarburized nickel-silver or the platinum black currently used for hydrogen peroxide fuel cells. The agency recommended further development, perhaps along the lines of potential use in automobiles.[5] Testing of platinum compounds (particularly Cis-Dichlorodiammine platinum-II) for their therapeutic value in cancer treatment is well along in many institutes in the United States and overseas. Although it is too early to do more than hint at possibilities, testing on humans indicates that the platinum compounds knock out or cause remissions in a very broad range of cancers, with little or no side effects. It also appears that platinum may have possibilities as an antiviral agent.

[4] Chemical Week. A New Support System for Platinum Gauze Catalyst. V. 109, No. 4, July 28, 1971, p. 39.

[5] American Metal Market. Nickel-Silver May Be Solution to Fuel Cell Catalyst Problem. V. 78, No. 142, July 27, 1971, p. 12.

Mining Journal. Platinum-Supply Position Clarified. V. 277, No. 7094, Aug. 6, 1971, p. 115.

Potash

By Donald E. Eilertsen [1]

Record consumption and imports, moderate production, sales, and exports, and higher prices were some of the outstanding features of the potassium industry in the United States in 1971. Imports were larger than production for the first time since 1937.

World production of potash was the largest ever reported and according to preliminary estimates, the United States dropped from being the fourth largest producer to that of fifth.

Table 1.—Salient statistics on potassium salts

(Thousand short tons and thousand dollars)

Item	1967	1968	1969	1970	1971
United States					
Production of potassium salts, marketable	5,649	4,769	4,918	4,853	4,543
Approximate K_2O equivalent	3,299	2,722	2,804	2,729	2,587
Value	$105,313	$75,664	$73,572	$98,123	$100,527
Sales of potassium salts by producers	5,363	5,091	5,340	4,703	4,578
Approximate K_2O equivalent	3,126	2,913	3,069	2,669	2,592
Value at plant	$100,566	$81,620	$78,062	$92,373	$102,099
Average value per ton	$18.75	$16.03	$14.62	$19.64	$22.30
Imports for consumption of potassium salts [1]	r 2,881	r 3,644	r 3,926	r 4,403	4,672
Approximate K_2O equivalent [1]	r 1,697	r 2,166	r 2,332	r 2,605	2,766
Value [1]	r $67,017	r $71,910	r $60,703	r $94,734	$111,844
Exports of potassium salts [1]	r 1,119	r 1,303	r 1,233	r 966	1,033
Approximate K_2O equivalent [1]	r 649	r 735	r 700	r 544	564
Value [1]	r $33,844	r $38,353	r $33,061	r $28,473	$35,323
Apparent consumption of potassium salts [2]	r 7,125	r 7,432	r 8,033	r 8,140	8,217
Approximate K_2O equivalent	r 4,174	r 4,344	r 4,701	r 4,730	4,794
World: Production, marketable:					
Approximate K_2O equivalent	17,353	17,867	19,198	20,416	22,119

r Revised.
[1] Excludes potassium chemicals and mixed fertilizers.
[2] Measured by sold or used plus imports minus exports.

DOMESTIC PRODUCTION

Domestic production of marketable potassium muriates, potassium sulfate, potassium-magnesium sulfate, and manure salts in terms of potassium monoxide (K_2O) equivalent in 1971 was 5.2 percent less than in 1970, and 22.1 percent below the record output of 1966. The general decline in production since 1966 has been largely attributed to the increase in imports of potassium muriate from Canada. Standard muriate, soluble muriate, and potassium sulfate were the only domestic salts that increased in production in 1971 compared with 1970. Statistical data on potassium sulfate were reported separately for the first time to facilitate more detailed analysis.

New Mexico accounted for 88.5 percent of the national output of marketable K_2O equivalent in 1971. The average grade of crude potassium salts mined in New Mexico was 17.3 percent K_2O in 1971 compared with 18.1 percent K_2O in 1970.

Ten firms in three States produced marketable potassium salts. They were AMAX Chemical Corp., (formerly Southwest Potash Corp.), Duval Corp., International Minerals & Chemical Corp., Kerr-McGee Corp., National Potash Co., Potash Company of America Division of Ideal Basic Industries, Inc., and United States Potash & Chemical Co. in New Mexico; Kerr-

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Marketable potassium salts produced and sold or used in the United States, in 1971, 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 1971:						
Muriate of potash, 60 percent K_2O minimum:						
Standard	871	531	$16,663	898	548	$17,219
Coarse	559	342	12,520	636	389	14,222
Granular	346	210	8,233	484	294	11,582
Potassium sulfate	208	106	7,509	250	128	8,934
Other potassium salts [2]	415	172	8,374	491	204	9,913
Total [3]	2,399	1,362	53,298	2,759	1,563	61,869
July-December 1971:						
Muriate of potash, 60 percent K_2O minimum:						
Standard	800	488	15,674	637	388	12,355
Coarse	456	279	9,262	403	246	8,115
Granular	309	188	6,563	272	165	5,686
Potassium sulfate	225	116	8,407	220	113	8,188
Other potassium salts [2]	355	155	7,323	288	116	5,887
Total [3]	2,145	1,226	47,228	1,819	1,029	40,230
Grand total [3]	4,543	2,587	100,527	4,578	2,592	102,099

[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] Mine production		Marketable potassium salts Production			Marketable potassium salts Sold or used		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1970								
January-June	8,096	1,476	2,164	1,198	42,260	2,192	1,224	42,377
July-December	8,150	1,459	2,123	1,192	43,617	1,774	1,003	35,922
Total [3]	16,246	2,935	4,286	2,390	85,877	3,966	2,227	78,299
1971								
January-June	8,293	1,453	2,136	1,210	46,195	2,484	1,404	54,462
July-December	7,824	1,338	1,894	1,081	40,494	1,617	914	34,863
Total [3]	16,117	2,792	4,030	2,291	86,689	4,101	2,317	89,325

[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.

McGee Corp. (American Potash Division) in California; and Kaiser Aluminum & Chemical Corp. and Great Salt Lake Minerals & Chemical Corp. in Utah.

Texas Gulf Sulphur Co. prepared to resume potash production at its facility near Moab, Utah. The company completed the conversion of its Cane Creek potash mine from underground to solution mining and constructed huge pond areas on the surface for solar evaporation of brine. The ponds were lined with sheets of polyvinyl chloride to prevent pollution and loss of potash. When method testing began, water was pumped into the mine to produce saturated brine containing potassium chloride and salt. Later, the brine was pumped from the mine into the ponds for the solar evaporation of water and the precipitation of salts. The whole operation is scheduled

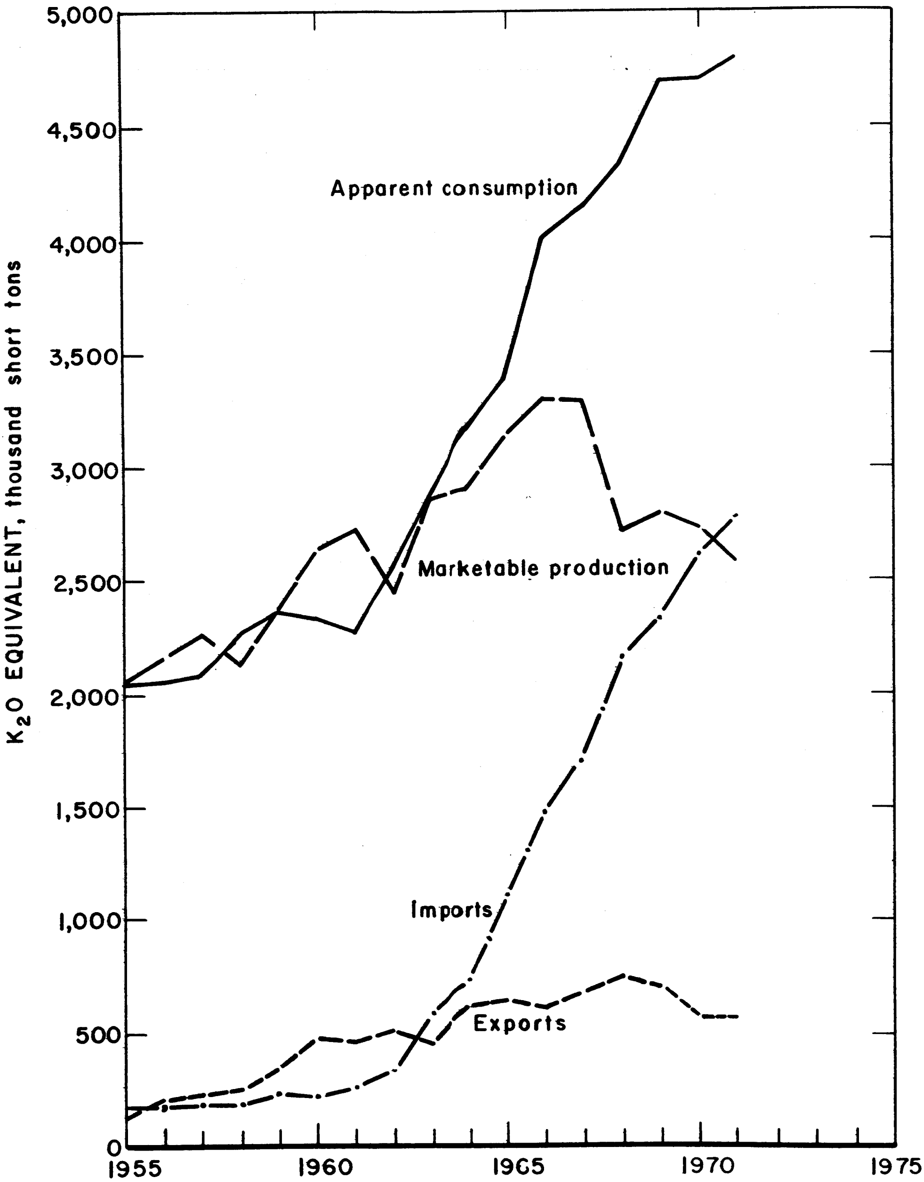

Figure 1.—Marketable production, apparent consumption, exports and imports of potassium salts measured in K_2O equivalent.

to go on stream in March 1972 when the first salts are harvested and processed in existing facilities for the recovery of potassium chloride.

Searles Lake Chemical Corp., a subsidiary of Occidental Petroleum Corp., continued to construct facilities at Searles Lake, Calif. to recover potassium sulfate, borax products, and soda ash from brines.

About 187,000 tons of liquid potassium hydroxide, 88 to 92 percent pure, was produced for chemical uses in the United States in 1971. During 1966 to 1970, the annual outputs ranged between 174,000 and 179,000 tons.[2] Reportedly, nine firms have facilities for producing caustic potash from chemical-grade potassium chloride; their capacities totaled 230,000 tons per year.[3]

CONSUMPTION AND USES

Apparent consumption of 8.217 million tons of potassium salts. (4.794 million tons of K_2O equivalent) was the largest ever reported. Figures on apparent consumption, imports, and exports in table 1 were revised for 1967–70 to report data uniformly as potassium salts excluding potassium chemicals and mixed fertilizers.

Deliveries of domestic and imported potash salts, as reported by the Potash Institute of North America, for agricultural and chemical purposes in the United States totaled 4.86 million tons of K_2O equivalent, breaking all records. Deliveries for agriculture soared to 4.61 million tons of K_2O (94.84 percent of the total) while those for chemicals reached a peak of 251,000 tons of K_2O. Illinois, Iowa, Indiana, Ohio, and Minnesota were the largest recipients of potash for agriculture and together accounted for 41.3 percent of this potash. New York, Illinois, and Alabama were the largest recipients of potash for chemicals and together accounted for about 65 percent of this potash.

Based on the deliveries of potash, slightly over 5 percent of the total potash

Table 4.—Deliveries of potash salts in 1971, by State of destination

(Short tons K_2O equivalent)

Destination	Agricultural potash	Chemical potash	Destination	Agricultural potash	Chemical potash
Alabama	101,047	32,831	Nebraska	38,096	167
Arizona	787	84	Nevada	59	635
Arkansas	74,645	396	New Hampshire	414	25
California	52,842	4,085	New Jersey	12,604	1,445
Colorado	8,359	340	New Mexico	2,110	242
Connecticut	3,421	806	New York	71,499	96,044
Delaware	18,016	14,685	North Carolina	150,706	37
Florida	233,171	699	North Dakota	11,960	--
Georgia	220,136	87	Ohio	330,096	5,525
Hawaii	22,432	--	Oklahoma	20,023	338
Idaho	7,118	--	Oregon	13,048	1,039
Illinois	518,131	33,885	Pennsylvania	55,324	3,529
Indiana	338,878	4,332	Rhode Island	1,977	965
Iowa	389,836	245	South Carolina	102,953	72
Kansas	39,698	1,297	South Dakota	8,393	--
Kentucky	87,936	14,749	Tennessee	106,706	32
Louisiana	66,156	632	Texas	211,478	21,030
Maine	14,443	112	Utah	661	68
Maryland	80,439	1,287	Vermont	5,572	--
Massachusetts	3,664	565	Virginia	98,239	587
Michigan	151,103	1,218	Washington	23,440	2,347
Minnesota	324,380	335	West Virginia	3,515	1,532
Mississippi	145,618	4	Wisconsin	220,739	478
Missouri	209,935	1,714	Wyoming	1,432	81
Montana	3,151	19			
			Total	[1] 4,606,386	[2] 250,625

[1] Distribution of K_2O—1,447,471 tons as standard muriate, 1,739,580 tons as coarse muriate, 924,661 tons as granular muriate, 303,550 tons as soluble muriate, and 191,124 tons as sulfates.
[2] Distribution of K_2O—184,417 tons as muriate, 63,694 tons as soluble muriate, and 2,514 tons as sulfates.

Source: Potash Institute of North America, Atlanta, Ga.

[2] Bureau of the Census. Current Industrial Reports, Inorganic Chemicals. Ser. M28A, (71)-13, May 1972, p. 2, and M28A, (70)-14, June 1972, p. 3.

[3] Jeffery, Thomas C. and L. C. Fuhrmeister. Report of the Electrolytic Industries for the Year 1970. J. Electrochem. Soc., v. 118, No. 10, October 1971, pp. 265C–271C.

demand was consumed to produce potassium chemicals for other than fertilizer uses.

Most potash for chemicals is in the form of chemical-grade potassium chloride, largely used as raw material for producing potassium hydroxide (caustic potash). This chemical has many direct applications and also is used as a starting material for making most other potassium compounds. The major consumers of potassium chemicals are reportedly the detergent and soap industries, 35 percent; glass and ceramics, 25 percent; textiles and dyes, 20 percent; and chemicals and drugs, 13 percent. Potassium hydroxide is used directly in most of these applications. Potassium carbonate and nitrate are widely used in the glass and ceramic industries; potassium sulfate, as an accelerator in making gypsum wallboard; potassium chlorate and potassium perchlorate in explosives and rocket fuels; and potassium bromide in the photographic industry. Potassium chemicals have many other uses.[4]

STOCKS

Producers yearend stocks of potassium salts contained 428,000 tons of K_2O equivalent—5.7 percent less than in 1970 and 50.4 percent less than the alltime high set in 1967. Yearend stocks of imported potassium salts were not available.

Table 5.—Yearend stocks of marketable potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31	
		Gross weight	K_2O equivalent
1967	12	1,501	863
1968	13	1,175	676
1969	12	723	392
1970	13	875	454
1971	11	796	428

PRICES

The Saskatchewan Government continued to regulate its huge new potash industry for the second consecutive year. Their production and pricing regulations have been largely responsible for higher worldwide potash prices since 1969, the year when prices were the lowest on record.

Standard domestic muriate of potash (KCl), f.o.b. shipping points (table 2), had an average sales value of $19.27 per ton of KCl in 1971, compared with $16.31 per ton in 1970 and $11.58 per ton in 1969. The average sales value of coarse domestic KCl, f.o.b. shipping points, was $21.50 per ton KCl in 1971, compared with $19.70 per ton KCl in 1970 and $13.66 per ton of KCl in 1969. The average sales value of domestic granular KCl, f.o.b. shipping points, was $22.84 per ton of KCl in 1971, compared with $20.92 per ton of KCl in 1970 and $14.09 per ton of KCl in 1969.

Imports for consumption of potassium chloride from Canada, type and grade unspecified, f.o.b. Canadian shipping points, had an average value of $23.18 per ton of KCl in 1971, compared with $20.76 per ton of KCl in 1970 and $14.72 per ton of KCl in 1969.

Quoted prices on various potash materials for 1971 are shown in tables 6 and 7.

[4] Industrial Minerals. Potash To-day, I: The Role of Potassium. V. 41, February 1971, pp. 9–13.

Table 6.—Prices for potassium products in 1971 [1]

Product	Jan. 1	Feb. 5	June 4	July 2	Sept. 3	Oct. 8	Oct. 29	Dec. 31
Potassium chloride, chemical grade (99.95 percent KCl), per short ton	$33.00	--	--	--	--	--	--	$33.00
Potassium muriate, per unit ton: [2]								
Standard, (60 percent K_2O minimum):								
New Mexico and Utah	.33–.34	$0.35	--	(3)				
Trona, Calif. (freight equalized)	.43	--	--	--	--		--	.43
Saskatchewan, Canada	.33–.3375	.35–.36	$0.3375–.35	(4)				
New Mexico and Canada	--	--	--	$0.3375	--	--	--	.3375
Soluble, fine standard:								
New Mexico and Canada	--	--	--	.35	--	$0.3425–.35	$0.3325–.35	.3325–.35
Coarse:								
New Mexico and Utah	.39	.42	--	(3)	--	--	--	--
Trona, Calif. (freight equalized)	.47	--	--	--	--	--	--	.47
Saskatchewan, Canada	.39–.40	.42–.43	.36–.42	(4)				
New Mexico and Canada	--	--	--	.36–.37	$0.35–.37	--	.3425–.37	.3425–.37
Granular:								
New Mexico and Utah	.41	.44	--	(3)	--	--	--	--
Saskatchewan, Canada	.41–.42	.44–.45	.37–.44	(4)				
New Mexico and Canada	--	--	--	.37–.38	.36–.38	--	--	.36–.38
Potassium sulfate, per unit ton: [2] Agricultural (50 percent K_2O minimum):								
Standard:								
New Mexico	.80	--	--	--	.76	--	--	.76
Trona, Calif	.93	.98	--	--	--	--	--	.98
Utah	--	.72	--	.76	--	--	--	.76
Granular:								
New Mexico	.90	--	--	--	.88	--	--	.88
Trona, Calif	1.03	1.08	--	--	--	--	--	1.08
Utah	--	--	--	--	.88	--	--	.88
Potassium manure salt, (20 percent K_2O minimum), per unit ton: [2]	.1765	--	--	--	--	--	--	.1765

[1] Bulk, carlots, works.
[2] 20 pounds of equivalent K_2O.
[3] Prices for Utah not quoted after June 25, 1971.
[4] Prices for Saskatchewan, Canada, combined with Carlsbad, N. Mex. after June 25, 1971.

Source: Oil, Paint and Drug Reporter.

Table 7.—Bulk prices for potash in 1971 [1]

(U.S. cents per unit K_2O)

	Jan. 1	July 1	Oct. 4	Oct. 25
Muriate, 60 percent K_2O minimum:				
Carlsbad, N. Mex.:				
Standard	33.75	--	--	--
Coarse	39	37	--	36.25
Granular	41	38	--	37.25
Potasco, Saskatchewan:				
Standard	33.75	--	--	--
Coarse	39	37	35.25	34.25
Granular	41	38	36.25	35.25
Sulfate of potash, 50 percent K_2O minimum:				
Carlsbad, N. Mex.:				
Regular	80	--	--	--
Granular	90	--	--	--
Mine run salts, minimum 20 percent K_2O, Carlsbad, N. Mex	17.65	--	--	--

[1] Carlots, f.o.b. cars.

Source: Potash Company of America, Division of Ideal Basic Industries, Inc.

FOREIGN TRADE

Exports and imports of all potash fertilizer and chemical materials are shown in tables 8 to 11.

Figures on exports and imports in table 1 were revised for 1967–70 so as to report data uniformly in terms of potassium salts. Exports of 564,000 tons of K_2O equivalent as potassium salts in 1971 were 3.6 percent larger than those in 1970, but 23.3 percent below the record of 1968. Imports for consumption of 2.77 million tons of K_2O as potassium salts in 1971 broke all records and also were larger than domestic production. A total of 4,440,054 tons of potassium chloride (2.66 million tons of K_2O) valued at $102,930,505 was imported from Canada in 1971 compared with 4,152,065 tons of potassium chloride (2.49 million tons of K_2O) valued at $86,201,091 imported in 1970.

Table 8.—U.S. exports of potash materials, by use

Materials	Approximate equivalent as potash (K_2O) percent	1970				1971			
		Short tons	Approximate equivalent as potash (K_2O)		Value (thousands)	Short tons	Approximate equivalent as potash (K_2O)		Value (thousands)
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly as fertilizers:									
Potassium chloride, all grades	60	793,763	476,258	r 83.3	$21,965	754,561	452,737	76.1	$23,766
Potassic chemical fertilizer, n.e.c	40	r 165,430	r 66,172	11.6	r 6,300	276,035	110,414	18.6	11,458
Natural potassic salt fertilizers, crude	20	6,445	1,289	.2	208	2,352	470	.1	99
Total	--	r 965,638	r 543,719	r 95.1	r 28,473	1,032,948	563,621	94.8	35,323
Used chiefly in chemical industries:									
Potassium hydroxide	80	6,853	5,482	r .9	969	27,885	22,308	3.8	2,029
Potassium peroxide	83	--	--	--	--	13	11	--	13
Potassium compounds, n.e.c	31	73,524	22,792	4.0	7,481	27,290	8,460	1.4	6,030
Total	--	80,377	28,274	r 4.9	8,450	55,188	30,779	5.2	8,072
Grand total	--	r 1,046,015	r 571,993	100.0	r 36,923	1,088,136	594,400	100.0	43,395

r Revised.

Table 9.—U.S. exports of potash materials, by country

Destination	Fertilizer: Chloride quantity 1970	Chloride quantity 1971	Chemical fertilizer n.e.c. quantity 1970	Chemical fertilizer n.e.c. quantity 1971	Total 1970 Quantity	Total 1970 Value	Total 1971 Quantity	Total 1971 Value	Chemical: Hydroxide (caustic) quantity 1970	Hydroxide (caustic) quantity 1971	Other, n.e.c. quantity 1970	Other, n.e.c. quantity 1971	Total 1970 Quantity	Total 1970 Value	Total 1971 Quantity	Total 1971 Value
Algeria	--	30,829	11,084	11,200	11,084	$442	[1] 42,140	[1] $2,231	--	--	--	--	--	--	--	--
Argentina	3,086	4,667	220	3,146	[1] 5,851	[1] 171	[1] 9,599	[1] 313	477	32	528	$307	1,005	$156	339	$95
Australia	80,174	66,866	5,796	12,294	85,970	r 2,217	79,160	2,252	271	80	504	367	775	186	447	114
Belgium-Luxembourg	--	--	55	--	55	4	--	--	3	--	87	78	90	58	78	61
Brazil	85,562	208,556	11,228	2,425	96,790	r 2,479	210,981	6,887	1,218	624	45,447	1,603	46,665	1,832	2,227	459
Canada	16,978	59,559	48,729	40,245	[1] 65,829	[1] 2,548	[1] 100,069	[1] 3,716	2,374	3,489	7,768	6,413	10,142	1,820	[2] 9,915	[2] 1,695
Chile	24,618	17,212	2,983	1,652	27,601	753	18,864	577	16	--	41	287	57	19	287	80
Colombia	58,351	21,536	7,397	5,384	65,748	1,849	26,920	836	138	68	70	185	208	52	253	58
Costa Rica	17,000	38,765	7,920	6,194	[1] 25,692	[1] 656	44,959	1,505	4	--	359	27	363	19	27	5
Germany, West	--	--	--	--	--	--	--	--	--	--	2,118	2,956	2,118	1,185	2,956	1,155
Honduras	1,386	1,785	492	277	1,878	78	2,062	113	--	6	385	583	385	30	589	39
India	--	--	--	--	--	--	--	--	--	--	250	155	250	58	155	67
Italy	--	--	2,180	26,896	2,180	105	26,896	1,078	--	--	240	50	240	110	50	10
Japan	200,585	107,079	33,838	109,313	[1] 236,163	[1] 6,957	216,392	7,632	--	--	221	140	221	93	140	65
Mexico	36,381	57,010	27,291	20,717	[1] 64,430	[1] 2,128	77,727	2,453	659	546	1,998	2,234	2,657	539	2,780	641
Netherlands	--	--	--	--	--	--	--	--	--	22	662	345	662	246	367	249
New Zealand	66,858	52,147	164	452	67,022	2,208	52,599	1,431	14	--	99	62	113	34	62	26
Pakistan	--	--	--	--	--	--	--	--	56	60	5,777	428	5,833	426	488	104
Philippines	28,941	67	--	15	28,941	751	82	3	9	12	51	63	60	46	75	41
Singapore	3,024	5,600	--	3,360	3,024	66	8,960	331	--	--	5	--	5	2	--	--
Sweden	8,660	8,066	55	4,684	8,715	208	12,750	413	--	--	106	65	106	27	65	19
Taiwan	91,160	32,012	--	5,236	91,160	2,653	[1] 37,317	[1] 1,136	4	--	30	129	34	13	129	63
U.S.S.R.	--	--	--	--	--	--	--	--	--	22,011	--	1,103	--	--	23,114	1,870
United Kingdom	11	40	--	--	11	1	40	1	25	--	1,396	978	1,421	542	978	215
Venezuela	5,588	166	--	9,800	5,588	108	9,966	418	351	240	345	5,512	696	147	5,752	367
Vietnam, South	--	--	--	2,866	--	--	2,866	179	574	110	3,562	2,442	4,136	344	2,552	204
Other	65,400	42,599	r 6,498	9,879	r 171,906	[1] 2,091	[1] 52,599	[1] 1,818	660	585	1,475	778	2,135	466	[2] 1,363	[2] 370
Total	793,763	754,561	r 165,430	276,035	r [1] 965,638	r [1] 28,473	[1] 1,032,948	[1] 35,323	6,853	27,885	73,524	27,290	80,377	8,450	[2] 55,188	[2] 8,072

r Revised.

[1] Includes crude natural potassic salt fertilizer—1970: Canada, 122 tons ($5,454), Mexico, 758 tons ($25,456), Costa Rica, 772 tons ($20,713), Bahamas, 8 tons ($275), Argentina, 2,545 tons ($95,738), Japan, 2,240 tons ($60,659). 1971: Canada, 265 tons ($8,880), Taiwan, 69 tons ($2,300), Algeria, 111 tons ($3,730), Argentina, 1,786 tons ($65,553), Guyana, 121 tons ($18,360).

[2] Includes potassium peroxide, 1971; Canada 13 tons ($12,950), British Honduras, less than 1 ton ($500).

Table 10.—U.S. imports for consumption of potash materials, by use

Materials	Approximate equivalent as potash (K_2O) percent	1970 Short tons	1970 Approximate equivalent as potash (K_2O) Short tons	1970 Approximate equivalent as potash (K_2O) Percent of total	1970 Value (thousands)	1971 Short tons	1971 Approximate equivalent as potash (K_2O) Short tons	1971 Approximate equivalent as potash (K_2O) Percent of total	1971 Value (thousands)
Used chiefly as fertilizers:									
Muriate (chloride)	60	4,256,408	2,553,845	97.8	$88,991	4,549,098	2,729,459	98.4	$106,180
Potassium nitrate, crude	40	14,531	5,812	.2	812	21,981	8,792	.3	1,421
Potassium sodium nitrate mixtures, crude	14	56,159	7,862	.3	2,231	61,168	8,564	.3	2,651
Potassium sulfate, crude	50	75,780	37,890	1.5	2,671	39,185	19,593	.7	1,575
Other potash fertilizer material	6	345	(1)	(1)	29	760	46	(1)	17
Total	--	4,403,223	2,605,409	99.8	94,734	4,672,192	2,766,454	99.7	111,844
Used chiefly in chemical industries:									
Bicarbonate	46	496	228		77	957	440		247
Bitartrate:									
Argols	20	6	(1)		2	11	2		4
Cream of tartar	25	1,156	289		657	1,235	309		728
Carbonate	61	77	47		14	684	417		88
Caustic	80	2,812	2,250		509	3,420	2,736		555
Chlorate and perchlorate	36	657	237	.2	144	623	224	.3	125
Cyanide	70	926	648		410	681	477		301
Ferricyanide	42	752	316		464	866	364		592
Ferrocyanide	44	1,197	527		457	1,039	457		386
Nitrate	50	623	312		84	179	90		23
Rochelle salts	22	482	106		214	299	66		123
All other	31	5,657	1,754		3,571	5,193	1,610		3,465
Total	--	14,841	r 6,714	.2	6,603	15,187	7,192	.3	6,637
Grand total	--	4,418,064	r 2,612,123	100.0	101,337	4,687,379	2,773,646	100.0	118,481

r Revised.
[1] Less than ½ unit.

Table 11.—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)
1970:												
Belgium-Luxembourg	--	68	--	--	--	20	--	--	5,968	1,375	7,431	$590
Canada	--	--	--	6	r4,152,065	30	174	--	--	765	r4,153,040	r 86,916
Chile	--	--	--	--	--	9,402	54,877	--	--	--	64,279	2,518
Congo	--	--	--	--	25,529	--	--	--	--	--	25,529	641
Finland	--	--	--	--	--	--	--	--	--	581	581	69
France	12	400	--	45	--	--	--	--	18,724	301	19,482	772
Germany, West	1	650	19	448	r 36	208	--	425	39,920	2,461	r 44,168	r 3,114
Israel	--	--	--	--	74,320	4,852	684	--	--	--	79,856	2,472
Italy	598	--	--	--	--	19	--	198	11,168	66	12,049	953
Japan	--	1,262	--	202	--	--	--	--	--	880	2,344	1,561
Netherlands	--	--	--	--	--	--	--	--	--	1,915	1,915	590
Spain	545	--	169	--	4,358	--	--	--	--	154	5,226	519
Sweden	--	432	326	--	--	--	--	--	--	--	758	202
United Kingdom	--	--	--	167	100	--	--	--	--	310	577	212
Other	--	--	143	58	--	--	424	(1)	--	204	829	208
Total	1,156	2,812	657	926	4,256,408	14,531	56,159	623	75,780	9,012	4,418,064	101,337
1971:												
Belgium-Luxembourg	--	168	--	--	--	--	--	--	1,498	933	2,599	467
Canada	--	7	--	12	4,440,054	170	381	--	48	1,178	4,441,850	103,612
Chile	--	--	--	--	--	5,061	51,774	--	--	17	56,852	2,313
Finland	--	--	--	--	--	--	--	--	--	943	943	116
France	2	346	--	50	--	--	--	--	1,166	745	2,309	354
Germany, West	--	1,382	--	269	16	20	--	40	34,745	2,759	39,231	2,940
Israel	--	--	--	--	94,650	14,730	8,813	--	--	5	118,198	4,445
Italy	710	--	--	--	--	--	--	139	1,722	36	2,607	545
Japan	--	1,380	--	182	--	--	--	--	--	1,213	2,775	1,863
Netherlands	--	--	--	20	--	--	--	--	--	1,476	1,496	480
Spain	501	--	193	--	7,903	--	--	--	--	139	8,736	656
Sweden	--	137	306	--	--	--	--	--	--	10	453	119
United Kingdom	--	--	--	148	--	--	--	(1)	--	285	433	211
Other	22	--	124	--	6,475	2,000	200	(1)	6	70	8,897	360
Total	1,235	3,420	623	681	4,549,098	21,981	61,168	179	39,185	9,809	4,687,379	118,481

r Revised.
1 Less than ½ unit.

WORLD PRODUCTION

World production of marketable potash broke all records in 1971 and according to preliminary figures, the United States slipped from being the fourth largest producer to that of fifth place.

Brazil.—Companhia de Pesquisa de Recursos Minerais (CPRM) asked for bids to exploit its evaporite deposits of potassium and associated minerals located near Carmopolis in the State of Sergipe, northeastern Brazil. Recent exploration in the area showed deposits containing 450 million metric tons of sylvinite (KCl and NaCl), 6.06 billion tons of carnallite (hydrous potassium-magnesium chloride), 4 billion tons of tachydrite (hydrous calcium-magnesium chloride), 525 million tons of halite, and 10 million tons of bromine in the tachydrite.

Table 12.—World production of marketable potash, by country

(Thousand short tons, K_2O equivalent)

Country	1969	1970	1971 p
Canada	r 3,748	3,420	3,872
Chile	19	24	29
Congo (Brazzaville)	45	139	e 139
France	2,136	2,099	e 2,100
Germany, East	2,586	2,666	e 2,700
Germany, West	2,895	2,916	3,213
Israel	r 408	611	e 670
Italy	280	251	236
Spain	701	656	676
U.S.S.R	r 3,576	e 4,905	e 5,897
United States	2,804	2,729	2,587
Total	r 19,198	20,416	22,119

e Estimate. p Preliminary r Revised.

Canada.—Potash was discovered in New Brunswick in 1971, near Sussex, a few miles away from water transportation to world markets. The deposits are at a depth of 900 to 1,000 feet and contain bed thicknesses up to 32 feet analyzing 21 to 25.5 percent K_2O equivalent.[5]

A potash map of Canada and the world was published showing where potash is produced geographically, listing the producers and their processing methods, and principal products and capacities.[6]

An excellent report on the potash potential of the Esterhazy, Belle Plaine, and Patience Lake Members of the Prairie Evaporite Formation in Saskatchewan was published. The report contains longitudinal, cross-sectional, and plan view maps of each member extending over a vast area. The plan-view maps show areas of sylvite mineable by conventional mining methods to depths of 3,500 feet and also areas mineable by solution mining methods at greater depths. The areas designated for conventional mining also show the extent of ores containing over 40 percent sylvite and ores containing 30 to 40 percent sylvite obtainable at an 8-foot thickness leaving substantial salt-back for water-seal between mine openings and overlying strata. The areas designated for solution mining show the extent of ore containing over 20 percent sylvite, less than 5 percent carnallite, and about 5 percent insolubles, which can be mined for a thickness of 10 feet, leaving over 20 feet of salt-back in place for water seal.[7]

Germany, West.—A major consolidation of the West German potash industry occurred in 1970. Wintershall A.G. of Celle/Kassel and Salzdetfurth A.G. of Hannover combined their potash and rock salt interests under one management which, subsequently, was renamed Kali-und Salz G.m.b.H. (K+S), Kassel. K+S produces about 85 percent of the West German potash output, whereas Kali Chemie A.G. of Hannover produces about 15 percent. K+S is largely owned by Badische Anilin & Soda Fabrik A.G. (BASF). Kali Chemie A.G. is controlled by Deutsche Solvay-Werke G.m.b.H., Solingen.[8] K+S now operates about 13 potash and rock salt mines

[5] Koepke, W. E. Potash. Canadian Minerals Yearbook 1970, Preprint No. 36, May 1971, 13 pp.

[6] Potash, Canada and the World. Map MR-5, Minerals Resources Branch, Department of Energy, Mines and Resources, Ottawa, 1971, 1 p.

[7] Holter, M. E. Geological Criteria for the Location of Economic Potash Deposits. Canadian Min. & Met. Bull., v. 64, No. 710, June 1971, pp. 44-49.

[8] Bureau of Mines. Mineral Trade Notes. V. 68, No. 8, August 1971, pp. 37-38.

in West Germany and also has 50 percent interest in Alwinsal Potash of Canada, Ltd.[9]

Spain.—Three companies with six mines produced all of Spain's potash. The mines are located in the northeast and preparations are underway to increase the total annual capacity to 1.3 million metric tons of K_2O equivalent by 1975, about 50 percent above that of 1970. Union Explosivos Rio Tinto, S.A. (UERT) has three potash mines—the Balsareny mine and recently-acquired Sallent mine, located about 12 kilometers northeast of Manresa, and the Cardona mine, located about 25 kilometers northwest of Manresa. Company plans include connecting the Balsareny and Sallent mines together underground and using one production shaft. After this is done and other improvements are made, the mines will have a total annual capacity of 250,000 tons of K_2O equivalent. UERT also plans to raise the annual capacity of its Cardona mine to 250,000 tons of K_2O equivalent. Minas de Potassas de Suria, S.A.'s Suria mine, located about 13 kilometers northwest of Manresa, will increase its annual capacity to 250,000 tons of K_2O equivalent. Potassas de Navarra, mostly Government-owned, operates the Esparza and Beriain mines, located about 7 kilometers south of Pamplona. The total annual capacity of these mines will soon be 550,000 tons of K_2O equivalent.[10]

United Kingdom.—Cleveland Potash, Ltd., jointly owned by Imperial Chemical Industries, Ltd., and Charter Consolidated, Ltd., was the only one of three firms with plans to begin potash production. The company was having two shafts sunk on contract at Boulby mine. Each shaft will be about 18 feet in diameter, No. 1 shaft, 3,716 feet deep, and No. 2 shaft, 3,709 feet deep. Each shaft will go through the water-bearing Bunter Sandstone 2,000 and 3,100 feet below the surface, and advance by simultaneous sinking and lining methods. Number 1 shaft will be driven through this section in previously frozen ground; the shaft lining will consist of two welded steel cylinders 2.5 feet apart filled with high-strength concrete. No. 2 shaft will be driven through the wet formation by a new drilling and grouting method. The wet section will be lined with cast iron tubing backfilled with high strength concrete.[11]

Yorkshire Potash Ltd., a subsidiary of Rio Tinto-Zinc Corp., stopped drilling for potash in northeastern Yorkshire, England. The geology of the ore deposit was found to be more complex than earlier drilling indicated. However, the drilling might continue when market conditions improve for potash. The company spent about $2.8 million on geological exploration and economic and environmental studies.[12]

Whitby Potash, Ltd., a subsidiary of Shell Petroleum, Ltd., postponed its plans to mine potash in Yorkshire until the market situation improves.

TECHNOLOGY

An excellent treatise on solution mining and refining of potassium chloride (KCl) was published. Since the report was prepared mostly on the bases of theory, small-scale studies, and recent patents, no published process and cost data on the world's only commercial solution mining operation in Saskatchewan were available for evaluation. The report describes the technology of solution mining and refining in great detail and assesses the feasibility of solution mining.

Production costs and capital outlays were calculated for 12 different plant layouts based on refineries with outputs of 250,000, 500,000 and 1 million tons of KCl annually using 20 and 25 percent K_2O ores at mineable thicknesses of 50 and 100 feet. The lowest estimated production cost was $16.15 per ton of KCl—that of a refinery with a production of 1 million tons of KCl annually using solution mined ore containing 25 percent K_2O and from an ore thickness of 100 feet. The total cost per ton of KCl was broken down as follows: Solution mining, $1.35 per ton; refining, $14.10 per ton; and administration and sales, $0.70 per ton. The capital outlay for the facility was estimated at $59.7 million. For 11

[9] Industrial Minerals. No. 49, October 1971, p. 56.

[10] Phosphorus and Potassium. Spanish Potash—1970 and After. No. 53, May–June 1971, pp. 36–39.

[11] Mining Journal. V. 276, No. 7069, Feb. 12, 1971, p. 113.

[12] Wall Street Journal. V. 178, No. 49, Sept. 5, 1971, p. 5.

other plant layouts, the production costs ranged from $16.85 to $27.50 per ton of KCl and capital outlays ranged from $61.2 to $101.5 million.[13]

Potassium nitrate, containing about 13 percent nitrogen and 44 percent K_2O, is an excellent high-nutrient fertilizer material for certain crops, but it has been slow to attain large markets mostly because of its high cost. Potassium nitrate can be prepared by a number of methods, such as by reacting potassium chloride with sodium nitrate or ammonium nitrate or calcium nitrate, reacting calcium nitrate with potassium sulfate, and reacting potassium chloride with nitric acid. The latter process is attracting attention especially as the prices of nitric acid decline. Routes to producing potassium nitrate were described and evaluated in detail[14]

The Federal Bureau of Mines investigated the concentration characteristics of high-clay sylvinite potential ores which exist in enormous quantities in the Carlsbad, New Mexico area and cannot effectively be processed by flotation methods now in use. Samples of ore obtained from four potash producers contained 13 to 22 percent K_2O and 3 to 7 percent clay slimes. Two-stage moderate scrubbing conditions and washing of the ore as opposed to strenuous attritioning was shown to be a solution to the problem. Flotation results indicated that concentrates containing 58.7 to 60.4 percent K_2O could be produced with recoveries of 71.0 to 83.4 percent of the K_2O values.[15]

[13] Husband, W.H.W. Application of Solution Mining to the Recovery of Potash. Soc. Min. Eng., AIME Trans., v. 250, No. 2, June 1971, pp. 141–149.

[14] Phosphorus and Potassium. Routes to Potassium Nitrate, Part 1. No. 51, January–February 1971, pp. 50–53.

Routes to Potassium Nitrate, Part 2. No. 52, March–April 1971, pp. 52–55.

[15] Johnson, Arthur B., Jerome O. Crabtree, Thomas L. McVay, and Paul E. Bennett. Beneficiation of High-Clay Potash Ores by Flotation. BuMines Tech. Prog. Rept. 41, September 1971, 12 pp.

Pumice and Volcanic Cinder

By Arthur C. Meisinger [1]

A 9-percent increase in the quantity of pumice, pumicite, and volcanic cinder sold or used by producers and pumice imported for consumption in 1971 reversed the 1970 decline in U.S. consumption of pumiceous materials. Domestic production was 280,000 short tons and $393,000 higher than in 1970, and pumice imports totaled nearly 400,000 tons valued at a record $1.1 million in 1971.

[1] Industry economist, Division of Nonmetallic Minerals.

DOMESTIC PRODUCTION

Domestic production of pumice, pumicite, and volcanic cinder in 1971 was 9 percent higher in quantity and 8 percent higher in value compared with that of 1970. Volcanic cinder comprised 84 percent of the U.S. output of pumiceous materials. Domestic output in 1971 came from 96 firms, individuals, and governmental agencies producing from 140 operations in 14 States. One mine, operated by the Samoan Government, was producing in American Samoa.

The principal producing States, in order of output, were Arizona, Oregon, and California. The combined output of the three States accounted for 76 percent of the national total. Significant output also came from Hawaii, New Mexico, and Nevada in 1971. Of the six leading States only Hawaii and Oregon showed a decrease in production from that of 1970. California and Arizona each had the largest number of active operations (32), followed by Hawaii with 20, and New Mexico with 13. Volcanic cinder was produced in 12 of the 14 States and American Samoa.

Table 1.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	776	$1,446	2,670	$3,685	3,446	$5,131
1968	481	1,360	3,049	4,210	3,530	5,570
1969	598	1,349	3,011	3,701	3,609	5,050
1970 r	490	1,233	2,546	3,438	3,036	4,671
1971	540	1,396	2,776	3,668	3,316	5,064

r Revised.
[1] Values f.o.b. mine.

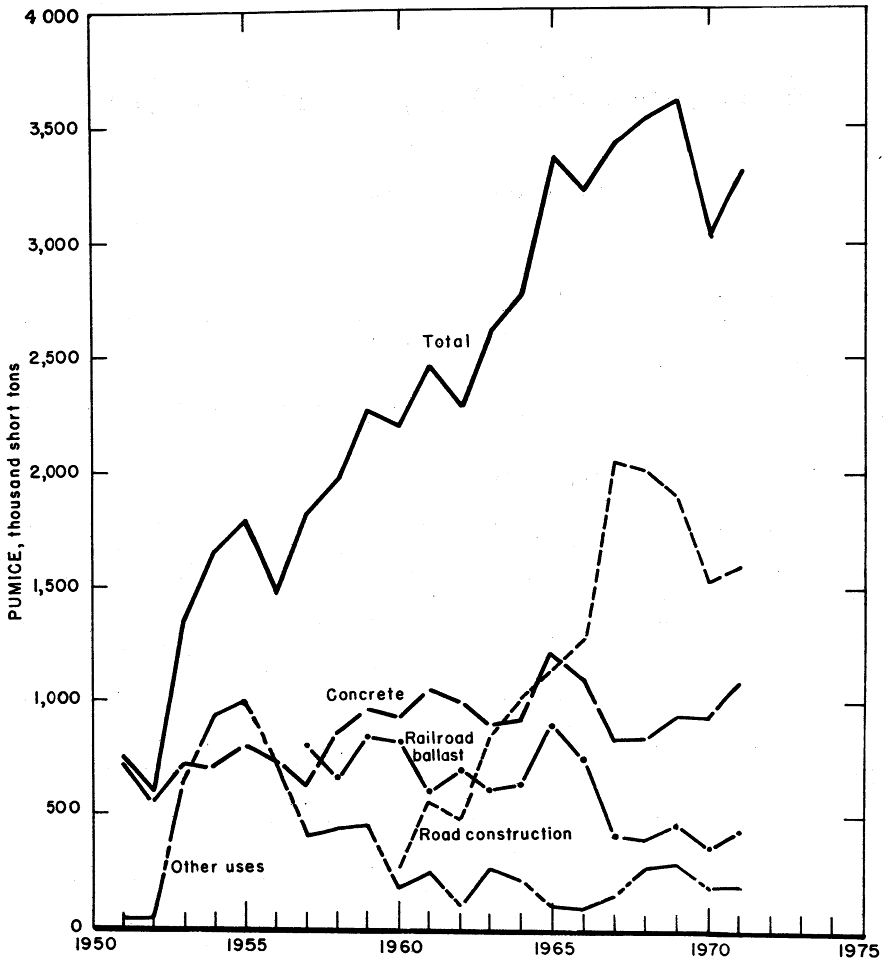

Figure 1.—Pumice sold or used by producers in the United States, by use.

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	1970		1971	
	Quantity	Value	Quantity	Value
Arizona	824	$627	949	$625
California	r 499	r 832	699	1,179
Colorado	W	W	62	W
Hawaii	350	933	289	779
Idaho	r 53	r 94	W	W
Nevada	80	191	112	232
New Mexico	203	442	287	601
Oregon	r 939	r 1.221	868	1,239
Texas	W	W	4	4
Utah	W	W	6	10
Other States [1]	r 89	r 330	40	395
Total [2]	r 3,036	r 4,671	3,316	5,064
American Samoa	2	6	10	35

r Revised.
W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Colorado (1971 value), Idaho (1971), Kansas, Nebraska, North Dakota (1970), Oklahoma, Texas (1970), Utah (1970), Washington.
[2] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Road construction and concrete admixture and aggregate continued to be the major domestic uses of pumiceous materials. Road construction in 1971 accounted for 48 percent of U.S. consumption of pumice and volcanic cinder; concrete admixture and concrete aggregate, 32 percent; railroad ballast, 13 percent; and abrasive materials and miscellaneous uses, 7 percent. Compared with consumption in 1970, use as abrasive materials in cleaning and scouring compounds increased 65 percent; use in concrete admixture and concrete, 16 percent; use in railroad ballast, 18 percent; use in road construction, including ice control and maintenance, 4 percent; and other uses, including miscellaneous abrasives, decreased insignificantly.

Table 3.—Pumic, pumicite, and volcanic cinder sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1970		1971	
	Quantity	Value	Quantity	Value
Abrasive-cleaning and scouring compounds	17	$22	28	$79
Concrete admixture and concrete aggregate	r 931	r 2,050	1,077	2,137
Railroad ballast	362	192	426	280
Road construction (includes ice control and maintenance)	r 1,531	r 1,618	1,589	1,755
Other uses [1]	r 196	r 790	195	813
Total [2]	r 3,036	r 4,671	3,316	5,064

r Revised.
[1] Includes miscellaneous abrasive uses, absorbents, heat-or-cold-insulating medium, landscaping, roofing, and miscellaneous uses.
[2] Data may not add to totals shown because of independent rounding.

PRICES

The average value for crude pumice and volcanic cinder sold and used decreased from $1.18 per ton in 1970 to $1.07 per ton in 1971. Prepared pumice and volcanic cinder, however, increased in average value from $2.13 per ton in 1970 to $2.18 per ton. The weighted average value of pumice and volcanic cinder sold and used was $1.53 per ton, compared with $1.54 per ton the previous year.

The average 1971 price per ton for pumice used in cleaning and scouring compounds was $2.82, an increase of $1.53 from the 1970 price; for concrete admixture and aggregate, $1.98, a $0.22 decrease; for railroad ballast, $0.66, a $0.13 increase; for road construction, $1.10, a $0.05 increase; and for other uses, including landscaping and roofing, $4.17, a $0.14 increase.

Price quotations in Oil, Paint, and Drug Reporter remained unchanged from 1970 and were as follows per pound, bagged, in ton lots; Domestic, fine $0.0460 to $0.0487; domestic, medium, $0.510; domestic, coarse, $0.0460; imported (Italian), silk-screened, coarse, $0.06 to $0.076; imported, fine, $0.05 and imported (Italian), sun-dried, fine and coarse, $91 per ton.

Prices quoted at yearend in the American Paint Journal also remained unchanged from 1970, and were as follows for pumice stone per pound, in barrels, f.o.b. New York or Chicago: Powdered, $0.0445 to $0.08, and lump, $0.0665 to $0.09.

FOREIGN TRADE

Pumice was exported to 11 countries in 1971 compared with 13 in 1970. Canada and Israel received most of the exports. The quantity exported in 1971 was 17 percent higher than in 1970, but the value was 27 percent lower.

Pumice imported for consumption in 1971 totaled nearly 400,000 short tons and was valued at $1.1 million. The 9-percent gain in imports over those in 1970 was due to the increase in pumice obtained primarily from Greece and Italy for use in the manufacture of concrete masonry products. Imports classed as crude or unmanufactured decreased 17 percent from 10,639 tons in 1970 to 8,833 tons, and pumice classed as wholly or partly manufactured declined also in 1971 by nearly 12 percent.

Pumice stone, TSUS No. 519.05, for use in concrete products continued to be admitted into the United States duty free. From August 16, 1971, to December 20, 1971, a 10-percent ad valorem surcharge was imposed on all dutiable imports up to the statutory limit. In accordance with the "Kennedy round" agreements, the duty was again reduced on January 1, 1972, for other pumice products. Duties were as follows: TSUS No. 519.11, crude or crushed pumice, value not over $15 per ton, 0.02 cents per pound; TSUS No. 519.14, crude or crushed pumice, value over $15 per ton, 0.04 cents per pound; TSUS No. 519.31, grains or ground, pulverized or refined, 0.17 cents 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 percent ad valorem.

Table 4.—U.S. exports of pumice

Year	Short tons	Value (thousands)
1968	624	$54
1969	533	[1] 77
1970	304	70
1971	357	51

[1] Adjusted by the Bureau of Mines.

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.
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Value (thousands)
1970:							
Greece	22	$1	--	--	203,066	$423	--
Italy	8,776	63	2,929	$126	147,784	350	$24
Leeward and Windward Islands	1,841	10	--	--	900	3	--
Other countries [1]	--	--	2	(2)	--	--	5
Total	10,639	74	2,931	126	351,750	776	29
1971:							
Greece	22	(2)	--	--	241,639	455	--
Italy	8,811	109	2,588	143	144,961	372	14
Leeward and Windward Islands	--	--	--	--	1,712	5	--
Other countries [2] [3]	--	--	--	--	--	--	4
Total	8,833	109	2,588	143	388,312	832	18

[1] Canada, Hong Kong, United Kingdom, and West Germany.
[2] Less than ½ unit.
[3] Canada, Hong Kong, Belgium-Luxembourg, United Kingdom.

Table 6.—Pumice and related volcanic material: world production by country

(Thousand short tons)

Country [1]	1969	1970	1971 [p]
Arab Republic of Egypt (formerly United Arab Republic)	(2)	(2)	(2)
Argentina [3]	33	36	[e] 36
Austria: Pozzolan	20	22	36
Cape Verde Islands: Pozzolan	20	20	5
Chile: Pozzolan	193	179	161
Dominica	[r] 62	68	[e] 68
France:			
Pumice	1	[e] 1	[e] 1
Pozzolan and lapilli	860	737	[e] 770
Germany, West (marketable)	4,410	4,644	8,724
Greece:			
Pumice	[r] 414	497	440
Pozzolan	[r] 602	645	657
Guadeloupe: Tuff (pozzolanic) [4]	49	[e] 49	[e] 50
Guatemala: Volcanic ash (for cement)	50	[e] 50	[e] 50
Iceland	[e] 11	12	26
Italy:			
Pumice	[r] 575	1,242	[e] 1,200
Pumiceous lapilli	[r] 281	[e] 276	[e] 280
Pozzolan	[r] 4,767	4,693	[e] 4,700
Martinique: Pumice [5] [6]	20	[e] 20	[e] 20
New Zealand	21	21	[e] 20
Spain [7]	255	220	[e] 220
United States (sold or used by producers):			
Pumice and pumicite	598	[r] 490	540
Volcanic cinder [8]	3,013	2,548	2,786
Total	16,255	16,470	20,790

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Pumice is also produced in Iran, Japan, Mexico, Turkey, and the U.S.S.R. (sizeable quantity), but data on production are not available. Japan's last available output figure was 110,000 tons in 1958.
[2] Less than ½ unit.
[3] Unspecified volcanic materials produced mainly for use in construction products.
[4] Data converted from cubic meters on basis of estimated specific gravity of 1.35 for pumice and tuff.
[5] Data converted from cubic meters on basis of estimated specific gravity of 1.0 for pumice and tuff.
[6] Output of material previously reported as tuff may actually represent calcareous tufa, and has been omitted pending clarification by source.
[7] Includes Canary Islands.
[8] Includes American Samoa.

Rare-Earth Minerals and Metals

By James S. Kennedy [1]

Production of contained rare-earth oxide (REO) as measured by output of bastnaesite and monazite concentrates increased in 1971. Shipments of rare-earth products from primary processors to domestic consumers increased although consumption of REO contained in raw materials by the primary processors declined during the year. Metallurgical applications accounted for the most substantial increase in consumption of rare-earth products while applications in petroleum cracking catalysts continued as the largest use by volume. Shipments of yttrium and europium oxides, although less than 1 percent of quantity accounted for 18 percent of the value.

Legislation and Government Programs.—At the end of 1971 the General Services Administration (GSA) held a total of 11,841 tons of REO equivalent in the forms of bastnaesite (3,243 tons), monazite (5,088 tons), chloride (653 tons), and sodium sulfate (2,857 tons) in the national and supplemental stockpiles. In August, GSA was authorized to dispose of 8,233 tons (REO content). The remaining 3,608 tons above that amount is available for disposal under authority of prior legislation. During the year GSA disposed of 1,496 tons of contained REO in rare-earth sodium sulfate.

DOMESTIC PRODUCTION

Concentrate.—REO production as measured by output of bastnaesite and monazite concentrates increased 5 percent during 1971. The Mountain Pass, Calif., mine and mill of Molybdenum Corporation of America (Molycorp), operating at 40 percent of the yearly throughput capacity of 450,000 tons of ore, processed about 181,000 tons of ore. Production of REO contained in flotation concentrate was 10,828 tons.[2] Concentrate output was 8 percent greater than the previous year while concentrate shipments increased 87 percent. Humphreys Mining Co. continued as the only domestic producer of monazite, which was obtained as a byproduct of titanium minerals and zircon from a beach sand deposit, controlled by E. I. du Pont de Nemours & Co., Inc. near Folkston, Ga. Production decreased 21 percent (REO content) to its lowest level in 5 years although REO content increased from 55 to 59 percent.

Kerr-McGee Chemical Corp., a subsidiary of Kerr-McGee Corp., conducted marketing studies on a heavy mineral placer deposit containing rutile, ilmenite, monazite, and zircon in Western Tennessee.

Construction of mining and milling facilities of Titanium Enterprises, owned jointly by American Cyanamid Co. and Union Camp Corp., continued on schedule. Production of ilmenite, byproduct zircon, and monazite was scheduled for the second quarter of 1972 and shipments, for the fourth quarter of that year.

Compounds and Metals.—The solvent extraction unit of Molycorp at Mountain Pass produced 30 percent less purified europium oxide than in 1970 while production of purified yttrium oxide at the company's Louviers plant increased more than 46 percent. Shipments of rare-earth chlorides produced by Molycorp at York, Pa., W. R. Grace & Co. at Chattanooga, Tenn., and Kerr-McGee Corp. at West Chicago, Ill., declined slightly overall indi-

[1] Industry economist, Division of Nonferrous Metals.

[2] Molybdenum Corporation of America. 1971 Annual Report. Apr. 12, 1972, 12 pp.

cating lessened demand for these products in petroleum cracking catalysts. Shipments of cerium oxide produced at York, Pa. and rare-earth silicides produced at Washington, Pa. by Molycorp, showed substantial increases reflecting increased demand by the glass and iron and steel industries, respectively. The Washington, Pa. plant, in addition to rare-earth silicides, produced high-purity lanthanum metal and, intermittently, small quantities of mischmetal during the year. Mischmetal production by the two primary domestic producers, Ronson Metals Corp. and American Metallurgical Products Co., Inc. increased 85 percent. Production, although increasing substantially, was adversely affected by a fire at the Newark, N.J. facility of Ronson.

In addition to output at Molycorp's Louviers, Colo. plant, Gallard-Schlesinger, W. R. Grace, Kerr-McGee, Michigan Chemical, and Nucor produced yttrium oxide and metal during the year.

Table 1.—U.S. processors of rare-earth elements

Company	Location
American Metallurgical Products Co., Inc	Pittsburgh, Pa.
Atomergic Chemetals Co., Div. of Gallard-Schlesinger Chemical Manufacturing Corp.	Carle Place, N.Y.
Davison Chemical Div., W. R. Grace & Co	Chattanooga, Tenn.
Lindsay Rare Earths Div., Kerr-McGee Chemical Corp	W. Chicago, Ill.
Michigan Chemical Corp	St. Louis, Mich.
Molybdenum Corp. of America	Mountain Pass, Calif.
	Louviers, Colo.
	Washington, Pa.
	York, Pa.
Research Chemicals Div., Nucor Corp	Phoenix, Ariz.
Ronson Metals Corp	Newark, N.J.
Transelco, Inc	Penn Yan, N.Y.

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 10,200 tons of REO contained in raw materials, an 11 percent decrease from the previous year. Bastnaesite consumption decreased 16 percent while consumption of monazite decreased 3 percent.

Shipments from processors to domestic consumers totaled about 6,350 tons REO valued at $12.5 million. This quantity includes intracompany shipments by Molycorp but does not include products derived from further processing at its plants in Pennsylvania and Colorado. The following breakdown of uses is based on information supplied by primary processors and on actual data from certain consumers: Petroleum cracking catalysts, 40 percent; ductile iron and steel, other alloys, and lighter flints, 27 percent; glass polishing, 20 percent; glass additives, 6 percent; arc light carbons, 5 percent; and miscellaneous, including research and development, 2 percent.

The application of rare-earth compounds in petroleum cracking catalysts remained as the largest use, although declining as in the previous year. Metallurgical applications of rare-earth metals and alloys more than doubled in 1971 and accounted for the largest increase in consumption. The addition of mischmetal, rare-earth silicide, and master alloys containing rare-earth metals to iron and steel improves its mechanical and plastic properties while enhancing deoxidation and desulfurization. The effectiveness of these rare-earth additions depend upon the amounts introduced and methods of introduction and can have deleterious effects if not accompanied by adequate process control. In a 4-year study of ductile iron conducted by the Illinois Institute of Technology's Research Institute, completed in 1970 and released to the public in 1971, it was demonstrated that by doubling or tripling the conventional amounts of cerium in nodularizing additions, costs of the additives can be reduced by as much as 10 percent without sacrificing quality.[3] It was further reported that such additives reduce fumes and reactivity of the alloy, thereby improving safety and helping foundries meet air pollution standards.[4]

[3] American Metal Market. Rare Earths Cut Costs in Ductile Casting. V. 78, No. 190, Oct. 1, 1971, p. 10.

[4] American Metal Market. Says Magnesium Alloy for Ductile Iron Cuts Fumes. V. 79, No. 35, Feb. 22, 1972, p. 12.

As a result of increased demand for mischmetal, shipments from the two primary domestic producers more than doubled while production increased 85 percent. Two-thirds of mischmetal production in 1971 was used as iron and steel additives and structural linings for incendiary devices with the remaining one-third used in the production of ferrocerium lighter flints.

The use of cerium oxide as a decolorizer of glass containers increased substantially, with shipments from the primary producer, Molycorp, increasing 69 percent. One-quarter of all domestic flint glass container plants have reportedly converted to the technique of adding about 4 ounces of cerium per 1½ tons of glass, since its first production trial in mid-1970.[5]

Praseodymium, cerium, samarium, lanthanum, and yttrium continued to be used in the manufacture of high-energy-product, high-coercive-force permanent magnets. Commercial production of permanent magnets, using samarium alloyed with cobalt, was announced during the year. Although these magnets are reportedly twice as strong as platinum-cobalt magnets, applications are restricted to aerospace, electronics, and other specialized uses because of their high cost.[6] A discussion of new applications for the rare-earth metals and alloys, including the magnet alloys, was published in 1971.[7]

Yttrium continued to be used principally as a host material, in the form of high-purity oxide, in color television phosphors. Yttrium-aluminum-garnets (YAG) and yttrium-iron-garnets (YIG) were used in lasers and microwave devices with cubic crystals of YAG used as a substitute for diamonds in jewelry.

STOCKS

Monazite concentrate held by two chemical processing companies was 21 percent less than at the end of 1970; bastnaesite concentrate held by the domestic producer and three processors decreased slightly. Yttrium oxide stocks held by five firms increased 34 percent while stocks of europium oxide, reported by four companies, increased 46 percent. Mischmetal stocks held by the two principal producers increased 25 percent and stocks of high-purity metals held by five firms were 47 percent higher in 1971.

PRICES

Prices in the United States for large lots of monazite were quoted periodically in Metals Week at \$180 to \$200 per long ton, nominal. The actual market price was lower than that quoted throughout the year and became further depressed during the second half of 1971. On the London market, the average c.i.f. price per long ton of Australian monazite with a minimum of 60 percent REO plus ThO_2, quoted in Metal Bulletin (London), began the year at \$192 to \$216, declined to \$189 to \$213 early in the year, and then declined further in May to \$187 to \$206 for the remainder of the year. Malaysian xenotime concentrate with a minimum of 25 percent yttrium oxide (Y_2O_3) content was quoted in Industrial Minerals (London) at \$2 to \$3 per pound of Y_2O_3 through February and then at \$3 to \$5 per pound for the remainder of the year.

Unleached, leached, and calcined bastnaesite containing 55 to 60 percent, 68 to 72 percent, and 85 to 90 percent REO remained at 30, 35, and 40 cents per pound of REO, respectively, f.o.b. Mountain Pass, Calif., or Nipton, Calif. in 100-pound paper bags or 55-gallon steel drums in truckload or carload lots.

Quoted prices per pound f.o.b. plant on certain rare-earth compounds (commercial grade) remained as follows: Mixed rare-earth oxides, 88 to 92 percent REO, \$0.45; chlorides, \$0.29; carbonates, \$0.55; nitrates, \$0.48; hydrates, \$0.50; and fluorides, \$0.90. Quoted prices on cerium hydrate in lots of 100 pounds or more were \$1.40 to \$1.75 per pound, depending on purity, through

[5] Molybdenum Corporation of America. Decolorizing Glass Containers Becomes Major Use for Cerium in Twenty Months. News Release, New York, May 15, 1972, 2 pp.

[6] American Metal Market. Rare Earth Metals: A Magnetic Breakthrough? V. 78, No. 224, Nov. 23, 1971, pp. 1a–8a.

[7] Hirschhorn, I. S. The Rare-Earth Metals—New Applications. Chem. Tech., May 1971, pp. 314–317.

mid-August and then dropped to $1.30 to $1.40 for the remainder of the year; prices for optical-grade cerium oxide in lots of 50 pounds or more remained at $1.85 to $1.90 per pound.[8]

Quoted prices on 1-pound ingots in 50- to 100-pound lots of 97-percent-pure didymium metal and cerium-free mischmetal remained at $15 and $5, respectively, f.o.b. plant. Prices on large lots, 1 ton or more, of cerium-containing mischmetal were increased about 10 percent in May from $2.60 to $2.85 per pound for 1-pound ingots, while the average 50- to 100-pound lot remained at $3 per pound, same basis. Rare-earth silicide was quoted at $0.44 per pound, f.o.b. plant, for truckload or carload quantities.

Rare-earth-cobalt permanent magnet alloys became available during the year at the following prices, per pound of single-phase alloy in 50-pound lots: Lanthanum, $23; cerium, $20; praseodymium, $41; samarium $47.75.

Cerium metal, 99 percent pure, delivered in the United Kingdom remained at $16.80 per pound, nominal.

Table 2.—Prices of high-purity oxides and metals in 1971 [1]

Element	Oxide [2] (dollars per pound)	Metal [3] (dollars per pound)
Cerium	$1.90	$21.00
Lanthanum	3.75	35.00
Praseodymium	32.00	100.00
Neodymium	13.00	100.00
Samarium	30.00	125.00
Europium	415.00	3,000.00
Gadolinium	45.00	170.00
Terbium	280.00	700.00
Dysprosium	53.00	140.00
Holmium	140.00	285.00
Erbium	60.00	180.00
Thulium	1,200.00	2,750.00
Ytterbium	100.00	250.00
Lutetium	1,795.00	6,500.00
Yttrium	30.00	140.00

[1] Lower prices are available for contract quantities within specified periods.
[2] Minimum of 99.9 percent purity.
[3] Minimum 1 pound.

FOREIGN TRADE

According to to the sole domestic producer, Molycorp, about 2,500 tons of REO contained in bastnaesite concentrate was exported in 1971. Ferrocerium and other pyrophoric alloys totaling 60,044 pounds, valued at $163,594, a quantitative decrease of 23 percent, were exported to the United Kingdom, Canada, Australia, and 14 other countries. The unit value of these exports ranged from $0.60 to $6.86 per pound. The decrease of $0.98 to $2.72 in unit value for these materials, as compared with 1970, was caused, in part, by the low-value shipments to Brazil, Finland, and West Germany, which amounted to 21 percent of total quantity and 5 percent of total value.

Total imports of monazite sand from Australia and Malaysia were only slightly less than the previous year. Imports from Australia decreased 9 percent while imports from Malaysia increased 20 percent.

Cerium oxide imports from France, West Germany, and Switzerland totaled 8,477 pounds. valued at $20,707, a substantial increase from the 1,100 pounds imported in 1970. Imports of cerium chloride from Austria totaled 725 pounds, valued at $955, a decrease of 9 percent from 1970. Other cerium imports from France and Austria increased to 5,461 pounds, valued at $7,761, from 500 pounds, valued at $1,788, in 1970.

Imports of mixed rare-earth chlorides from India and Brazil, resulting from the processing of monazite, are estimated at 786 tons of REO equivalent. Accurate quantitative data are not available as these imports are included in a classification which does not differentiate chlorides from mixtures of other inorganic compounds.

The unit value of rare-earth metals imported from the U.S.S.R. was much lower than that of shipments in previous years and including similar imports from West Germany are apparently low-value alloys. Imports of ferrocerium and other pyrophoric alloys increased to 16,190 pounds, valued at $82,277, compared with 1970 receipts of 9,373 pounds, valued at $53,885. Japan supplied 13,687 pounds, valued at $65,453 (85 percent of quantity and 80 percent of value), followed by West Germany, the Republic of Korea, the United Kingdom, Austria, Mexico, and France. The decrease in unit value to $5.08 from $5.75 in 1970 was due primarily to the lower value of the Japanese mate-

[8] Oil, Paint, and Drug Reporter. Current Prices of Chemicals and Related Materials. V. 199, Nos. 1–25, Jan. 4–June 21, 1971; v. 200, Nos. 1–26, July 5–Dec. 27, 1971.

rial. Imports of mischmetal from West Germany and the United Kingdom totaled 63,204 pounds, valued at $123,888.

Under the General Agreement on Tariffs and Trade ("Kennedy round") the tariff on cerium chloride and oxide will be reduced from the January 1, 1971 level of 18 percent ad valorem to 15 percent on January 1, 1972. The rate for alloys of rare-earth metals and mischmetal will be reduced from 60 cents per pound to 50 cents per pound while the rate for ferrocerium and other pyrophoric alloys will be decreased from 60 cents per pound plus 7 percent ad valorem to 50 cents per pound plus 6 percent ad valorem.

Table 3.—U.S. imports for consumption of monazite, by country

Country	1967		1968		1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	1,540	$195	2,810	$369	2,478	$300	1,977	$251	1,802	$219
Germany, West	24	4	24	4	--	--	--	--	--	--
Hong Kong	--	--	--	--	167	20	--	--	--	--
Indonesia	72	13	--	--	--	--	--	--	--	--
Korea, Republic of	49	7	--	--	--	--	--	--	--	--
Malaysia	273	38	1,514	188	1,561	174	1,307	157	1,571	165
Nigeria	133	13	19	2	--	--	--	--	--	--
Thailand	--	--	--	--	--	--	164	19	--	--
Total	2,091	270	4,367	563	4,206	494	3,448	427	3,373	384
REO content [e]	1,150	XX	2,400	XX	2,310	XX	1,900	XX	1,860	XX

[e] Estimate. XX Not applicable.

Table 4.—U.S. imports for consumption of rare-earth metals
(Including scandium and yttrium)

Country	1969		1970		1971	
	Pounds	Value	Pounds	Value	Pounds	Value
Australia	--	--	1	$704	--	--
Germany, West	--	--	343	5,150	153	$4,197
Japan	254	$22,916	25	2,005	25	4,169
U.S.S.R.	54	17,324	89	9,183	395	8,689
United Kingdom	7	6,724	16	3,731	15	4,553
Total	315	46,964	474	20,773	588	21,608

WORLD REVIEW

Australia.—Comstock Minerals, Ltd., announced a mineral sand find at Israelite Bay, 150 miles east of Esperance, in Western Australia. Preliminary reports indicate the area may contain 500 million cubic yards of mineralized sand averaging 2.7 percent heavy minerals, including the following: Leucoxene, 11 percent; zircon, 18 percent; monazite, 0.6 percent; and ilmenite, 25 percent.[9]

Brazil.—The Comissão Nacional de Energia Nuclear (CNEN) recovered monazite from beach sands at two locations. Barra de Itabapoana in Rio de Janeiro and Cumuruxatiba in Bahia. A private company, Monazita e Ilmenita do Brasil, under contract to CNEN, recovered monazite at Guarapari, Espírito Santo. The monazite concentrate was processed at São Paulo by CNEN, Administração da Produção da Monazita (APM). In 1970, the latest year for which data are available, 2,275 short tons of rare-earth chloride and 6 short tons of rare-earth oxide were produced.

Burundi.—Production of bastnaesite by Société Minerale de Karonge (SOMIKA) continued at a reduced level at Karonge in Bujumbura Province. Estimated production was 260 tons. The concentrate was exported to France for processing.

France.—Foote Allevard, a joint venture of Foote Mineral Company and Forges D'Allevard, major ferroalloy producers in the United States and France, respectively, was established and began production of rare earth and other metallic inocular and deoxidation alloys.[10]

[9] Engineering and Mining Journal. V. 172, No. 2, February 1971, p. 30.
[10] Metal Bulletin (London). Setting up Foote Allevard. Mar., 14, 1972, p. 16.

Table 5.—Monazite concentrates: World production by country

(Short tons)

Country [1]	1969	1970	1971 p
Australia	r 4,249	5,027	e 4,400
Brazil	2,204	2,544	e 2,600
Ceylon	62	18	e 18
India [2]	2,708	4,004	e 4,400
Malagasy Republic	2	--	--
Malaysia [3]	r 1,770	1,827	e 1,800
Mauritania	115	e 110	e 110
Mozambique	--	2	e 2
Nigeria	14	14	100
Thailand	72	119	123
United States	W	W	W
Zaire (formerly Congo-Kinshasa)	196	158	--
Total	11,392	13,823	13,553

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 insufficient to make reliable estimates of output levels.

[2] Year beginning April 1 of that stated.

[3] In addition to the monazite listed here, Malaysia also records the export of "other ores of thorium" (not more exactly described) as follows in short tons: 1969—180; 1970—433; 1971—NA.

India.—The Alwaye plant, Kerala State, owned by Indian Rare Earths, Ltd. (IRE), Bombay, processed 3,900 tons of monazite and produced 4,300 tons of rare-earth chloride, 40 tons of rare-earth fluoride, and 28 tons of rare-earth oxide for the year ending March 31, 1971, according to the firm's annual report. Supplies of monazite from the Manavalakurichi separation plant for processing at Alwaye increased to 4,000 tons, compared with 2,700-tons during the previous reporting period. Annual capacity at the Alwaye plant was increased to 5,950 tons of rare-earth chloride. Although monazite production increased, it was below the level anticipated due to the lower content of the mineral in the raw sand.

Sales of rare-earth chloride decreased to 4,363 short tons, valued at $1,015,000. Sales of rare-earth fluoride, rare-earth oxide, and rare-earth hydrate increased to 45, 26, and 35 tons, respectively.

Japan.—Shin-etsu Chemical Industry Co., Ltd. began production of high-purity samarium metal in a new facility at the company's plant at Takefu. The metal will be alloyed with cobalt and marketed to manufacturers of magnets in Japan; the remainder will be exported.[11]

Production of cerium oxide declined to 126 tons from 170 tons in 1970. Lanthanum oxide production likewise declined to 105 tons from 137 tons in 1970. Japanese demand was estimated to be 19 tons of yttrium and europium oxide, 198 tons of lanthanum oxide, 583 tons of cerium oxide, 242 tons of mischmetal, and 165 tons of rare-earth fluoride.[12]

Norway.—A/S Megon (Metal Extractor Group of Norway) began operation of a pilot plant designed for the production of 5 tons of yttrium oxide per year. The plant uses xenotime concentrate obtained from feldspar operations in southern Norway. Feasibility studies were conducted on a commercial scale plant with annual capacity of 30 to 50 tons yttrium oxide.

Apatite deposits, located about 60 miles south of Oslo, and carbonatite deposits, located about 75 miles southwest of Oslo, were investigated for possible commercial scale production of yttrium and rare earths. The apatite deposits reportedly contain substantially more yttrium than deposits of the Kola peninsula, U.S.S.R., although recovery would be practical only as a byproduct of phosphate production. Rare-earth extraction from the carbonatite deposits has been unsuccessful due to the extremely fine grain size and complex distribution of the minerals.[13]

[11] World Minerals. No. I, May–June 1971, p. 33.

[12] Japan Metal Bulletin (Tokyo). Jan. 19, 1972, p. 5.

[13] Gaudernack, B., and O. Braaten. Occurrence and Extraction of Rare Earths in Norway. A/S Megon (Metal Extractor Group of Norway). Paper pres. at the 9th Rare Earth Res. Conf. Oct. 10–14, 1971, Blacksburg, Va., 17 pp.

TECHNOLOGY

Bureau of Mines research continued into development of a system for producing low-cost yttrium from byproduct apatite obtained from iron ore processing operations. Primary amine extraction systems were studied and found capable of upgrading the yttrium content of rare-earth mixtures by shifting the normal extraction sequence. The addition of ammonium sulfate to the feed solution was found to increase separation efficiency by 20 percent. In addition, the results of a preliminary survey conducted to determine the extent of rare-earth minerals in the iron-bearing formations of New York State was prepared during the year.[14] An earlier Bureau of Mines survey had indicated resources of yttrium and REO in the tailing piles of the Mineville-Port Henry Iron District of New York in excess of 76,000 tons.

The Bureau of Mines published the results of an investigation conducted in cooperation with industry and the University of Alabama to determine the occurrence and recoverability of heavy minerals, including monazite, in sand and gravel operations in Alabama, Georgia, South Carolina, and North Carolina.[15]

Bureau of Mines research continued on low cost separation of rare earths from complex mixtures, purification of rare-earth metals by electrotransport, and electrolytic preparation of rare-earth alloys. Solvent extraction separation of light group rare-earth elements using a commercially available mixture of quaternary ammonium compounds was achieved with values significantly higher than those obtained using organophosphate extractants.[16] Samarium oxide, greater than 99 percent pure, was separated from a light group rare-earth mixture, with 76 percent recovery, using a continuous countercurrent operation.[17] In addition, liquid-liquid chromatography was demonstrated as an effective technique for the separation of neodymium, samarium, and gadolinium.[18] In electrotransport studies the use of a high pulsed current was shown to be more effective than a lower steady current. Impurities that showed movement with the pulsed current but not with the steady current were molybdenum and oxygen in cerium, aluminum, iron, and molybdenum in lanthanum.[19]

Evaluation studies on electrolytic techniques for preparing rare-earth-cobalt alloys for ultimate use in permanent magnets continued. The temperature of the cathode, alloy collection, and oxide feed zones in electrolytic preparation and recovery were shown to have an appreciable effect on yield and quality of the alloy.[20] An optimal composition of the samarium-cobalt alloy for permanent magnets was found to be 37.4 percent samarium and 62.2 percent cobalt, by weight.[21]

Although commercial-scale production of samarium-cobalt magnets has been announced, applications have been restricted due to the relatively high cost of the magnets. Considerable interest has therefore been shown in finding a substitute for samarium in order to maximize the magnetic energy per unit cost. Research on the cobalt-mischmetal-samarium system indicates that a substantial part of the samarium can be replaced by mischmetal while retaining high magnetic properties.[22]

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[14] Evans, George C. Rare-Earths in New York State. BuMines Situation Report (Mineral Supply), June 1971, 19 pp. Available for reference at Eastern Field Operation Center, Pittsburgh, Pa.

[15] Davis, E. G., and G. V. Sullivan. Recovery of Heavy Minerals From Sand and Gravel Operations in the Southeastern States. BuMines RI 7517, 1971, 25 pp.

[16] Bauer, D. J., and R. E. Lindstrom. Differential Extraction of Rare-Earth Elements in Quaternary Ammonium Compound-Chelating Agent Systems. BuMines RI 7524, 1971, 16 pp.

[17] Bauer, D. J., L. E. Schultze, and R. E. Lindstrom. Separation of Samarium by a Selective Stripping Procedure. Paper in the Proc. of the 9th Rare-Earth Res. Conf., Blacksburg, Va., Oct. 10–14, 1971, pp. 294–301. Available from National Technical Information Service, Springfield, Va.

[18] Winget, J. O., and R. E. Lindstrom. Liquid-liquid Chromatographic Separation of Neodymium, Samarium, and Gadolinium. Separation Science, v. 6, No. 4, August 1971, pp. 573–581.

[19] Marchant, J. D., E. S. Shedd, T. A. Henrie, and M. M. Wong. Electrotransport of Impurities in Rare-Earth Metals, Using a Pulsed Current. BuMines RI 7480, 1971, 13 pp.

[20] Morrice, E., and M. M. Wong. Effect of Temperature on the Electrolytic Preparation and Recovery of Samarium-Cobalt Alloy. BuMines RI 7556, 1971, 11 pp.

[21] Walkiewicz, J. W., J. S. Winston, and M. M. Wong. The Effect of Composition on the Magnetic Properties of Sm-Co Alloys. Proc. of the 9th Rare-Earth Res. Conf., Blacksburg, Va., Oct. 10–14, 1971, pp. 242–247. Available from National Technical Information Service, Springfield, Va.

[22] Benz, M. G. and D. L. Martin. Co-MM-Sm Permanent Magnet Alloys: Process and Properties. J. Appl. Phys., v. 43, No. 7, June 1971, pp. 2786–2789.

Metallurgical interest in the rare-earth metals has intensified as a result of their growing use in the iron and steel industry. The standard heats and free energies of formation for the rare-earth compounds used in steelmaking were calculated in a consolidated study.[23]

Two developments were announced during the year indicating that the rare-earth elements may play an increasingly important role in environmental pollution control. Research is continuing on a new type auto exhaust catalyst composed of compounds containing rare-earth elements and elements with half-filled d-bands of electrons, such as lanthanum/cobalt oxide ($LaCoO_3$), offering a possible substitute for platinum in this application.[24] In addition, a neodymium-doped laser capable of determining and evaluating the location and density of smoke and dust clouds was developed.[25]

A green emitting $CaS:Ce^{+3}$ phosphor was developed for use in color television tubes. This cerium-doped phosphor is reportedly equal to the ZnS-type phosphor now being used at low beam current and is superior at high current.[26]

The Ninth Rare Earth Research Conference was held at Blacksburg, Va., from October 10 to 14, 1971. The technical sessions included subjects such as magnetic structure and electrical properties of the metals and alloys, solid state physics, chemistry, metallurgy, spectroscopy, luminiscence properties, and biochemistry.[27]

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[23] Gschneidner, K. A., Jr., and Nancy Kippenhan. Thermochemistry of the Rare Earth Carbides, Nitrides, and Sulfides for Steelmaking. Rare Earth Information Center, Inst. for Atomic Res., Iowa State University, Report IS–RIC–5, August 1971, 27 pp.

[24] Libby, Williard F. Auto Exhaust Catalysis by Rare Earth-Transition Metal Oxides. Pres. at 9th Rare-Earth Res. Conf., Blacksburg, Va., Oct. 10–14, 1971, p. 1. Available from National Technical Information Service, Springfield, Va.

[25] American Metal Market. Neodymium Laser Device is Siemens' Pollution Tool. V. 79, No. 15, Jan. 21, 1972, p. 13.

[26] Rare-Earth Information Center News. Glowing Green. V. 6, No. 2, June 1, 1971, p. 3.

[27] Field, P. E. (ed.). Proceedings of the 9th Rare Earth Research Conference, Oct. 10–14, 1971, Blacksburg, Va. Conf.–711001 (V. 1–2), Chemistry (TID–4500), 1971, 803 pp. Available from National Technical Information Service, Springfield, Va.

Rhenium

By Richard F. Stevens, Jr. [1]

Rhenium production increased significantly during the first half of 1971 to meet the growing demand for bimetallic platinum-rhenium catalysts used in nonleaded gasoline refining operations. As a result of this demand the quoted price of rhenium metal powder was increased in 1971. Production of rhenium fell off during the last half of the year as several companies substituted other materials for rhenium as catalysts in petroleum refining operations.

DOMESTIC PRODUCTION

Production of rhenium, a byproduct material recovered primarily from the molybdenite (MoS_2) associated with southwestern and Chilean porphyry copper ores, increased during 1971 to an estimated 7,250 pounds of rhenium contained in rhenium salts. Cleveland Refractory Metals (CRM), Solon, Ohio, a division of Chase Brass & Copper Co. (a subsidiary of Kennecott Copper Corp.), continued to be the country's major rhenium producer. CRM reported that sales of rhenium chemicals, used as catalysts in petroleum refining operations to produce low-pollution gasolines, were strong during the first half of the year, but declined sharply during the second half.[2] In 1971, the company's sales and earnings fell below 1970 levels primarily because other platinum group materials were substituted for rhenium in catalytic applications. Rhenium salts were recovered for CRM at Kennecott's molybdenite roasting facility (Figure 1) near Garfield, Utah, from domestic molybdenite concentrates and from MoS_2 imported from Chile.

Concentrate containing 90 percent MoS_2 recovered from Kennecott's Ely, Nev., copper operation is believed to contain between 2,000 and 3,500 parts per million (ppm) of rhenium.

Rich rhenium-bearing molybdenite was recovered from porphyry copper ores at the San Manuel mine of Magma Copper Co. in Pinal County, Ariz. In 1971, Magma, a subsidiary of Newmont Mining Corp., sold this material to Engelhard Minerals & Chemicals Corp. Shattuck Chemical Co., Denver, Colo., a division of Engelhard, reportedly operated at peak capacity during the year and recovered rhenium salts from the Magma MoS_2 concentrate. M&R Refractory Metals, Inc., recovered rhenium salts primarily from Magma concentrates for Engelhard on a "toll" or contract con-

[1] Metallurgical engineer, Division of Ferrous Metals.
[2] Kennecott Copper Corp. Annual Report 1971. 32 pp.

Table 1.—Salient rhenium statistics

(Pounds of contained rhenium)

	1967	1968	1969	1970	1971
Production (in rhenium salts) e	1,725	2,400	3,500	5,900	7,250
Consumption (metal) e	850	775	r 3,250	r 5,100	7,600
Imports (metal and scrap) gross weight	96	436	9,780	210	377
Stocks, Dec. 31 (metal) e	40	130	1,710	r 2,050	2,500

e Estimate. r Revised.

version basis at their plant in Winslow, N.J., with recoveries reportedly in excess of 60 percent.[3] This facility has capacity for processing about 1,200 tons of molybdenite concentrate annually.

During the year, a process was developed by Molybdenum Corp. of America (Molycorp) and special facilities were installed at the company's plant in Washington, Pa., for production of high-purity molybdenum oxide and recovery of byproduct rhenium from MoS_2 concentrate associated with porphyry copper ores and from primary molybdenite recovered from the Questa molybdenum mine in New Mexico.[4] This new facility, which will have an initial capacity of over 1 million pounds of contained molybdenum (about 830 tons of molybdenite) per year, is expected to be completed and to begin full-scale rhenium recovery operations by mid-1972. The primary molybdenite feed material from Questa is believed to contain about 50 to 70 ppm of rhenium.

During the year, Continental Rhenium Corp., a wholly-owned subsidiary of Continental Ore Corp., completed construction of a large semiproduction pilot plant for

[3] Metals Week. Whittaker Selling M&R Holdings. V. 42, No. 46, Nov. 15, 1971, pp. 2–3.

[4] International Mining Corp. Annual Report 1971. 17 pp.

Molybdenum Corporation of America. Annual Report 1971. 12 pp.

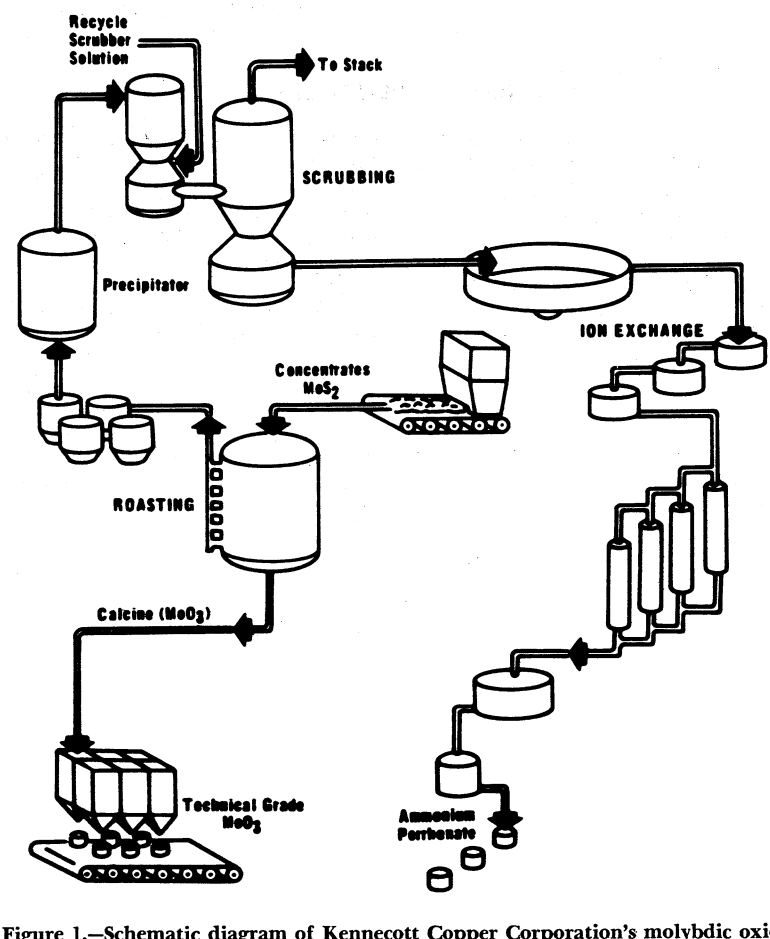

Figure 1.—Schematic diagram of Kennecott Copper Corporation's molybdic oxide plant. (Courtesy of Kennecott Copper Corp.)

the recovery of rhenium at Golden, Colo.[5] The plant is scheduled to be fully operational by mid-1972 with an annual capacity of over 1,000 tons of molybdenum concentrate. Preliminary information indicates that the operation can process both foreign and domestic molybdenite feed materials to various rhenium salts at recoveries in excess of 80 percent.

At its Danbury, Conn., Metallurgical Research Center, Newmont Exploration Ltd., a subsidiary of Newmont Mining Corp., started a long-range study of methods to improve the recovery yield of rhenium from molybdenum.[6] If successful methods are developed, a pilot plant may be constructed to evaluate the economics of large-volume recovery operations.

Other domestic molybdenite roasting facilities which might be adapted for rhenium recovery include those of Climax Molybdenum Co. at Langeloth, Pa., Duval Corp. at Mineral Park, Ariz., Duval-Sierrita Corp. at Esperanza, Ariz., and Republic Steel Corp. at Canton, Ohio.

Porphyry copper deposits in Canada, Chile, Mexico, Peru, Zaire (formerly Congo-Kinshasa), the United States, and the U.S.S.R. represent the major significant or potential sources of rhenium. Rhenium recovery facilities exist at molybdenite roasting plants in Belgium, France, Sweden, the Soviet Union, the United Kingdom, the United States, and West Germany.

CONSUMPTION AND USES

Approximately 95 percent of the estimated 1971 rhenium metal consumption of 7,600 pounds was used as bimetallic platinum-rhenium catalysts impregnated on durable alumina-base carriers for refining high octane unleaded gasoline.[7] This application received added impetus during the year as requirements were developed for obtaining reduced levels of air pollution from automotive emissions through the use of lead-free gasoline.

During the past 3 years (1969–1971) the accumulated rhenium consumption in catalytic applications in the U.S. and Canada was estimated to total about 12,800 pounds. Consumption of rhenium metal as catalysts in the rest of the free world was estimated to total over 7,000 pounds during this period. By the end of 1971, platinum-rhenium catalysts were being used in about 125 refining or reforming units in some 35 countries. The total capacity of these units is believed to be about 1.4 million barrels per stream day (BPSD). An additional 28 units in seven countries having a capacity of 0.4 million BPSD were scheduled to become operational in early 1972.

Shortly before the first commercial use of Engelhard Mineral & Chemical Corp.'s platinum-rhenium catalysts began, patents were issued to Chevron Research Co., a subsidiary of Standard Oil Co. of Calif., covering the use of platinum-rhenium catalysts. An agreement was entered into between Engelhard and Chevron whereby users of Engelhard's platinum-rhenium catalysts have worldwide rights to operate under Chevron's patents covering such catalysts.[8]

To meet anticipated demand for bimetallic platinum-rhenium catalysts, Engelhard redesigned a catalytic production facility in Newark, N.J.

During the year, an estimated 300 pounds of rhenium was consumed as metal powder primarily in refractory metal alloys. Other applications of rhenium continued to be in high-temperatures thermocouples, flashbulb filament wires, electrical contacts, and coatings.

Special reviews of rhenium were published which discussed and evaluated supply-demand patterns and projected these relationships to future years.[9] These reviews indicated that continued development of platinum-rhenium catalysts could cause a short-term rhenium supply problem.

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[5] International Minerals & Chemical Corp. Annual Report 1971. 12 pp.

[6] Newmont Mining Corp. Annual Report 1971. 32 pp.

[7] Engelhard Minerals & Chemicals Corp. Annual Report 1971. 20 pp.
Standard Oil Co. of Calif. Annual Report 1971. 34 pp.
Universal Oil Products Co. Annual Report 1971. 34 pp.

[8] Nevison, John A., M. H. Dalson, and John Mooi. Catalytic Reforming Advances With E-501 Catalyst. Proc. API Division of Refining, v. 50, 1970, pp. 304–323.

[9] American Metal Market. International Exotic Metals Report, Sec. 2. Dec. 23, 1971, 8 pp.
Metals Week. Precious Metals—Platinum: Focus on Reforming. V. 42, No. 19, May 10, 1971, pp. 6–7.

PRICES

During the year, prices paid for rhenium metal powder used in rhenium metal wire and in mill products made from rhenium-refractory metal alloys reportedly ranged from $875 to $1,600 per pound of rhenium. The prices paid for rhenium used in catalytic applications ranged from about $1,200 to $1,400 per pound.

Effective June 1, 1971, CRM, increased prices for rhenium salts and metal powder to contract customers. The price of rhenium metal powder, in lots of 10 or more pounds, was increased to $1,400 per pound from the previous quotations of $875 to $1,200 per pound, depending upon quantity purchased. CRM's new quotation for perrhenic acid ($HReO_4$), feed material for bimetallic platinum-rhenium catalyst production, became $1,325 per pound.

FOREIGN TRADE

Imports of unwrought rhenium metal and scrap increased 80 percent during 1971 and totaled 377 pounds, gross weight, valued at $452,842. These imports, all of which represented rhenium metal powder, came primarily from Belgium-Luxembourg (58 percent), West Germany (29 percent), and France (12 percent). There were no imports of rhenium scrap during the year. Rhenium imports from Belgium were believed to have been recovered from molybdenite associated with porphyry copper ores from Zaire. The remaining, unwrought rhenium imports were believed to have been recovered from byproduct molybdenite obtained from porphyry copper ores mined in Chile. The price of unwrought rhenium metal imports, excluding U.S. duty, averaged $1,201 per pound during the year and ranged from $397 per pound (United Kingdom) to $1,273 per pound (West Germany). Two pounds of wrought rhenium valued at $1,498, excluding U.S. duty, were imported from France during 1971.

Effective January 1, 1971, the tariff on unwrought rhenium metal was reduced to 6 percent ad valorem and the duty on wrought rhenium was reduced to 10.5 percent ad valorem. From August 16 through December 20, 1971, a 10-percent ad valorem surcharge (Presidential Proclamation 4074) was imposed on all imports. During this period, the duty on unwrought rhenium was 16 percent ad valorem and the duty on wrought rhenium was 20.5 percent ad valorem.

As the final part of the 5-year program of tariff reductions agreed upon at the Kennedy Round Tariff Negotiations, duties on unwrought and wrought rhenium imports from non-Communist countries were further reduced. Effective January 1, 1972, the import duty on unwrought rhenium metal and scrap was reduced from 6 to 5 percent ad valorem and that for wrought rhenium from 10.5 to 9 percent ad valorem. The import duty on unwrought rhenium from Communist Bloc countries remained unchanged at 25 percent ad valorem and that on wrought rhenium remained unchanged at 45 percent ad valorem.

During 1971 the import duty on rhenium scrap was suspended.

Table 2.—U.S. imports for consumption of rhenium (including scrap), by country

(Gross weight)

Country	1969		1970		1971	
	Pounds	Value	Pounds	Value	Pounds	Value
Belgium-Luxembourg	--	--	--	--	220	$262,278
France	109	$53,045	58	$53,789	45	49,770
Germany, West	9,230	153,358	79	34,373	110	140,000
Sweden	215	72,681	--	--	--	--
U.S.S.R.	222	71,660	73	23,467	--	--
United Kingdom	4	1,364	--	--	2	794
Total	9,780	352,108	210	111,629	377	452,842

WORLD REVIEW

Canada.—Copper-molybdenum ores of Utah Interntional, Inc.'s, (formerly Utah Construction and Mining Co.) Island Copper mine on Vancouver Island near Port Hardy, British Columbia, contain significant quantities of byproduct rhenium. Preliminary information indicates that the rhenium content in concentrates containing 90 percent MoS_2 ranges from 1,100 to 2,250 ppm and averages about 0.2 percent (2,000 ppm).[10] Reported reserves of the ore body total 280 million tons having an average grade of 0.52 percent copper and about 0.042 percent MoS_2. On the basis of this information, the total calculated rhenium content assuming 90-percent recovery could exceed 400,000 pounds.

Shipments of molybdenum concentrates from initial open pit production at the Island Copper mine were marketed by Philipp Brothers, a wholly owned trading di-

[10] Mining Engineering. Rhenium Found at Utah Construction Cu Site. V. 23, No. 4, April 1971, p. 14.

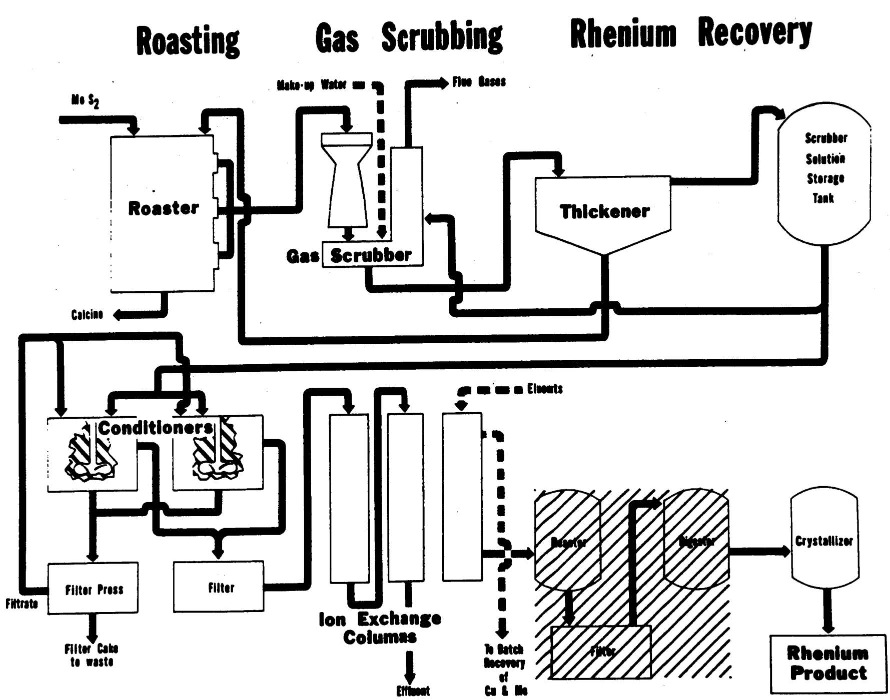

Figure 2.—Revised rhenium recovery flowsheet at Kennecott Copper Corporation's molybdic oxide plant. (Courtesy of Kennecott Copper Corp.)

vision of Engelhard Minerals & Chemicals Corp., as agents for Utah International. When full production is reached early in 1972, the output of molybdenum concentrate is expected to total about 1,800 tons annually.[11]

A feasibility study of rhenium extraction is being conducted and, if favorable, a processing plant will be built to recover the rhenium and to produce technical-grade molybdic oxide. Philipp Brothers indicated that, initially, rhenium contained in this material will probably be recovered in Western Europe since domestic processing facilities are reportedly operating at near capacity primarily on domestic material. The recovered rhenium will be sold on the open market to the petroleum industry for catalytic use.

Germany, West.—Facilities for production of rhenium-base catalysts were redesigned and installed by Kali-Chemie Engelhard, an affiliate of Engelhard Minerals & Chemicals Corp., at its refinery in Nienburg.

In West Germany, rhenium metal was recovered from molybdenite concentrates obtained from Chilean porphyry copper ores and was marketed by Herman C. Stark, Inc., in Goslar.

Japan.—A detailed evaluation of the rhenium content of various molybdenite concentrates indicated that there was a distinct difference between samples from northeast and southwest Japan.[12] The most significant rhenium contents were found in samples of volcanic sublimate from Io-zima, Kagoshima, in southwestern Japan, which contained about 0.2 to 0.4 percent rhenium (2,000 to 4,000 ppm).

Philippines.—A sample of molybdenite concentrate recovered from a porphyry copper deposit near Sipalay reportedly contains 0.17 percent (1,700 ppm) rhenium.[13]

TECHNOLOGY

As part of the Government's Heavy Metals Program, studies were conducted by Bureau of Mines metallurgists which evaluated electrolytic oxidation (electrooxidation) processes to economically recover gold, molybdenum, and rhenium byproduct materials.[14] Further electrooxidation studies are being conducted by Bureau engineers in an attempt to increase the rhenium yield by this recovery technique. Additional studies were conducted by Bureau geologists to determine the economic availability of domestic byproduct rhenium.

A simplified rhenium recovery process (fig. 2) was developed by Kennecott Copper Corp. in which ammonium thiocyanate (NH_4CNS) is substituted for the more expensive and hazardous perchloric acid ($HClO_4$).[15] During the roasting of molybdenite concentrates, 90 percent of the contained rhenium is volatilized into the off gases at a concentration of 10 to 20 ppm. The flue dust and gases are scrubbed to absorb rhenium oxide and the resulting solution is processed by ion exchange to selectively separate rhenium. In the new process, ammonium thiocyanate eluant is added to the ion exchange columns. The resulting rhenium-rich ammonium thiocyanate solution is directly evaporated and 98+ percent of the rhenium is crystallized out as ammonium perrhenate.

By using this new process the final processing steps formerly utilized, neither eluting rhenium from the ion exchange resin with perchloric acid (which must be acidified), reaction with hydrogen sulfide (H_2S), conversion to ammonium perrhenate, nor filtration is necessary, these steps

[11] The Northern Miner (Toronto). Utah Construction Starts Tuning Up. V. 57, No. 30, Oct. 14, 1971, p. 1.
Utah International Inc. Annual Report 1971. 36 pp.

[12] Terada, Kikuo, Susumu Osaki, Shunso Ishihara, and Toshiyasu Kiba. Distribution of Rhenium in Molybdenites From Japan. Geochem. J., v. 4, 1971, pp. 123–141.

[13] Page 130 of work cited in footnote 12.

[14] Prokopovitsh, Andrew S. Mineral Processing in 1971. Mining Congress J., v. 58, No. 2, Feb. 1972, pp. 127–137.
Scheiner, B. J., R. E. Lindstrom, and T. A. Henrie. Oxidation Process for Improving Gold Recovery From Carbon-Bearing Gold Ores. BuMines Rept. of Inv. 7573, 1971, 14 pp.
Scheiner, B. J., and R. E. Lindstrom. Extraction of Molybdenum From Ores by Electrooxidation. BuMines Tech. Prog. Rept. 47, 1972, 9 pp.

[15] Chemical Engineering. New Route to Rhenium. V. 78, No. 18, Aug. 9, 1971, p. 58.
Prater, J. D., and R. N. Platzke. Extractive Metallurgy of Rhenium. Pres. at Ann. Meeting of AIME, New York, Feb. 28 to Mar. 4, 1971, TMS–AIME Paper A 71–67, 24 pp.
Prater, John D., and Ronald N. Platzke (assigned to Kennecott Copper Corp., New York). Process for Recovering Rhenium Values From Ion Exchange Materials. U.S. Pat. 3,558,268, Jan. 26, 1971, 5 pp.

have been eliminated, as indicated in Figure 2.

Soviet scientists developed a special method of melting base-metal (primarily copper sulfide) ores in a cyclone chamber where rhenium and other byproduct mineral values were volatilized and recovered from the vapor.[16]

Microhardness studies of the effect of rhenium additions on the softening of Group VIA metals [chromium (Cr), molybdenum (Mo), and tungsten (W)] indicated that alloy softening was similar in all three systems (Cr-Re, Mo-Re, and W-Re) and occurred at rhenium concentrations of less than 16 atomic-percent.[17] The rhenium content required to produce a hardness minimum diminished rapidly with increasing test temperature. A sharp temperature dependence of hardness was observed in dilute alloys that exhibited alloy softening.

The creep-rupture properties of tungsten-25 percent rhenium materials consolidated by arc-melting and powder-metallurgy (PM) techniques compared at 1650° and 2200°C for rupture times up to 1,000 hours indicated that, at comparable stresses, the PM material had a shorter rupture life and lower rupture ductility.[18] Optical and electron metallography showed that while voids formed at the grain boundaries of both materials, massive growth of voids in the PM material initiated fractures with very little deformation.

The creep deformation in electron-beam-melted (EB) polycrystalline rhenium sheet was compared with PM rhenium at temperatures from 2200° to 4200°F and pressures from $4x10^{3}$ to $4x10^{4}$ pounds per square inch.[19] The EB rhenium had greater ductility, higher primary creep rate, and longer rupture life, especially at lower temperatures.

[16] Kostin, V. N., I. V. Paramanov, and V. V. Tsyganov (assigned to Ministerstvo Tsvetnoi Metallurgii, Moscow, U.S.S.R.). Canadian Pat. 869,477, Apr. 27, 1971, 10 pp.

[17] Stephens, J. R., and W. R. Witzke. Alloy Softening in Group VIA Metals Alloyed With Rhenium. J. Less-Common Metals, v. 23, No. 4, April 1971, pp. 325–342.

[18] Stephenson, R. L. Comparative Creep-Rupture Properties of Tungsten-25% Rhenium Consolidated by Arc-Melting and Power-Metallurgy Techniques. J. Less-Common Metals, v. 24, No. 2, June 1971, pp. 173–182.

[19] Witzke, Walter R., and Peter L. Raffo. Creep Behavior of Electron-Beam-Melted Rhenium. Met. Trans., v. 2, No. 9, September 1971, pp. 2533–2539.

Salt

By Robert T. MacMillan [1]

Following 12 years of uninterrupted expansion, domestic salt (sodium chloride) production declined 4 percent in 1971 compared with the production level of the previous year. From 1958 until 1971 the salt industry exhibited steady growth, averaging a 4.4-percent annual compound increase in production. In 1971, however, the output of salt in brine decreased 6.8 percent and that of rock salt decreased 3.3 percent compared with the previous year's outputs. Evaporated salt, on the other hand, increased 7.8 percent. The decrease in output of both salt in brine and rock salt reflected the lower production level of the chemical manufacturing industries, which require large quantities of chlorine, caustic soda, and soda ash produced from salt.

Imports of salt continued to increase, with a 9-percent gain. Since 1958 salt imports have increased at a compound rate of 10.7 percent per year; in 1971 imports provided 8.2 percent of the apparent consumption.

Legislation and Government Programs.—The Michigan State Department of Natural Resources issued an order restricting hydraulic mining of salt at Grosse Ile following the development of two large sinkholes on property owned by a salt company on an island in the Detroit River. The caved areas, which were 100 to 200 feet in diameter and 30 to 40 feet in depth, were believed to be caused by removal of salt from beds lying about 1,100 feet beneath the surface. Salt has been mined in the area since 1948 by drilling wells into the salt bed, injecting fresh water, dissolving the salt, and pumping out the saturated brine. A thorough study of the problems associated with salt mining in the area was planned by State officials before deciding on a course of action.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Production	NA	NA	NA	r1 46,764	2 44,700
Sold or used by producers	38,946	41,274	44,245	1 45,896	2 44,077
Value	$251,210	$272,275	$287,680	$304,759	$303,687
Exports	678	728	716	423	670
Value	$4,583	$4,650	$4,486	$3,657	$4,182
Imports for consumption	2,843	3,456	3,302	3,536	3,855
Value	$8,541	$11,487	$11,990	$13,329	$14,429
Consumption, apparent	41,111	44,002	46,831	r 49,009	47,262
World: Production	131,092	138,426	150,495	160,416	157,299

r Revised.
NA Not available.
1 Excludes 32,000 short tons from Puerto Rico.
2 Excludes 28,500 short tons from Puerto Rico.

DOMESTIC PRODUCTION

Seventeen States recorded salt production in 1971. The two leading States, Louisiana and Texas, produced 51 percent of the total output. Michigan, Ohio, and New York contributed 35 percent. Salt was produced by 58 companies at 103 plants in

[1] Physical scientist, Division of Nonmetallic Minerals.

the United States and Puerto Rico in 1971. Twelve companies, each producing more than 1 million tons in 1971, operated 45 plants and accounted for 87 percent of the total U.S. salt output. Seventeen companies with a production of less than 1 million tons but more than 100,000 tons operated 28 plants and accounted for 12 percent of the total production. Twenty-nine other companies whose individual production was less than 100,000 tons operated 30 plants and supplied the remaining 1 percent of the total salt output.

Twelve plants, each with a production of over 1 million tons, accounted for 57 percent of the total domestic salt output. Thirteen plants, each producing between 500,000 and 1 million tons, accounted for 19 percent of the total. The remaining 24 percent was supplied by 78 plants.

Despite lower production in 1971 the salt industry continued to expand its production capacity. Morton Salt Co., a Division of Morton International, Inc., opened a new rock salt mine at Himrod, Yates County, New York.[2] Two 18-foot-diameter, concrete-lined shafts opened the way to the Seneca Lake salt strata, the first of which lies 1,600 feet below the surface. Production was initiated, however, at 1,954 feet. The company expected to attain a yearly production level of 2.5 million tons by the end of the year. Reserves are believed sufficient for at least 50 years of production.

Other developments completed by Morton Salt Co. included a new 12-foot-diameter shaft at its Grand Saline mine in Texas and a $2-million expansion program at its Fairport mine in Ohio.

The International Salt Co., known as Akzona following a merger with American Enka in 1971, completed a new production shaft at the Avery Island mine in Louisiana. Production capacity of the improved facility was estimated at 2.5 million tons per year.

Improvements underway at other facilities of Akzona in Ohio, Michigan, and New York were expected to increase the company's total production capacity substantially.[3]

A second shaft was completed at the Belle Isle, La., mine of Cargill, Inc. Modernization was underway at the Cayuga Rock Salt Co. (an affiliate of Cargill, Inc.) mine at South Lansing, N.Y.

The Salt Supply Co., Inc., of New Mexico expanded its production capacity by acquiring the Carlsbad rock salt facilities of the New Mexico Salt Co. The Salt Supply Co. is a subsidiary of United Salt Corp., of Houston, Tex.[4]

The Western Salt Co. of Erick, Okla. which produced solar-evaporated salt from natural brine ceased production in May 1971, because of legal problems relating to a brine pipeline.

[2] Skillings Mining Review. Morton to Open Mine. V. 16, No. 25, June 19, 1971, pp. 1, 12–13.
[3] Jacoby, Charles, H. Salt. Min. Eng., v. 24, No. 1, January 1972, pp. 52–53.
[4] Carlsbad Current Argus. Salt Supply to Expand Here Soon. V. 85, No. 36, Dec. 10, 1971.

Table 2.—Salt sold or used by producers in the United States, by method of recovery

(Thousand short tons and thousand dollars)

Recovery method	1970		1971	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	348	$10,253	335	$8,745
Vacuum pans	3,114	78,052	3,289	86,478
Solar	r 1,669	r 14,835	1,937	21,432
Pressed blocks	r 368	r 10,085	367	10,532
Total [1]	r 5,498	r 113,224	5,928	127,186
Rock:				
Bulk	14,090	93,023	13,613	87,226
Pressed blocks	79	2,269	87	2,095
Total [1]	14,170	95,291	13,700	89,321
Salt in brine (sold or used as such)	r 26,228	r 96,243	24,449	87,180
Grand total [1]	r 45,896	r 304,759	44,077	303,687

r Revised.
[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	1970		1971	
	Quantity	Value	Quantity	Value
California	1,656	r $15,053	1,887	$21,142
Kansas [1]	1,230	18,206	1,240	18,712
Louisiana	13,584	64,854	13,352	67,950
Michigan	4,899	49,963	4,458	49,007
New Mexico	W	W	146	1,130
New York	5,990	47,254	5,303	43,601
Ohio	5,329	47,498	5,709	46,651
Texas	10,184	45,000	9,217	40,838
Utah	r 450	r 4,192	614	5,213
West Virginia	1,190	5,171	1,174	4,778
Other States [2]	r 1,384	r 7,568	976	4,667
Total [3]	r 45,896	r 304,759	44,077	303,687
Puerto Rico	32	395	29	570

r Revised. 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, North Dakota, Oklahoma, Virginia, 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	1970		1971	
	Quantity	Value	Quantity	Value
California	1,358	$14,095	1,592	$20,164
Kansas	670	15,178	676	15,847
Louisiana	270	7,888	275	9,399
Michigan	1,186	28,948	1,174	30,042
New York	628	18,087	658	19,842
Ohio	771	W	763	21,072
Other States [1]	r 616	r 29,028	790	10,819
Total [2]	r 5,498	r 113,224	5,928	127,186
Puerto Rico	32	395	29	570

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes Hawaii, Nevada, New Mexico, North Dakota, Oklahoma, Texas, Utah, and States indicated by symbol W.

[2] Data may not add to totals 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
1967	11,661	$71,953
1968	12,461	79,867
1969	13,397	86,452
1970	14,170	95,291
1971	13,700	89,321

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		From rock salt		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1967	344	$8,367	63	$1,853	407	$10,220
1968	357	9,246	85	2,321	442	11,567
1969	369	9,622	83	2,352	452	11,974
1970	r 368	r 10,085	79	2,269	r 447	r 12,353
1971	367	10,532	87	2,095	454	12,627

r Revised.

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

CONSUMPTION AND USES

Of the total salt consumed in 1971, 55 percent was produced and consumed as brine, 31 percent as rock salt, and 14 percent as evaporated salt. The production of chlorine required 44 percent of the total salt output, soda ash manufacturing required 14 percent, and all other chemicals required 3 percent, totaling 61 percent for the chemical industry as a whole in 1971. This compared with 64 percent for the previous year. Most of the decrease was in the salt required for chlorine production.

The second largest use of salt was for deicing streets and highways and for road bed stabilization. This use, which is tabulated in table 7 opposite "States, counties, and other political subdivisions (except Federal)," required 18 percent of the salt output in 1971 compared with 17 percent in the previous year. Salt used for food and food-related uses was 6.6 percent of the total consumed compared with 5.6 percent in 1970. The categories included in food-related consumption were—meat packers, tanners, etc.; fishing, dairy, canning, and baking; flour processing; other food processing; and grocery stores. Salt sold to grocery stores was heretofore assumed to be largely for table use; however, 1971 growth in this category of salt consumption was attributed in part to salt sold for water softeners.

Table 7.—Salt sold or used by producers in the United States, by class and consumer or use

(Thousand short tons)

Consumer or use	1970				1971			
	Evaporated	Rock	Brine	Total [1]	Evaporated	Rock	Brine	Total [1]
Chlorine	262	2,629	18,354	21,245	282	2,733	16,605	19,621
Soda ash	(2)	(2)	6,445	6,445	1	(2)	6,357	6,358
Soap (including detergents)	(3)	(3)	(3)	(3)	24	W	W	27
All other chemicals	335	579	495	1,409	426	346	487	1,259
Textile, and dyeing	115	82	--	197	118	75	--	193
Meatpackers, tanners, and casing manufacturers	266	370	--	636	283	370	--	653
Fishing	25	5	--	30	33	4	--	37
Dairy	51	8	--	60	55	6	--	61
Canning	159	63	(2)	222	185	55	(2)	241
Baking	107	8	(2)	116	110	6	--	116
Flour processors (including cereal)	68	11	(2)	79	68	11	(2)	79
Other food processing	440	43	(2)	483	475	40	(2)	515
Ice manufacturers and cold storage companies	(4)	(4)	(4)	(4)	1	2	--	4
Feed dealers	[r] 836	543	--	[r] 1,379	862	493	--	1,355
Feed mixers	330	216	--	546	329	258	--	586
Metals	63	W	W	[r] 260	47	135	(2)	182
Ceramics (including glass)	(4)	(4)	--	(4)	4	4	--	8
Rubber	71	W	W	206	74	W	W	172
Oil	51	78	85	214	54	60	51	164
Paper and pulp	[r] 183	135	[r] 61	380	105	115	59	279
Water softener manufacturers and service companies	[r] 459	W	W	[r] 704	418	W	W	680
Grocery stores	642	294	--	936	795	441	--	1,236
Railroads	(4)	(4)	--	(4)	1	2	--	3
Bus and transit companies	(4)	(4)	--	(4)	1	3	--	3
States, counties, and other political subdivisions (except Federal)	[r] 217	7,586	4	[r] 7,807	331	7,571	4	7,905
U.S. Government	30	77	(2)	107	24	34	(2)	59
Miscellaneous [5]	690	972	608	2,270	1,074	620	792	2,487
Total [1]	[r,6] 5,402	[6] 14,180	[r,6] 26,150	[r,7] 45,732	[6] 6,180	[6] 13,640	[6] 24,463	[7] 44,283

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Total."
1 Data may not add to totals shown because of independent rounding.
2 Less than ½ unit.
3 Included with all other chemicals.
4 Included with miscellaneous.
5 Includes some exports and consumption in overseas areas administered by the United States.
6 Differs from totals in tables 2, 4, and 5 because of changes in reporting data.
7 Differs from totals in tables 1, 2, and 3 because of changes in reporting data.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1970 Evaporated	1970 Rock	1971 Evaporated	1971 Rock
Alabama	51	417	52	329
Alaska	5	W	W	W
Arizona	13	W	28	W
Arkansas	23	109	20	89
California	852	89	1,193	82
Colorado	100	46	106	51
Connecticut	27	W	19	129
Delaware	7	W	7	196
District of Columbia	4	W	5	31
Florida	41	130	41	135
Georgia	65	260	62	248
Hawaii	W	--	4	--
Idaho	r 47	W	51	W
Illinois	325	729	341	870
Indiana	159	480	154	416
Iowa	191	288	196	307
Kansas	80	166	80	222
Kentucky	47	534	47	516
Louisiana	41	288	52	380
Maine	9	W	10	172
Maryland	47	W	47	74
Massachusetts	44	544	46	481
Michigan	192	W	190	463
Minnesota	144	352	151	371
Mississippi	25	97	21	102
Missouri	99	356	99	294
Montana	r 39	1	51	1
Nebraska	98	75	106	83
Nevada	28	W	33	211
New Hampshire	7	W	7	162
New Jersey	161	614	158	531
New Mexico	21	89	43	68
New York	331	W	313	1,666
North Carolina	120	171	132	178
North Dakota	58	6	27	4
Ohio	335	1,388	351	1,361
Oklahoma	48	68	40	61
Oregon	7	W	W	W
Pennsylvania	184	1,105	192	1,114
Rhode Island	10	W	10	82
South Carolina	44	25	37	25
South Dakota	49	26	53	27
Tennessee	124	W	120	535
Texas	118	319	95	187
Utah	r 174	W	313	W
Vermont	7	W	6	156
Virginia	96	W	103	147
Washington	W	W	161	W
West Virginia	24	178	22	161
Wisconsin	170	488	176	544
Wyoming	20	2	20	3
Other [1]	r 490	4,740	591	373
Total [2]	r [3] 5,402	[3] 14,180	[3] 6,180	[3] 13,640

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and States indicated by symbol W.
[2] Data may not add to totals shown because of independent rounding.
[3] Differs from totals in tables 2, 4, and 5 because of differences at the point in which the data were recorded.

PRICES

Prices per 100 pounds of salt quoted in Oil, Paint and Drug Reporter for various grades in 1971 were as follows:

	January	June	July	December
Salt, evaporated, common, in bags, carlots, or truck lots, works	$1.33	$1.33	$1.43	$1.43
Salt, chemical-grade, same basis	1.44	1.44	1.54	1.54
Salt, rock, medium, coarse, same basis	.87	.87	.97	.97
Salt, rock, extra coarse, same basis	.92	.92	1.02	1.02

The average value of evaporated salt reported by producers to the Bureau of Mines in 1971 was $21.46 per ton. On the same basis the average value of rock salt was $6.52, and that of salt in brine was $3.57.

FOREIGN TRADE

Exports of salt increased substantially in 1971 but were less than 2 percent of the total output. Canada and Japan received 98 percent of U.S. exports of salt. Comparatively small quantities were shipped to several other countries.

Imports increased 9 percent in 1971 and were 8.2 percent of the apparent consumption of salt. Canada, Mexico, and the Bahamas supplied 87.6 percent of the total salt imported. Gains in imports were mostly from Mexico and the Bahamas, each of which showed a 23-percent increase over the previous year's totals.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas [1] administered by the United States

Area	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
American Samoa	329	$13	199	$11
Puerto Rico	15,504	943	19,060	1,856
Virgin Islands	230	13	150	31

[1] Beginning Jan. 1, 1970, Guam data no longer reported.

Table 10.—U.S. exports of salt by country

(Thousand short tons and thousand dollars)

Destination	1970		1971	
	Quantity	Value	Quantity	Value
Australia	1	$97	(1)	$34
Bahamas	2	63	2	70
Canada	221	1,803	398	2,350
Costa Rica	1	48	1	25
Japan	187	909	260	1,100
Mexico	3	98	1	59
Netherlands Antilles	2	47	2	87
New Zealand	1	55	1	37
Saudi Arabia	2	180	1	70
South Africa, Republic of	(1)	14	1	16
Other	3	343	3	334
Total	423	3,657	670	4,182

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of salt, by country [1]

(Thousand short tons and thousand dollars)

Country	1970		1971	
	Quantity	Value	Quantity	Value
Bahamas	706	$2,817	865	$3,328
Canada	1,383	6,560	1,457	7,059
Chile	293	1,145	280	873
Ireland	--	--	60	148
Mexico	858	1,816	1,056	2,595
Romania	19	177	--	--
Spain	17	47	18	47
Tunisia	134	357	106	299
United Kingdom	49	135	(2)	3
Venezuela	77	266	13	46
Other	(2)	9	(2)	31
Total	3,536	13,329	3,855	14,429

[1] Includes salt brine from Canada through Buffalo customs district for 1971, 1,000 short tons ($1,089;) Seattle customs district, 28,738 short tons ($198,108).
[2] 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)		Bulk (dutiable)[1]	
	Quantity	Value	Quantity	Value
1969	11	$316	3,291	$11,674
1970	45	625	3,491	12,704
1971	27	574	3,828	13,855

[1] Includes salt brine from West Germany through the New York City customs district for 1969; 601 short tons ($5,912); 1970, none; 1971, 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 [1]

(Thousand short tons and thousand dollars)

Customs district	1970		1971	
	Quantity	Value	Quantity	Value
Anchorage, Alaska	--	--	(2)	$3
Baltimore, Md	304	$1,048	382	1,117
Boston, Mass	207	755	332	935
Bridgeport, Conn	154	525	53	245
Buffalo, N.Y	13	62	34	149
Chicago, Ill	295	1,327	163	734
Cleveland, Ohio	191	853	120	561
Detroit, Mich	642	3,199	690	3,453
Duluth, Minn	33	159	40	188
Los Angles, Calif	227	471	159	337
Milwaukee, Wisc	138	604	318	1,469
New York City	141	552	137	550
Norfolk, Va	9	36	27	115
Ogdensburg, N.Y	(2)	(2)	(2)	3
Philadelphia, Pa	--	--	104	304
Portland, Maine	296	1,405	260	1,319
Portland, Oreg	149	207	161	258
Providence, R.I	87	318	140	486
St. Albans, Vt	(2)	3	(2)	(2)
San Juan, Puerto Rico	12	72	99	415
Savannah, Ga	222	822	200	739
Seattle, Wash	388	844	415	985
Wilmington, N.C	28	67	21	59
Other	(2)	(2)	(2)	5
Total	3,536	13,329	3,855	14,429

[1] Includes salt brine from Canada through Buffalo customs district for 1971, 1,000 short tons ($1,089); Seattle customs district, 28,738 short tons ($198,108).
[2] Less than ½ unit.

Table 14.—U.S. imports for consumption of salt, by use

Use	Thousand short tons	
	1970	1971
Government (highway use)	2,285	1,954
Chemical industry	228	96
Water conditioning service companies	204	110
Other	196	344
Total	2,913	[1] 2,505

[1] Data may not add to totals 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

Australia.—Growth in demand for salt by highly industrialized nations such as Japan lead to development of new sources of this commodity in Australia for the world market. Although few economically important rock salt deposits have been discovered in Australia, conditions for the production of solar salt, both from sea-water and lake or underground brines, were found to be particularly advantageous and a number of new solar salt fields have been developed since about 1965.[5] The area around Adelaide, South Australia, was the first commercially important source of Australian salt, but large solar-salt-producing areas in northwest Australia have become increasingly important and have the advantage of greater accessibility to the growing Japanese market. Most Australian exporters have Japanese equity in their capital structures.

By using modern materials-handling technology, the natural advantages of 20-foot tides for filling evaporation ponds, and favorable climate and topography, Australian solar salt was competitive with Chilean rock salt on the world market. For many years rock salt was the cheapest form of salt except for salt in brine, which is normally used close to its point of production and does not enter into world trade.

Dampier Salt Ltd. announced plans to increase its solar-salt-producing capacity from 850,000 to 2,200,000 tons annually. The company is owned by Australian and Japanese interests and is situated on the coast 150 miles southwest of Port Headland in western Australia. As the output of the company is largely for the export market, chiefly Japan, deep water shipping facilities were reported to be under construction.[6]

Bahamas.—After nearly 10 years of difficulties, the solar salt operation of Diamond Crystal Salt Co. on Long Island achieved a production of 222,000 tons in 1971, nearly 4 times the previous record of 60,000 tons. The firm planned to expand its salt producing facilities in the Bahamas.[7]

Poland.—Development of a modern salt mine in the neighborhood of Gora, Inowroclaw Powiat, was reported. The salt is mined hydraulically by injecting fresh water into the salt formation and removing the brine, which was to be used in a soda ash plant. Brine was pumped from four of the scheduled 15 openings into the salt formation.[8]

Salt has been mined in Poland for many centuries. Production of rock salt from the historic Wieliczka mine became uneconomic in 1964 but production of brine continued.

Syrian Arab Republic.—Production of rock salt from a deposit in Deir el-Zor Province was expected to begin in 1971 at a rate of 36,000 tons per year. Production may increase to 140,000 tons in the mid-1970's. Reserves of 96 million tons were proved and an additional 812 million were estimated.[9]

[5] U.S. Bureau of Mines. Salt: Australia. Mineral Trade Notes, v. 68, No. 4, April 1971, pp. 30–36.
[6] Industrial Minerals (London). Dampier Salt to Increase Productivity Capacity to 2.2 Million Tons. No. 6, July 1971, p. 29.
[7] U.S. Embassy, Nassau. State Department Airgram A-243, Dec. 9, 1971, 2 pp.
[8] U.S. Embassy, Warsaw, Poland. State Department Airgram A-162, Apr. 26, 1971, 2 pp.
[9] U.S. Bureau of Mines. Salt: Syrian Arab Republic. Mineral Trade Notes, v. 68, No. 5, May 1971, p. 12.

Table 15.—Salt: World production by country

(Thousand short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Bahamas	750	685	1,337
Canada	4,657	5,359	5,334
Costa Rica	10	8	12
El Salvador	30	35	34
Honduras	31	[e] 30	[e] 30
Martinique	[r] 357	[e] 330	[e] 330
Mexico	[r] 4,288	4,578	4,806
Nicaragua [e]	11	11	50
United States (including Puerto Rico):			
Rock salt	13,397	14,170	13,700
Other salt:			
United States	30,848	31,726	30,377
Puerto Rico	32	32	29
South America:			
Argentina	520	1,056	[e] 1,060
Brazil	1,796	2,013	1,628
Chile	1,467	569	468
Colombia:			
Rock salt	379	587	372
Other salt	368	254	331
Dominican Republic	28	42	[e] 42
Peru	102	210	[e] 200
Venezuela	188	293	[e] 290
Europe:			
Austria:			
Rock salt	1	1	1
Other salt	460	542	530
Bulgaria	139	149	[e] 150
Czechoslovakia	183	[e] 200	[e] 200
Denmark [2]	271	481	147
France:			
Rock salt and brine salt	[r] 4,362	4,636	5,786
Marine salt	1,064	1,408	[e] 1,430
Germany:			
East	[r] 2,173	2,403	[e] 2,400
West (marketable):			
Rock salt	[r] 7,475	9,176	8,434
Marine salt and other	[r] 2,290	2,339	840
Greece	83	77	[e] 80
Italy:			
Rock salt and brine salt	3,086	3,165	[e] 3,200
Marine salt	1,264	1,650	[e] 1,700
Malta	2	3	[e] 3
Netherlands	2,942	3,163	3,491
Poland:			
Rock salt	1,285	1,349	1,346
Other salt	1,820	1,851	1,916
Portugal:			
Rock salt	183	214	259
Marine salt	157	228	[e] 220
Romania	3,004	2,493	[e] 2,500
Spain:			
Rock salt	1,186	1,241	[e] 1,200
Marine salt [3]	850	1,023	[e] 1,025
Switzerland	294	368	321
U.S.S.R.	13,228	[e] 14,300	[e] 14,300
United Kingdom:			
Rock salt	[r] 1,697	1,936	1,991
Other salt	[r] 7,923	8,192	[e] 8,200
Yugoslavia	234	231	230
Africa:			
Algeria	165	110	[e] 110
Angola	88	97	100
Arab Republic of Egypt (formerly United Arab Republic)	424	489	[e] 550
Ethiopia (including Eritrea) [4]	258	287	320
Ghana	40	18	52
Kenya	47	39	48
Malagasy Republic	24	24	31
Mali	3	[e] 3	[e] 3
Mauritania	1	[e] 1	[e] 1
Mauritius	4	4	[e] 4
Morocco	74	63	58
Mozambique	[5] 11	[5] 32	[e] 32
Niger [e]	4	4	4
Senegal	88	130	136
Somali Republic	2	[e] 2	[e] 2
South Africa, Republic of	417	463	389

See footnotes at end of table.

Table 15.—Salt: World production by country—Continued

(Thousand short tons)

Country [1]	1969	1970	1971 p
Africa—Continued			
South-West Africa, Territory of: Marine salt e	121	121	121
Sudan	56	58	64
Tanzania	r 36	46	39
Tunisia	312	331	387
Uganda	5	3	3
Asia:			
Afghanistan [4]	41	42	e 40
Burma	194	173	205
Ceylon	125	71	95
China, People's Republic of e	16,500	17,600	16,500
Cyprus	6	8	7
India (including Goa)	7,033	6,160	6,382
Indonesia e	20	20	20
Iran [4]	r 427	430	e 430
Iraq	55	51	e 60
Israel	74	74	88
Japan	1,082	1,060	1,043
Jordan	21	28	26
Korea:			
North e	600	600	600
Republic of	319	446	410
Kuwait	4	3	e 3
Laos	3	1	(6)
Lebanon e	31	41	42
Mongolia e	9	9	9
Pakistan:			
Rock salt	r 298	349	380
Other salt	612	491	330
Philippines	255	232	250
Ryukyu Islands	7	e 7	e 7
Southern Yemen	69	e 66	e 66
Syrian Arab Republic	24	e 24	e 24
Taiwan	422	590	737
Thailand [6] e	220	220	176
Turkey	e 628	639	e 730
Vietnam:			
North e	165	165	165
South	130	e 132	132
Yemen e	120	109	110
Oceania:			
Australia	1,852	3,385	e 3,400
New Zealand	54	58	48
Total	r 150,495	160,416	157,299

e Estimate. p Preliminary. r Revised.

[1] Salt is produced in many other countries, including The Khmer Republic (formerly Cambodia) Cape Verde Islands and Libya, but quantities are relatively insignificant or reliable data are not available.

[2] 1969 and 1970 data are sales.

[3] Includes an average annual production in the Canary Islands of 15,000 metric tons of marine salt.

[4] Year beginning March 21 of year stated.

[5] Marine salt only.

[6] Less than ½ unit.

TECHNOLOGY

A theoretical review of the mechanism by which crystalline salt (sodium chloride) or mixed halites are dissolved in water was published.[10] Factors causing variations in the rate of salt removal from a solid salt surface under both laminar and turbulent flow conditions were discussed. The influence of these factors on the size and shape of solution cavities produced in salt formations was determined and applications of the theories to practical field operations were made. Controlling the size and shape of solution cavities in salt formations is of increasing importance not only to companies producing salt and other soluble compounds by solution methods, but also to petroleum companies interested in creating storage cavities in salt formations for storing gas and petroleum products.

A comprehensive study of the environmental significance of salt was published by a professor of Environmental Science at Louisiana State University.[11] The saline

[10] Jessen, F. W. Total Solution Mechanism. Trans. Soc. Eng. AIME, v. 250, No. 4, December 1971, pp. 298–303.

[11] Martinez, Joseph D. Environmental Significance of Salt. Am. Assoc. Petrol. Geol. Bull., v. 55, No. 6, June 1971, pp. 810–825.

waters and salt deposits of the continents are considered an integral part of the world's ecological system. The presence of salt in the environment has both beneficial and deleterious effects. The impact of salt on the ecosystem was discussed under the following headings: as nuclei of raindrops, a factor in land subsidence, a rock mass for waste disposal as well as for temporary storage of desirable materials, a basic raw material, a link in industrial pollution, a natural pollutant of ocean waters, an essential nutrient, and a pollutant of surface and underground waters.

Environmental effects of using deicing salt for two decades on the streets and highways near Rochester, N.Y., were investigated by scientists from the University of Rochester.[12] The use of deicing salt increased nationally at a phenomenal rate from 1940 to 1971—nearly doubling each 5 years. The possibility that using large quantities of salt (7.9 million tons in 1971) for melting ice and snow and producing bare pavements during the winter months might eventually result in irreparable damage to the environment has been considered by conservationists on numerous occasions. Deicing salt after dissolving in water finds its way into streams, lakes, and aquifers, causing ecological problems not only because of its salinity but also because of the increased density of brine compared with water. Stratification of the water in lakes may occur, resulting in incomplete or retarded vertical mixing of the water, which normally results from seasonal thermal gradients. Reduced oxygen content of the water results from retarded vertical mixing and eutrofication may result. Such effects are likely to occur gradually at first and in localized areas where topography may retard normal circulation. Results of the study near Rochester indicated that a fivefold increase in salinity of the lake had occurred since 1939 and that the period of stratification of the waters had increased by one month.

An ingenious adaptation of existing technology resulted in the development of a system for dissolving rock salt and producing a brine containing low sulfate (100 to 150 parts per million). Normally, evaporated salt priced $6 per ton higher than rock salt was used to produce brine of comparable purity. Rock salt treated to retard calcium sulfate solubility was dissolved by fresh water pumped upward through the bed. As the salt dissolved, the insoluble calcium sulfate settled to the bottom and was flushed from the tank. The system was said to be particularly adaptable to small plants.[13]

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[12] Bubeck, Robert C. et al. Runoff of Deicing Salt: Effect on Irondequoit Bay, Rochester, New York. Science, v. 172, No. 3988, June 11, 1971, pp. 1128–1132.

[13] Chemical Engineering News. Salt to Brine. V. 49, No. 29, July 29, 1971, p. 44.

Sand and Gravel

By Walter Pajalich [1]

Sand and gravel production decreased about 2.6 percent to 920 million short tons. The value of production increased 3 percent and established a new record of $1,148,969,000. Output from commercial operations increased 5 percent while Government-and-contractor production declined 30 percent. The production of sand and gravel in the Nation's leading State, California, dropped from 140 million short tons in 1970 to 115 million short tons in 1971.

DOMESTIC PRODUCTION

California with 115 million tons ranked first in sand and gravel output and produced more than twice as much as second-ranked Michigan. Other States producing substantial quantities of sand and gravel in descending order of production were Illinois, Minnesota, Ohio, Wisconsin, and Texas. Combined production from the seven leading States was 375 million tons, about 41 percent of the U.S. total output. The value of sand and gravel produced in these seven States was $456 million, 40 percent of the Nation's total.

Nationwide commercial operations continued to dominate production with 84 percent of the output, while Government-and-contractor operations accounted for 16 percent. The number of commercial operations continued to decline from 5,918 in 1970 to 5,738 in 1971.

Factors which had added to the consumer cost of sand and gravel include increased labor costs, growing land values, cost of land rehabilitation and longer haulage distances which increase transportation cost, and the need to produce from lower quality deposits as better ones become depleted or covered by urban expansion.

There were 4,676 commercial operations with production under 200,000 tons per year. These operations accounted for 34 percent of the total U.S. production. There were 767 operations with production between 200,000 and 500,000 tons, and they accounted for 31 percent of U.S. production. The remaining 295 operations, with production over one-half million tons, accounted for 35 percent of U.S. production.

The use of larger operating units, more efficient portable and semiportable plants, versatility of plant capacity and greater awareness of pollution control and rehabilitation were the key note of progress in 1971.

Automatic controls were installed in many of the larger and newer operations. These, together with improved equipment, have permitted recovery of salable fractions from deposits previously considered too low in quality for profitable exploitation. The industry continued to expand and improve its operations.

Descriptions of several new mechanized sand and gravel plants were published, illustrating equipment and technology. Special Aggregates Corporation, near Poland, N.Y., built an operation that would in every way protect the local environment, including a unique 350-ton-per-hour sand plant where gravity and water do all of the work except screening. The electric motors installed total 445 horsepower, most of which is used for moving water. A wide range of sand products are made, as well as several uncrushed gravel blends.[2]

Davison Sand & Gravel Co., of New Kensington, Pa., started up a new dredging operation in the Allegheny River above

[1] Mining engineer, Division of Nonmetallic Minerals.

[2] Trauffer, Walter E. Unique 350-tph Sand Plant Does All Handling by Water or Gravity. Pit and Quarry, v. 64, No. 7, January 1972, pp. 98–102.

Pittsburgh. They are reworking the beds of coarse gravel wasted in past years. The deposit is mostly 1¼- to 4½-inch gravel. Digging of this material is done by a clamshell dredge. The plant capacity is about 300 tons per hour. Most of the product is subbase material for a freeway project.[3]

As urban land deposits of sand and gravel become depleted, more and more local bodies of water are being investigated for new deposits. Large quantities of good aggregate material has already been extracted in western Lake Erie and also along the Lake Ontario shore line. A study was started in 1968 to evaluate the distribution and character of the sand and gravel deposits along the New York shore line in Lake Ontario with the intension of extending the study to Lake Erie. The findings have indicated that most of the Lake Ontario nearshore deposits consist of boulder beds of glacial till (75 percent), layers of sand and gravel (15 percent), and bedrock.[4]

[3] Trauffer, Walter E. Wasted Gravel Dredged and Processed for Highway Sub-Base. Pit and Quarry, v. 63, No. 8, February 1971, pp. 84–88.
[4] Woodrow, Donald L., Thomas L. Lewis, and Robert G. Sutton. Lake Ontario As A Source of Sand. Rock Products, v. 74, No. 4, April 1971, pp. 72–73.

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	1970		1971	
	Quantity	Value	Quantity	Value
Construction:				
Building:				
Sand	166,211	$197,553	177,664	$225,278
Gravel	129,964	191,342	145,202	218,046
Paving:				
Sand	138,959	147,988	134,311	152,747
Gravel	363,577	384,515	311,467	357,278
Fill:				
Sand	33,467	21,209	46,647	26,904
Gravel	43,210	26,582	35,093	23,382
Railroad ballast:				
Sand	1,235	727	1,869	2,224
Gravel	2,768	2,416	2,347	2,570
Other:				
Sand	14,360	16,040	14,103	18,220
Gravel	12,392	14,620	14,590	18,271
Total construction [2]	906,139	1,002,986	883,291	1,044,916
Industrial sand:				
Unground:				
Glass	10,813	39,492	9,683	36,445
Molding	8,087	24,544	7,302	21,763
Grinding and polishing	313	744	243	688
Blast sand	1,103	5,489	892	5,361
Fire or furnace	368	842	257	680
Engine	844	2,062	708	1,685
Filtration	257	618	200	612
Oil hydrafrac	296	2,360	302	1,883
Other	4,858	9,819	4,664	9,385
Total [2]	26,931	85,968	24,248	78,483
Ground sand [3]	2,211	15,226	1,911	12,893
Total industrial [2]	29,145	101,191	26,161	91,371
Miscellaneous gravel	8,658	11,521	10,142	12,682
Grand total [2]	943,941	1,115,705	919,593	1,148,969
Commercial:				
Sand	332,545	438,670	362,607	480,713
Gravel	399,942	483,894	409,773	527,032
Government-and-contractor [4]				
Sand	50,833	46,052	38,151	36,037
Gravel	160,619	147,089	109,063	105,194

[1] Excludes American Samoa, Panama Canal Zone (1971), and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] See table 10 for use breakdown.
[4] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

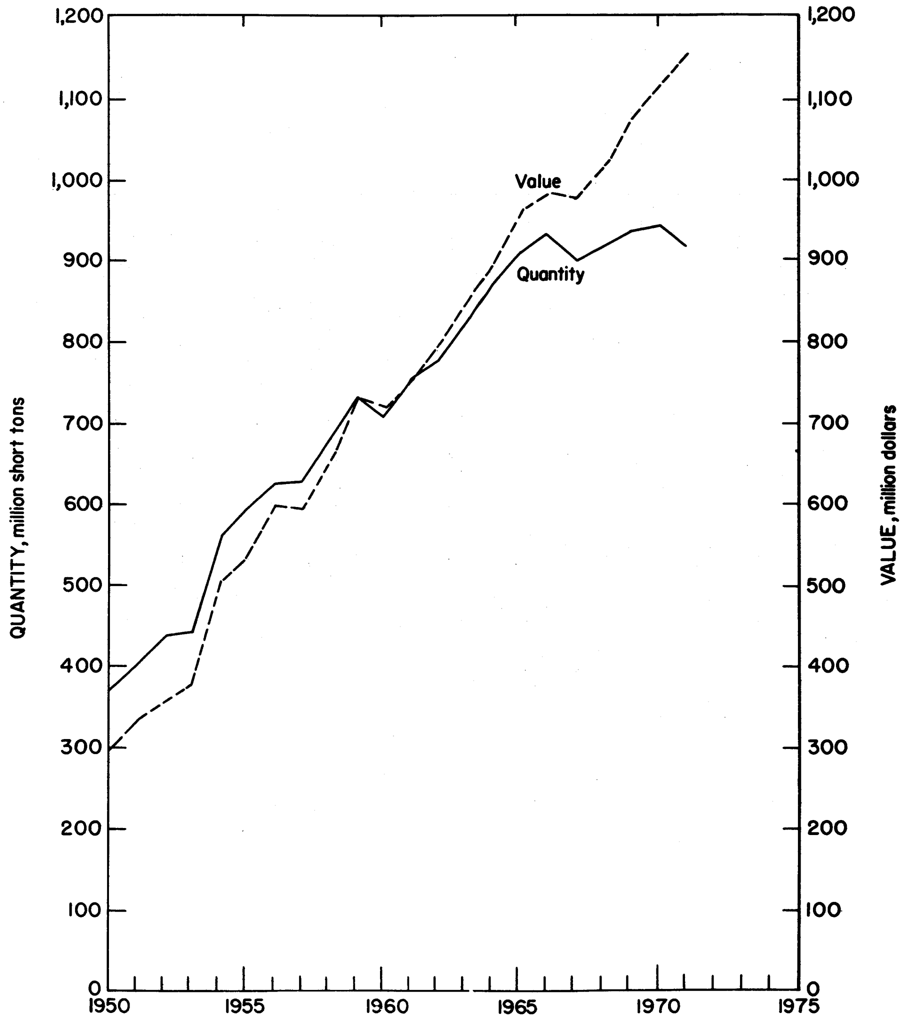

Figure 1.—Production and value of sand and gravel in the United States.

CONSUMPTION AND USES

U.S. consumption of sand and gravel amounted to 920 million tons valued at $1.1 billion in 1971. The construction industry, the prime user of sand and gravel, consumed 96 percent of the tonnage and 91 percent by value of the sand and gravel output in 1971. Of the amount of sand and gravel consumed by the construction industry, 50 percent went into paving, 37 percent into building, about 9 percent into fill, and 4 percent into other uses. The principal consumers of higher priced industrial sands were the glass and foundry industries.

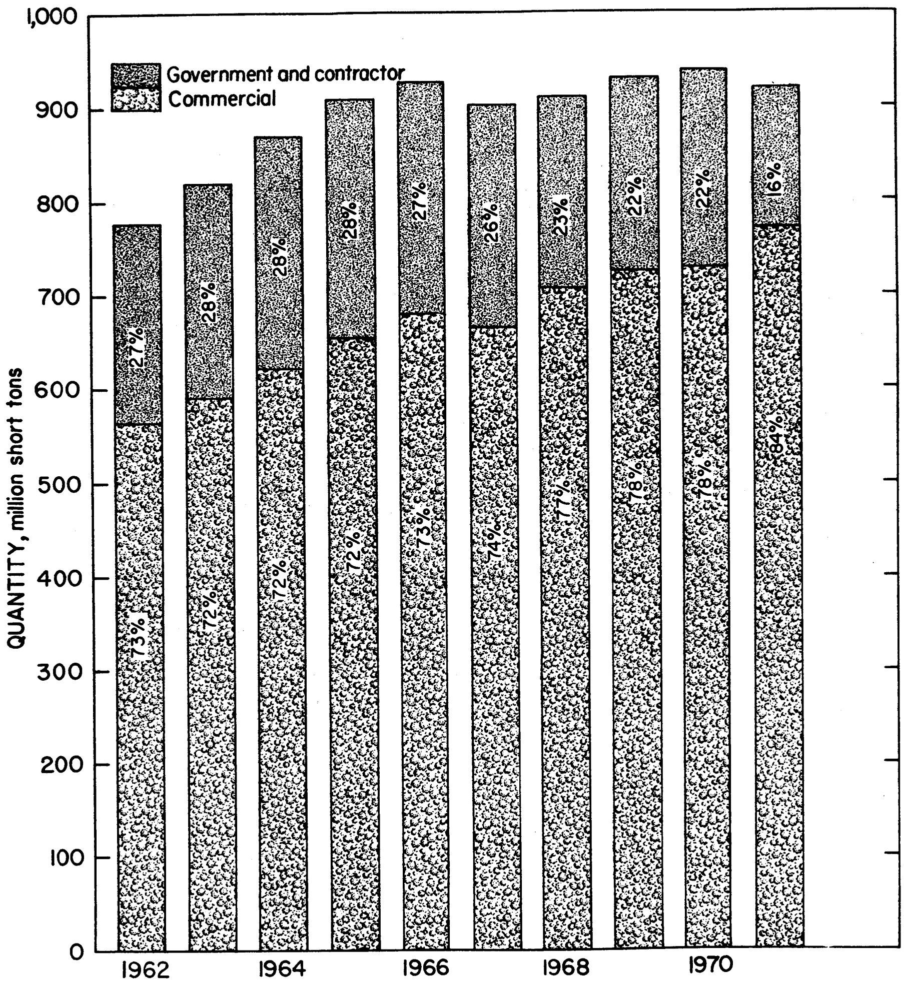

Figure 2.—Sand and gravel sold or used in the United States.

PRICES

Representative carload-lot prices of sand in 20 cities at the end of 1971 ranged from $1.00 per ton in Detroit to $6.25 per ton in Atlanta, according to the Engineering News-Record. The average of the sand prices reported was $3.23 per ton, compared with $3.03 per ton in 1970. Prices for either ¾- or 1½-inch gravel ranged from $1.70 per ton in Cincinnati to $7 per ton in New Orleans. The average of the ¾-inch gravel prices reported for 18 cities was $3.67 per ton, compared with $3.18 per ton in 1970. For 1½-inch gravel, the average for 15 cities was $3.48 per ton, compared with $3.06 per ton in 1970. The average value of sand and gravel sold or used by producers, f.o.b. plant, was $1.25 per ton; the comparable value in 1970 was $1.18 per ton.

The average price of sand in Montreal and Toronto, Canada, at the end of 1971, was $2.90 per ton; ¾-inch gravel was $3.20 per ton, and 1½-inch gravel was $2.60 per ton.

FOREIGN TRADE

Canada received 83 percent of U.S. exports of construction sand, the Bahamas received 12 percent, and Mexico received less than one percent. The remainder went to 28 different countries. Exports of construction sand totaled 328,471 short tons, valued at $903,357. Canada received 89 percent of U.S. exports of common sand and gravel, the Bahamas received 8 percent, and Mexico received 3 percent. Total exports of common sand and gravel were 520,127 short tons, valued at $743,039. Of U.S. exports of industrial sand, which amounted to 879,142 short tons valued at $5,098,570, Canada received 78 percent, Mexico 14 percent, and the Bahamas about 4 percent. The remainder went to 60 different countries.

Most of the crude sand and gravel imported in 1971 was from Canada. Almost all of the imported glass sand was from Australia.

WORLD REVIEW

Austria.—Proposed new legislation to protect water sources from pollution presents problems for the aggregate industry. A complex procedure was proposed in connection with this legislation, including a hydrographic survey and test drill holes for water table fluctuation. Regular chemical and bacteriological analyses were demanded, and regulations stipulated that no dry operation can be opened in areas where underground water must be protected.[5]

Canada.—The Consolidated Sand and Gravel Company has put into operation a new 800-ton-per-hour plant near Stouffville, 30 miles northeast of downtown Toronto. Eventual production of the plant will be 1,000 tons per hour of finished products. It is capable of producing twelve standard sizes of aggregates. Site rehabilitation is an integral part of the operation. Worked-out areas are being graded and reclaimed with top soil.[6]

The aggregate industries, which are among the largest and fastest growing in the primary sector of the Ontario economy, are receiving governmental attention. The government has been involved in regulating the quality of the environment during and after operations. Efforts are being made to increase the understanding of the diverse elements of the sand and gravel industry, to make them more compatible with the environmental aspirations of society.

United Kingdom.—In the United Kingdom there are over 1,000 firms with interests in sand and gravel. Production of sand and gravel in 1971 was about 120 million short tons. Owing to a great deal of integration during the past decade, the industry is dominated by a small number of very large firms. About 43 percent of the aggregate market is held by six leading producers and the first 12 producers hold over one-half. This has resulted in a reduction in the number of workings, and a very large increase in the average production per pit. It is estimated that the annual production of sand and gravel pits increased from 37,200 cubic yards in 1957 to 66,900 cubic yards in 1969. Ready Mixed Concrete Ltd. (R.M.C.) was the largest producer, with an estimated 18 to 19 million tons of sand and gravel per year.[7]

Based on trends in the aggregate industry in United Kingdom, it is predicted that the industry will ultimately be comprised of fewer and larger groups controlling a much greater slice of the industry, because of competition, shortage of reserves, and the necessity to improve the return on capital. Also, aggregate prices will have to be raised to cover increased costs. It is predicted that the optimum size of the majority of operations will be an output of one-half million tons per year, with a few in the 1- to 3-million-tons-per-year bracket. Reserves of aggregate may become critical unless there is a major change in planning policy. Sea-dredging sources are not consid-

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[5] The Quarry Managers' Journal. V. 55, No. 5, May 1971, p. 145.

[6] Rock Products. V. 74, No. 8, August 1971, p. 18.

[7] Industrial Minerals. No. 49, October 1971, pp. 9–23.

ered to be any more inexhaustible than land aggregates. Inferior materials will have to be brought into use. As a result of the exhaustion of reserves either physically or by planning restrictions, the industry will have to transport more than 1 day's round-trip journey from the point of use. Rail transportation will then become a serious competitor to road transportation.[8]

Future aggregate demand is based on anticipated growth in the construction industry. The current estimate is 5 percent growth per year during the next ten years.[9]

TECHNOLOGY

The 55th annual convention of the National Sand and Gravel Association held in San Francisco, Calif., in January, stressed the necessity for increased attention to environmental problems and safety. The program covered topics such as management and operating problems, planned land conservation and reclamation, pollution and noise control, and research and engineering.[10]

Recently, an in-depth study of railroad shipment of construction aggregates was begun by Construction Aggregates Rail Shippers (CARS). CARS, a non-profit association, sponsored by the National Crushed Stone Association, the National Limestone Institute, the National Sand and Gravel Association, and the National Slag Association, awarded the contract for the study to A. T. Kearney & Co., Inc. The study will cover general industry statistics and specific information on aggregate production, marketing, and distribution practices. It will analyze train handlings and elapsed times involved in specific aggregate shipments, with particular attention to possible improvements in aggregate handling by shippers, better equipment utilization, and lower unit costs. The second phase of the report will cover areas for further in-depth investigations of innovative handling techniques and new equipment that could make aggregate rail movements more attractive to both shippers and carriers.[11]

Results of electronic color sorting for the recovery of colorless glass concentrates from mixed glass products were reported in the Bureau of Mines' Technical Progress Report 45. Tests were made using glass recovered from unincinerated (raw) urban refuse and residues resulting from the incineration of refuse. The study showed that a concentrate of 86 percent of colorless glass could be recovered. Recovery of incinerated glass was more difficult. Multiple-stage processing was required to recover colorless glass material.[12]

A 1,000-foot stretch of road in Toledo, Ohio, is the world's first road to include waste glass in all four subsurface layers. It was constructed under the direction of the Ohio Department of Highways. It is anticipated that the surface layer containing glass aggregate will promote highway safety by providing a good level of skid resistance.[13]

In Technical Progress Report 36, the Bureau of Mines announced a method of reclaiming foundry sand. Many foundries use sand mixed with starch-binding medium to make the molds for casting their product. Upon casting, some of the starch which has turned to carbon, adheres to the sand. Each time the sand is formed into a new mold, the contamination builds up until after a few cycles the sand is discarded. Bureau researchers found that by heating the waste sand for 15 minutes at 700 degrees centigrade, they burned off the carbon impurities and restored the sand to molding quality.[14]

In a German patent on the beneficiation of silica sand or heavy mineral sand, the granular material is allowed to fall freely in a laminar stream through a corona which charges the mixed particles electri-

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[8] Carleton, J. E. The Shape of the Industry and Its Trends. The Quarry Managers' J., v. 54, No. 4, April 1971, pp. 143–145.
[9] Work cited in footnote 8.
[10] Trauffer, Walter E. NSGA Convention in San Francisco. Pit and Quarry, v. 63, No. 10, April 1971, pp. 78–81, 83.
[11] Pit and Quarry. News of the Industry. V. 63, No. 9, March 1971, p. 31.
[12] Palumbo, F. J., M. H. Stanczyk, and P. M. Sullivan. Electronic Color Sorting of Glass From Urban Waste. BuMines Tech. Prog. Rept. 45, October 1971, 9 pp.
[13] The Glass Industry, Newsletter. V. 52, No. 11, November 1971, pp. 386.
[14] Barnard, P. G., R. A. Ritchey, and H. Kenworthy. Recovery of Chromite and Silica from Steel Foundry Waste Molding Sands. BuMines Tech. Prog. Rept. 36, August 1971, 21 pp.

cally. The falling particles are passed through an electrostatic field whereby they are differently deflected as a result of the forces associated with their charges.[15]

[15] Schickel, A. (assigned to Deutsche Akademie Der Wissenschaften Zu Berlin Institut fur Aufbereitung). German Pat. 209–127B, Dec. 7, 1971, (U.S. Pat. 3,625,360).

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
1967	358,812	$409,481	547,087	$571,138	905,899	$980,619
1968	369,221	433,088	548,247	587,019	917,468	1,020,107
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

[1] Excludes American Samoa, (1971), and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.

Table 3.—Sand and gravel sold or used by producers in the United States, by State, and class of operation [1]

(Thousand short tons and thousand dollars)

State	1970						1971					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	6,705	$8,076	20	$68	6,725	$8,144	6,655	$7,466	19	$48	6,674	$7,513
Alaska	2,441	3,755	23,384	37,337	25,825	41,092	3,618	4,321	19,999	28,484	23,617	32,806
Arizona	11,272	14,140	6,549	5,664	17,822	19,804	17,210	21,766	2,581	2,624	19,791	24,391
Arkansas	10,639	13,553	2,662	2,484	13,301	16,036	9,850	13,993	1,779	1,611	11,630	15,603
California	103,726	143,459	36,533	30,762	140,259	174,221	104,220	142,279	11,248	15,404	115,468	157,683
Colorado	15,360	17,827	6,902	6,363	22,261	24,190	19,145	24,873	7,854	5,283	27,000	30,155
Connecticut	6,615	9,073	150	129	6,765	9,202	6,566	9,815	355	447	6,921	10,262
Delaware	1,565	1,603	--	--	1,565	1,603	2,205	2,231	--	--	2,205	2,231
Florida	12,182	12,086	300	168	12,482	12,254	22,915	18,666	314	169	23,228	18,836
Georgia	3,667	4,437	--	--	3,667	4,437	3,697	5,310	--	--	3,697	5,310
Hawaii	514	1,679	--	--	514	1,679	836	1,967	--	--	836	1,697
Idaho	4,895	3,911	8,058	6,111	12,953	10,022	4,404	6,421	6,876	5,016	11,279	11,437
Illinois	43,508	59,884	418	271	43,926	60,155	44,827	58,907	536	490	45,364	59,397
Indiana	22,566	25,280	911	516	23,476	25,796	23,689	28,326	1,293	767	24,982	29,094
Iowa	16,333	17,333	4,726	3,309	21,058	20,642	16,954	19,216	1,325	1,314	18,279	20,530
Kansas	10,457	10,619	2,511	1,733	12,968	12,351	10,056	9,991	1,807	1,361	11,862	11,351
Kentucky	8,522	10,373	239	101	8,760	10,474	8,031	11,023	171	37	8,202	11,061
Louisiana	17,746	21,527	410	836	18,155	22,363	18,823	23,861	405	631	19,228	24,492
Maine	3,612	3,299	9,358	3,589	12,971	6,888	3,865	4,210	4,427	1,671	8,292	5,881
Maryland	12,821	20,415	129	19	12,951	20,434	12,730	23,185	112	16	12,842	23,201
Massachusetts	15,305	19,773	2,620	2,472	17,925	22,244	14,938	20,872	2,404	2,186	17,343	23,058
Michigan	45,235	49,768	7,857	4,878	53,092	54,646	51,356	59,047	5,257	3,851	56,613	62,898
Minnesota	37,733	33,172	9,119	5,630	46,851	38,802	35,936	33,113	8,980	4,532	44,916	37,645
Mississippi	10,599	11,738	260	211	10,859	11,950	11,234	13,413	55	114	11,289	13,526
Missouri	12,395	15,327	51	52	12,446	15,379	10,263	15,031	64	78	10,327	15,109
Montana	2,189	2,761	17,086	17,488	19,275	20,249	1,909	2,244	13,872	22,963	15,781	25,207
Nebraska	11,301	12,065	931	910	12,232	12,974	12,575	13,218	649	408	13,224	13,626
Nevada	6,405	8,143	2,169	1,677	8,574	9,819	6,508	10,191	2,871	2,034	9,379	12,225
New Hampshire	5,160	4,458	1,369	295	6,529	4,753	6,174	6,132	2,230	644	8,404	6,777
New Jersey	16,723	31,564	10	8	16,732	31,571	18,505	38,275	7	4	18,511	38,279
New Mexico	5,710	4,993	4,956	5,523	10,666	10,516	7,573	6,374	1,296	1,601	8,869	7,975
New York	26,128	32,759	9,408	6,079	35,537	38,839	21,284	27,678	1,937	650	23,221	28,328
North Carolina	9,089	11,133	3,683	2,143	12,772	13,277	10,191	13,306	4,049	1,385	14,240	14,690
North Dakota	6,950	5,909	1,140	427	8,090	6,336	6,053	5,251	2,144	959	8,196	6,210
Ohio	41,844	57,283	225	223	42,069	57,506	40,539	53,790	259	254	40,797	54,044
Oklahoma	3,878	5,891	1,798	1,367	5,675	7,258	4,864	7,375	849	885	5,713	8,259
Oregon	12,158	15,307	5,375	10,671	17,532	25,978	16,875	23,978	3,355	4,729	20,230	28,707
Pennsylvania	18,504	33,915	--	--	18,504	33,915	19,668	36,162	--	--	19,668	36,162
Rhode Island	2,297	2,801	90	113	2,387	2,913	2,252	3,052	--	--	2,252	3,052
South Carolina	5,864	7,766	--	--	5,864	7,766	6,438	9,119	--	--	6,438	9,119
South Dakota	7,015	6,238	9,541	10,419	16,556	16,656	8,117	8,218	8,610	10,174	16,727	18,392
Tennessee	5,931	9,945	785	694	6,715	10,639	7,242	11,357	776	488	8,018	11,845

Texas	27,464	42,252	3,973	4,110	31,438	46,362	29,607	48,831	3,181	2,983	32,788	51,814
Utah	8,993	8,466	3,017	1,973	12,010	10,439	8,451	8,823	2,054	1,367	10,505	10,190
Vermont	2,986	3,575	1,061	547	4,046	4,122	2,993	3,249	768	268	3,761	3,518
Virginia	11,062	15,207	64	22	11,126	15,229	12,776	20,198	20	3	12,796	20,201
Washington	18,166	23,125	6,923	4,777	25,089	27,902	19,648	24,260	3,054	2,399	22,702	26,658
West Virginia	4,396	11,473	--	--	4,396	11,473	7,107	16,756	--	--	7,107	16,756
Wisconsin	30,529	28,227	10,574	6,880	41,103	35,107	26,703	26,595	11,857	6,153	38,561	32,748
Wyoming	6,338	5,201	4,109	4,096	9,447	9,298	4,307	4,006	5,513	4,744	9,820	8,750
Total [2]	732,493	922,564	211,454	193,145	943,941	1,115,705	772,382	1,007,741	147,212	141,229	919,593	1,148,969
American Samoa	--	--	26	25	26	25	--	--	32	25	32	25
Panama Canal Zone	[e] 60	[e] 97	--	--	[e] 60	[e] 97	--	--	--	--	--	--
Puerto Rico	[e] 9,265	[e] 22,774	[e] 167	[e] 522	[e] 9,432	[e] 23,296	[e] 7,168	[e] 20,227	[e] 124	[e] 381	[e] 7,292	[e] 20,601

[e] Estimated.
[1] Includes American Samoa, Panama Canal Zone (1970), and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.

Table 4.—Sand and gravel sold or used by producers in the United States in 1971, by State, use, and class of operation [1]

(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	1,969	$2,213	8	$21	553	$666	--	--
Alaska	144	321	20	58	83	233	5,749	$8,561
Arizona	6,769	8,438	--	--	1,512	1,281	527	737
Arkansas	1,947	2,752	3	2	2,050	2,122	713	697
California	22,084	31,905	8	20	14,085	17,687	3,393	6,100
Colorado	2,533	3,420	186	191	277	348	431	448
Connecticut	1,983	3,005	--	--	939	1,456	22	18
Delaware	364	520	--	--	261	375	--	--
Florida	8,687	8,764	--	--	1,268	1,272	8	8
Georgia	2,523	2,384	--	--	W	W	--	--
Hawaii	351	1,165	--	--	23	30	--	--
Idaho	591	1,219	--	--	W	W	2,653	2,476
Illinois	7,810	8,330	5	5	8,499	10,199	81	79
Indiana	3,816	3,928	--	--	5,144	5,446	76	58
Iowa	3,021	3,652	--	--	2,929	3,674	327	430
Kansas	3,923	4,098	13	14	3,408	3,314	816	695
Kentucky	3,564	5,027	--	--	1,784	2,303	24	24
Louisiana	5,628	6,104	161	246	1,696	1,934	--	--
Maine	592	594	1	2	670	690	1,472	614
Maryland	4,252	7,170	--	--	1,232	2,412	--	--
Massachusetts	3,145	4,462	--	--	2,316	2,787	644	386
Michigan	8,568	7,952	34	3	6,773	6,610	886	461
Minnesota	4,458	4,075	--	--	5,217	4,256	1,692	1,020
Mississippi	2,595	2,348	--	--	1,719	1,746	25	37
Missouri	3,587	4,095	--	--	1,624	1,576	17	18
Montana	167	272	3	10	61	85	1,133	2,939
Nebraska	2,705	2,543	--	--	1,788	2,058	75	30
Nevada	895	1,448	--	--	W	W	535	498
New Hampshire	1,521	1,843	--	--	428	404	653	227
New Jersey	5,726	8,678	--	--	2,989	3,952	--	--
New Mexico	1,138	1,503	--	--	441	452	91	95
New York	7,829	10,841	--	--	2,731	3,496	19	10
North Carolina	3,912	3,945	4	2	1,893	1,709	2,237	889
North Dakota	555	769	--	--	457	382	126	145
Ohio	6,788	8,595	--	--	7,814	9,620	89	93
Oklahoma	2,158	2,389	408	516	1,508	1,813	267	143
Oregon	1,960	2,594	28	84	535	738	77	77
Pennsylvania	4,651	8,352	--	--	2,678	4,700	--	--
Rhode Island	569	773	--	--	305	414	--	--
South Carolina	2,948	1,889	--	--	1,002	460	--	--
South Dakota	794	983	--	--	564	807	178	185
Tennessee	2,420	3,755	--	--	876	1,658	7	8

Texas	9,017	13,959	159	42	4,157	5,198	417	539
Utah	1,553	1,514	3	7	581	591	103	112
Vermont	480	582	--	--	705	436	491	166
Virginia	4,617	6,816	--	--	2,703	2,641	--	--
Washington	3,093	4,277	382	263	1,746	2,037	210	305
West Virginia	2,124	3,526	--	--	576	984	--	--
Wisconsin	3,479	3,703	7	1	2,766	2,719	1,305	498
Wyoming	228	299	1	2	176	145	2,765	2,220
Undistributed	--	--	--	--	435	785	--	--
Total	176,230	233,789	1,434	1,489	103,977	120,701	30,334	32,046
American Samoa	5	5	--	--	--	--	--	--
Puerto Rico [e]	2,299	6,006	83	234	1,134	3,018	41	146

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes American Samoa and Puerto Rico.

Table 4.—Sand and gravel sold or used by producers in the United States in 1971, by State, use, and class of operation [1]—Continued

(Thousand short tons and thousand dollars)

State	Sand, construction—Continued									
	Railroad ballast (commercial)		Fill				Other [2]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	W	W	--	--	W	W	--	--
Alaska	--	--	W	W	31	$40	W	W	10	$77
Arizona	W	W	766	$434	16	9	45	$61	--	--
Arkansas	--	--	164	122	--	--	W	W	--	--
California	W	W	4,570	3,222	275	49	2,481	3,368	6	6
Colorado	W	W	344	355	25	25	428	596	60	14
Connecticut	--	--	352	331	15	30	283	403	224	318
Delaware	--	--	W	W	--	--	W	W	--	--
Florida	--	--	W	W	304	152	W	W	--	--
Georgia	--	--	48	44	--	--	183	253	--	--
Hawaii	--	--	W	W	--	--	--	--	--	--
Idaho	W	W	50	47	61	50	W	W	7	4
Illinois	W	W	2,398	1,965	--	--	545	583	--	--
Indiana	11	$8	854	618	23	22	220	224	--	--
Iowa	W	W	W	W	--	--	745	1,147	48	54
Kansas	W	W	960	551	33	26	77	107	--	--
Kentucky	W	W	971	873	--	--	--	--	--	--
Louisiana	--	--	4	3	--	--	--	--	--	--
Maine	--	--	412	240	26	6	52	51	35	10
Maryland	--	--	191	118	--	--	W	W	--	--
Massachusetts	--	--	567	255	176	38	516	651	64	100
Michigan	18	27	3,184	1,619	1,091	303	271	268	183	79
Minnesota	93	63	1,240	922	461	155	241	194	56	38
Mississippi	W	W	W	W	--	--	W	W	--	--
Missouri	W	W	275	197	1	1	W	W	--	--
Montana	--	--	14	21	--	--	139	220	8	4
Nebraska	--	--	494	427	--	--	31	27	--	--
Nevada	--	--	195	244	45	32	W	W	1	1
New Hampshire	--	--	W	W	--	--	58	53	--	--
New Jersey	W	W	1,446	1,048	--	--	W	W	2	2
New Mexico	--	--	268	136	28	27	W	W	2	1
New York	W	W	1,383	496	144	17	334	468	365	219
North Carolina	W	W	381	200	572	57	W	W	777	258
North Dakota	--	--	194	160	45	8	13	16	--	--
Ohio	W	W	1,364	1,218	--	--	473	644	--	--
Oklahoma	9	9	271	106	9	9	W	W	7	1
Oregon	W	W	727	569	--	--	42	65	--	--
Pennsylvania	--	--	135	250	--	--	1,475	1,813	--	--
Rhode Island	--	--	W	W	--	--	39	43	--	--
South Carolina	W	W	W	W	--	--	W	W	--	--
South Dakota	--	--	140	65	1	(3)	9	2	--	--
Tennessee	W	W	W	W	--	--	W	W	--	--

Texas	W	W	760	563	1	(3)	W	W	--	--
Utah	--	--	177	89	1	1	--	--	36	1
Vermont	W	W	82	19	--	--	95	100	33	10
Virginia	W	W	425	186	14	1	31	38	2	2
Washington	--	--	752	685	12	2	W	W	81	53
West Virginia	W	W	54	84	--	--	--	--	--	--
Wisconsin	W	W	1,998	1,150	676	85	W	W	290	105
Wyoming	--	--	22	13	--	--	25	25	1	3
Undistributed	1,738	2,117	13,929	6,114	--	--	2,954	5,440	--	--
Total	1,869	2,224	42,561	25,759	4,086	1,145	11,805	16,860	2,298	1,360
American Samoa	--	--	27	20	--	--	--	--	--	--
Puerto Rico [e]	--	--	650	706	--	--	--	--	--	--

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes American Samoa and Puerto Rico.
[2] Includes unspecified.
[3] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1971, by State, use, and class of operation [1]—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)									
	Glass		Molding		Grinding and polishing		Blast		Fire or furnace	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	--	--	W	W	--	--	--	--	--	--
Alaska	--	--	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	(2)	W	--	--
Arkansas	W	W	W	W	--	--	W	W	--	--
California	W	W	(2)	W	--	--	W	W	W	W
Colorado	--	--	--	--	--	--	W	W	--	--
Connecticut	--	--	--	--	--	--	--	--	--	--
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	W	W	--	--	--	--	W	W	--	--
Georgia	W	W	W	W	--	--	W	W	--	--
Hawaii	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	--	--	--	--	--	--	--	--
Illinois	1,382	$4,242	807	$3,036	--	--	95	$318	--	--
Indiana	W	W	--	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	W	W	--	--
Kansas	--	--	--	--	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	11	108	3	$23
Louisiana	--	--	--	--	--	--	W	W	--	--
Maine	--	--	--	--	--	--	--	--	--	--
Maryland	--	--	--	--	--	--	--	--	--	--
Massachusetts	--	--	W	W	--	--	W	W	--	--
Michigan	W	W	3,435	7,063	W	W	W	W	--	--
Minnesota	W	W	W	W	--	--	--	--	--	--
Mississippi	--	--	W	W	--	--	--	--	--	--
Missouri	W	W	W	W	W	W	W	W	W	W
Montana	--	--	--	--	--	--	--	--	--	--
Nebraska	--	--	--	--	--	--	--	--	--	--
Nevada	W	W	W	W	--	--	--	--	--	--
New Hampshire	--	--	--	--	--	--	--	--	W	W
New Jersey	W	W	499	2,493	W	W	128	799	W	W
New Mexico	--	--	--	--	--	--	--	--	--	--
New York	--	--	W	W	--	--	--	--	--	--
North Carolina	--	--	--	--	--	--	--	--	--	--
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	--	--	207	719	(2)	W	W	W	W	W
Oklahoma	W	W	W	W	--	--	W	W	--	--
Oregon	--	--	--	--	--	--	--	--	--	--
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	W	W	W	W	W	W
Texas	W	W	102	351	--	--	W	W	--	--
Utah	--	--	--	--	--	--	W	W	--	--

Vermont	--	--	--	--	--	--	--	--	--	--
Virginia	W	W	W	W	--	--	W	W	W	W
Washington	W	W	--	--	--	--	--	--	--	--
West Virginia	W	W	W	W	W	W	W	W	W	W
Wisconsin	W	W	673	2,058	--	--	W	W	--	--
Wyoming	--	--	--	--	--	--	--	--	--	--
Undistributed	8,301	32,203	1,579	6,043	243	$688	658	4,136	254	657
Total	9,683	36,445	7,302	21,763	243	688	892	5,361	257	680
American Samoa	--	--	--	--	--	--	--	--	--	--
Puerto Rico [e]	--	--	--	--	--	--	--	--	--	--

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes American Samoa and Puerto Rico.

[2] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1971, by State, use, and class of operation [1]—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	193	$193	--	--	--	--	W	W	--	--
Alaska	--	--	--	--	--	--	W	W	--	--
Arizona	--	--	--	--	W	W	--	--	--	--
Arkansas	--	--	--	--	--	--	W	W	W	W
California	46	159	W	W	W	W	1,181	$1,656	205	$1,361
Colorado	W	W	W	W	W	W	W	W	--	--
Connecticut	--	--	--	--	--	--	W	W	W	W
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	W	W	W	W	--	--	W	W	W	W
Georgia	W	W	W	W	--	--	W	W	W	W
Hawaii	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	--	--	--	--	W	W	--	--
Illinois	W	W	--	--	W	W	W	W	70	306
Indiana	W	W	--	--	--	--	--	--	W	W
Iowa	--	--	W	W	--	--	W	W	--	--
Kansas	--	--	--	--	--	--	W	W	--	--
Kentucky	--	--	--	--	--	--	W	W	2	61
Louisiana	--	--	--	--	--	--	--	--	W	W
Maine	W	W	--	--	--	--	W	W	--	--
Maryland	--	--	--	--	--	--	W	W	--	--
Massachusetts	--	--	W	W	--	--	225	312	--	--
Michigan	39	104	--	--	--	--	W	W	105	593
Minnesota	W	W	--	--	W	W	138	102	25	172
Mississippi	--	--	--	--	--	--	--	--	--	--
Missouri	W	W	W	W	--	--	W	W	W	W
Montana	--	--	--	--	--	--	13	W	--	--
Nebraska	--	--	--	--	--	--	W	W	--	--
Nevada	--	--	--	--	--	--	W	W	W	W
New Hampshire	--	--	--	--	--	--	W	W	--	--
New Jersey	16	47	W	W	--	--	W	W	585	3,010
New Mexico	--	--	--	--	--	--	W	W	--	--
New York	--	W	W	W	--	--	18	27	W	W
North Carolina	W	--	--	--	--	--	W	W	--	--
North Dakota	W	--	--	--	--	--	--	--	--	--
Ohio	--	W	W	W	--	--	W	W	58	162
Oklahoma	--	--	--	--	W	W	W	W	76	714
Oregon	W	W	--	--	--	--	W	W	--	--
Pennsylvania	W	W	W	W	W	W	726	1,237	61	671
Rhode Island	--	--	--	--	--	--	W	W	--	--
South Carolina	W	W	W	W	--	--	W	W	W	W
South Dakota	--	--	--	--	--	--	--	--	--	--
Tennessee	W	W	--	--	--	--	--	--	--	--
Texas	(2)	W	W	W	W	W	W	W	100	W
Utah	W	W	--	--	--	--	--	--	W	W

Vermont	W	W	--	--	--	--	--	--	--	--
Virginia	W	W	(2)	W	--	--	W	W	W	W
Washington	--	--	--	--	--	--	--	--	--	--
West Virginia	W	W	(2)	W	--	--	W	W	W	W
Wisconsin	W	W	W	W	W	W	W	W	--	--
Wyoming	--	--	--	--	--	--	--	--	--	--
Undistributed	414	1,182	200	$612	302	$1,883	2,363	6,031	624	5,843
Total	708	1,685	200	612	302	1,883	4,664	9,365	1,911	12,893
American Samoa	--	--	--	--	--	--	--	--	--	--
Puerto Rico [e]	--	--	--	--	--	--	--	--	--	--

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes American Samoa and Puerto Rico.
[2] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1971, by State, use, and class of operation [1]—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	1,427	$2,193	11	$27	1,158	$1,243	--	--
Alaska	147	299	7	7	575	996	13,543	$19,216
Arizona	4,319	6,450	37	36	2,770	3,737	1,102	1,441
Arkansas	1,862	3,809	--	--	2,837	3,254	1,058	911
California	24,922	35,505	4	18	28,497	36,983	7,235	9,139
Colorado	4,270	7,076	165	228	9,375	10,515	4,738	3,853
Connecticut	1,178	1,991	--	--	976	1,742	43	43
Delaware	106	183	--	--	1,041	860	--	--
Florida	W	W	--	--	W	W	2	10
Georgia	12	24	--	--	--	--	--	--
Hawaii	441	720	--	--	9	26	--	--
Idaho	1,452	1,786	136	105	1,726	2,641	3,222	1,991
Illinois	7,642	9,081	16	21	13,377	18,229	408	349
Indiana	3,843	5,227	205	161	7,666	9,782	854	431
Iowa	1,384	2,463	1	2	6,557	5,996	798	733
Kansas	179	293	105	60	1,094	1,160	765	518
Kentucky	820	1,271	--	--	782	1,197	145	13
Louisiana	7,448	10,157	244	386	3,846	5,205	--	--
Maine	575	710	23	20	960	1,341	2,836	1,010
Maryland	3,402	6,713	--	--	986	1,588	112	16
Massachusetts	3,258	5,883	74	184	2,735	3,555	1,428	1,458
Michigan	6,359	10,596	163	145	19,103	19,098	2,650	2,768
Minnesota	4,502	6,324	679	387	15,907	13,700	5,862	2,841
Mississippi	2,729	3,516	--	--	3,910	5,330	31	77
Missouri	1,853	2,659	--	--	1,372	1,414	40	55
Montana	279	397	40	40	823	729	12,364	19,793
Nebraska	995	1,043	36	4	5,862	6,462	447	243
Nevada	1,172	1,920	36	71	1,934	2,620	2,241	1,421
New Hampshire	805	1,373	--	--	565	805	1,578	417
New Jersey	1,977	4,341	--	--	941	1,793	--	--
New Mexico	1,592	2,249	--	--	3,616	1,778	769	1,253
New York	4,089	6,450	45	51	3,156	3,603	801	255
North Carolina	1,438	3,016	--	--	1,748	2,537	460	178
North Dakota	1,159	1,363	286	39	3,266	2,244	1,579	748
Ohio	7,065	10,007	3	5	13,802	19,047	162	154
Oklahoma	62	93	115	201	102	279	44	15
Oregon	4,802	6,716	148	224	7,113	11,523	3,001	4,268
Pennsylvania	4,330	6,874	--	--	2,994	6,141	--	--
Rhode Island	595	924	--	--	356	483	--	--
South Carolina	W	W	--	--	W	W	--	--
South Dakota	329	461	26	24	5,031	5,102	8,220	9,834
Tennessee	1,498	2,175	--	--	1,444	1,457	727	438

Texas	8,207	14,396	63	82	4,937	8,146	2,379	2,200
Utah	1,729	1,471	50	35	4,069	4,928	1,033	904
Vermont	909	1,424	--	--	497	573	222	82
Virginia	3,242	6,874	--	--	882	1,535	--	--
Washington	3,990	5,412	36	61	7,676	9,663	2,028	1,607
West Virginia	1,505	2,685	--	--	W	W	--	--
Wisconsin	4,067	4,442	78	26	11,506	10,610	8,826	5,234
Wyoming	332	424	25	17	2,810	2,669	2,700	2,493
Undistributed	2,046	3,920	--	--	2,625	4,549	--	--
Total	142,344	215,379	2,857	2,667	215,014	258,868	96,453	98,410
American Samoa	--	--	--	--	--	--	--	--
Puerto Rico [e]	1,991	7,207	--	--	840	2,971	--	--

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes American Samoa and Puerto Rico.

Table 4.—Sand and gravel sold or used by producers in the United States in 1971, by State, use, and class of operation [1]—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction—Continued										Gravel Miscellaneous (commercial)	
	Railroad Ballast (commercial)		Fill				Other					
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	--	--	W	W	--	--	W	W	--	--	91	$108
Alaska	--	--	1,791	$722	533	$486	W	W	106	$41	W	W
Arizona	W	W	729	610	791	278	60	$96	108	124	W	W
Arkansas	W	W	22	27	--	--	W	W	5	1	332	371
California	276	$246	1,839	1,242	325	68	2,461	3,082	2	5	525	758
Colorado	90	129	427	407	1,700	448	789	1,046	551	79	562	677
Connecticut	--	--	417	221	51	38	188	270	--	--	107	164
Delaware	--	--	W	W	--	--	--	--	--	--	--	--
Florida	W	W	--	--	--	--	--	--	--	--	W	W
Georgia	--	--	--	--	--	--	61	126	--	--	W	W
Hawaii	--	--	W	W	--	--	--	--	--	--	--	--
Idaho	W	W	211	108	673	254	W	W	126	135	35	46
Illinois	W	W	1,255	1,068	27	37	359	406	--	--	360	364
Indiana	26	31	1,182	935	73	32	308	346	60	62	298	286
Iowa	W	W	W	W	8	1	812	741	143	93	93	152
Kansas	10	11	76	75	38	39	18	25	37	10	207	247
Kentucky	--	--	18	20	2	1	W	W	--	--	W	W
Louisiana	--	--	--	--	--	--	(2)	W	--	--	W	W
Maine	W	W	161	108	34	10	126	87	--	--	279	358
Maryland	--	--	1,090	1,115	--	--	W	W	--	--	W	W
Massachusetts	W	W	1,275	947	16	16	227	434	2	5	520	660
Michigan	19	35	463	263	248	92	799	624	1	(2)	1,206	1,476
Minnesota	201	194	2,392	706	204	89	982	1,060	25	2	186	190
Mississippi	--	--	W	W	--	--	W	W	--	--	W	W
Missouri	--	--	39	21	1	1	W	W	6	4	89	88
Montana	W	W	125	114	198	97	201	278	126	80	W	W
Nebraska	W	W	162	138	--	--	225	225	90	131	W	W
Nevada	--	--	1,483	1,297	11	6	W	W	2	4	W	W
New Hampshire	W	W	927	628	--	--	W	W	--	--	362	292
New Jersey	8	20	1,461	2,076	2	1	78	105	3	1	219	530
New Mexico	--	--	345	65	373	191	W	W	34	33	W	W
New York	--	--	912	771	386	76	183	266	177	22	440	413
North Carolina	W	W	42	50	--	--	553	1,582	--	--	W	W
North Dakota	W	W	154	149	99	20	W	W	8	1	47	39
Ohio	W	W	1,485	1,206	5	1	570	748	--	--	664	1,027
Oklahoma	--	--	W	W	--	--	(2)	W	--	--	5	6
Oregon	W	W	969	896	100	77	246	195	--	--	360	538
Pennsylvania	--	--	768	1,001	--	--	W	W	--	--	W	W
Rhode Island	W	W	W	W	--	--	--	--	--	--	W	W
South Carolina	--	--	W	W	--	--	W	W	--	--	--	--
South Dakota	W	W	459	252	62	8	109	30	122	122	W	W
Tennessee	W	W	50	58	42	42	W	W	--	--	111	113
Texas	--	--	231	87	130	106	501	868	31	14	64	144

Utah	W	W	255	119	787	269	W	W	41	38	W	W
Vermont	W	W	191	64	23	11	W	W	--	--	W	W
Virginia	W	W	W	W	5	(2)	W	W	--	--	W	W
Washington	322	240	1,911	1,323	291	106	82	96	15	1	15	23
West Virginia	W	W	50	76	--	--	--	--	--	--	--	--
Wisconsin	W	W	1,238	700	466	71	W	W	210	133	231	208
Wyoming	W	W	60	40	19	9	W	W	2	2	207	48
Undistributed	1,395	1,664	705	696	--	--	2,619	4,392	--	--	2,527	3,356
Total	2,347	2,570	27,370	20,401	7,723	2,981	12,557	17,128	2,033	1,143	10,142	12,682
American Samoa	--	--	--	--	--	--	--	--	--	--	--	--
Puerto Rico [e]	--	--	255	319	--	--	--	--	--	--	--	--

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes American Samoa and Puerto Rico.

[2] Less than ½ unit.

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		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1967	660	$800	38,497	$31,512	11,747	$8,737	2,738	$1,836
1968	819	893	35,550	27,297	7,327	3,997	2,615	1,920
1969	1,016	1,320	32,123	28,317	6,123	3,745	2,168	1,014
1970	883	1,058	43,130	41,965	5,234	2,195	1,632	834
1971	1,434	1,489	30,334	32,046	4,086	1,145	2,298	1,360

Year	Gravel								Total Government-and-contractor sand and gravel [2]	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1967	863	$1,074	153,274	$132,734	26,145	$21,500	4,374	$4,062	238,298	$202,233
1968	1,830	1,841	121,893	103,803	32,837	27,679	3,934	3,972	206,805	171,327
1969	1,976	2,522	133,127	116,774	28,240	19,481	1,423	890	206,189	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

[1] Excludes American Samoa, Panama Panama 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	1967		1968		1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	68,655	$44,903	62,939	$42,146	65,786	$45,691	67,238	$39,446	58,820	$30,428
Contractor	169,643	157,330	143,866	129,176	140,403	128,377	144,214	153,699	88,395	110,800
Total [2]	238,298	202,233	206,805	171,327	206,189	174,070	211,454	193,145	147,212	141,229
State	148,697	134,243	125,627	108,980	122,484	108,414	136,800	134,482	79,213	85,347
County	60,004	41,390	53,087	38,408	52,547	39,429	58,180	37,159	56,175	38,176
Municipalities	3,001	2,202	4,200	3,208	3,784	4,466	3,285	3,125	2,266	2,013
Federal agencies	26,596	24,398	23,891	20,731	27,374	21,761	13,189	18,379	9,558	15,693
Total	238,298	202,233	206,805	171,327	206,189	174,070	211,454	193,145	147,212	141,229

[1] Excludes American Samoa, Panama 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]

(Thousand short tons and thousand dollars)

	1970		1971	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	680,319	$887,792	712,627	$963,180
Unprepared	52,167	34,794	59,760	44,564
Total [2]	732,493	922,564	772,382	1,007,741
Government-and-contractor operations:				
Prepared	184,120	177,976	135,791	135,825
Unprepared	27,333	15,164	11,418	5,400
Total [2]	211,454	193,145	147,212	141,229
Grand Total [2]	943,941	1,115,705	919,593	1,148,969

[1] Excludes American Samoa, Panama Canal Zone (1970), and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.

Table 8.—Number and production of domestic commercial sand and gravel plants, by size of operation [1]

Annual production (short tons)	1970 Plants [2] Number	1970 Plants [2] Percent of total	1970 Production Thousand short tons	1970 Production Percent of total	1971 Plants [2] Number	1971 Plants [2] Percent of total	1971 Production Thousand short tons	1971 Production Percent of total
Less than 25,000	2,042	34.5	22,133	3.0	1,835	32.0	21,049	2.7
25,000 to 50,000	1,016	17.2	36,929	5.1	949	16.5	37,244	4.8
50,000 to 100,000	1,020	17.2	75,971	10.4	984	17.1	74,015	9.6
100,000 to 200,000	856	14.5	124,013	16.9	908	15.8	132,900	17.2
200,000 to 300,000	371	6.3	92,858	12.7	415	7.2	101,406	13.1
300,000 to 400,000	216	3.6	75,000	10.2	240	4.2	85,153	11.0
400,000 to 500,000	130	2.2	58,271	8.0	112	2.1	50,349	6.5
500,000 to 600,000	62	1.0	34,707	4.7	76	1.3	42,083	5.4
600,000 to 700,000	51	.9	32,984	4.5	59	1.0	39,778	5.2
700,000 to 800,000	31	.5	23,240	3.2	36	.6	26,877	3.5
800,000 to 900,000	30	.5	25,773	3.5	33	.6	28,057	3.6
900,000 to 1,000,000	24	.4	23,741	3.2	21	.4	19,960	2.6
1,000,000 and over	69	1.2	106,873	14.6	70	1.2	113,511	14.8
Total	[3] 5,918	100.0	732,493	100.0	[3] 5,738	100.0	772,382	100.0

[1] Excludes American Samoa, Panama Canal Zone (1970), and Puerto Rico.
[2] Includes a few companies operating more than one plant but not submitting returns for individual plants.
[3] Not comparable to previous years.

Table 9.—Sand and gravel sold or used in the United States, by class of operation and method of transportation [1]

	1970 Thousand short tons	1970 Percent of total	1971 Thousand short tons	1971 Percent of total
Commercial:				
Truck	643,853	68	699,339	76
Rail	52,034	6	43,286	4
Waterway	30,638	3	27,298	3
Unspecified	5,957	1	2,461	1
Total commercial [2]	732,493	78	772,382	84
Government-and-contractor: Truck [3]	211,454	22	147,212	16
Grand total [2]	943,941	100	919,593	100

[1] Excludes American Samoa, Panama Canal Zone (1970), and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[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	1970 Quantity	1970 Value	1971 Quantity	1971 Value
Abrasives	260	$2,196	171	$1,706
Chemicals	77	651	26	220
Enamel	45	450	36	342
Filler	152	1,281	170	1,411
Foundry uses	206	1,485	709	3,710
Glass	349	2,080	346	1,257
Pottery, porcelain, and tile	261	3,168	187	1,958
Unspecified	861	3,912	268	2,291
Total [3]	2,211	15,226	1,911	12,893

[1] Arkansas, Connecticut (1971), Florida, Georgia, Illinois, Indiana, Kansas (1970), Kentucky, Louisiana Maryland (1970), Michigan, Minnesota, Missouri, Nevada, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee (1970), Texas, Utah, Virginia, Washington (1970), West Virginia, and Wisconsin (1970).
[2] Excludes American Samoa, Panama Canal Zone (1970), and Puerto Rico.
[3] Data may not add to totals 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
1969	43	$194	855	$1,253	898	$1,447
1970	64	262	815	1,338	879	1,600
1971	48	243	667	984	715	1,227

[1] Classification reads: "Sands containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."

Silicon

By E. Shekarchi [1]

The output of ferrosilicon and silicon metal in 1971 declined for the first time since 1960, partly because of a depressed steel market and partly because of the price differential in favor of imports. Consequently, imports outweighed exports by a large margin. A noticeable increase in production of specialty alloys, particularly rare earth silicide, was observed. With the introduction of the new 3-inch wafers of high-purity and ultra-high-purity metals, the demand of device manufacturing was met.

DOMESTIC PRODUCTION

Overall domestic production of ferrosilicon, paralleling steel production, was lower in 1971 than in the previous year. Silicon metal for metallurgical uses was produced in 25 plants of 12 companies as shown in table 2.

Molybdenum Corp. of America, a leader in the rare earths industry, produces a rare earth silicide containing 30 to 35 percent silicon, 30 to 35 percent iron, and 30 to 35 percent rare earths including cerium, lanthanum, neodymium, praseodymium, and others. Union Carbide Corp., Foote Mineral Co., and Ohio Ferro-Alloys were reportedly also producing rare earth silicides.

Semiconductor materials, principally single-crystal ingots, some of which were as large as 4 inches in diameter, were being produced by Monsanto Chemical Co. Alabama Metallurgical Corp. (ALMET), a subsidiary of Leckenby of Seattle, Wash., with plants located along the Alabama River at Selma, Ala., expanded its production. To permit shipment of ferrosilicon directly to customers, ALMET also improved existing dock facilities.

Dow Corning, since entering the semiconductor market with high-purity silicon, has expanded and improved its line of products from hyperpure silicon to silicon tetrachloride and silicon carbide coating in electronic units. In 1971 Dow Corning remained one of the world's largest producers of polycrystalline silicon.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1971 [1]

(Short tons, gross weight)

Alloy	Silicon content (percent)	Producers' stocks as of Dec. 31, 1970[r]	Production	Shipments	Producers' stocks as of Dec. 31, 1971
Silvery pig iron	5-24	W	W	W	W
Ferrosilicon (includes briquets)	25-55	62,962	399,573	336,442	66,135
Do	56-70	9,491	54,912	49,289	12,316
Do	71-80	22,758	96,401	93,251	27,824
Do	81-95	1,602	11,086	9,171	2,179
Silicon metal (excludes semiconductor grades)	96-99	6,089	107,407	88,268	13,055
Miscellaneous silicon alloys (exclusive of silicomanganese)	--	8,706	52,747	46,359	10,136
Other silicon alloys and products	--	2,890	7,495	7,333	2,622

[r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Excludes ferrosilicon used to make other silicon alloys.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1971

Producers	Plant location	Product
Air Reduction Co. Inc., Airco Alloys and Carbide Division.	Calvert City, Ky	FeSi.
Do	Charleston, S.C	Do.
Do	Mobile, Ala	Do.
Do	Niagara Falls, N.Y	FeSi, Si, Silvery iron.
Alabama Metallurgical Corp	Selma, Ala	FeSi.
Chromium Mining and Smelting Corp	Woodstock, Tenn	Do.
Foote Mineral Co	Graham, W.Va	FeSi, Si.
Do	Keokuk, Iowa	Silvery iron.
Do	Vancoram, Ohio	FeSi.
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	Si.
Do	Tacoma, Wash	FeSi, Si.
Reynolds Metal Co	Sheffield, Ala	Si.
Union Carbide Corp., Ferro Alloys 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.

CONSUMPTION AND USES

Silicones, giant molecules of silicon and oxygen atoms with organic side groups such as methyl, phenyl, or vinyl attached to the silicons, have evolved from research curiosities into the basis of a major global business. Silicone insulation was used in almost every type of electrical and electronic equipment. Millions of transistors and other electronic devices were molded into silicone resins, which provide outstanding environmental protection.

The semiconductor industry expects to have 3-inch single crystals of silicon available in 1972, which will partially replace the 2- and 2¼-inch crystals currently in use. This advance is well timed, for industry sources are expecting that the free world's electronic market will probably top

Table 3.—Consumption by major end uses and stocks of silicon alloys and metal in the United States in 1971

(Short tons)

	Silvery pig iron	Ferrosilicon [1]				Silicon metal	Miscellaneous silicon alloys [2]
		Silicon content (percent)					
	5–24	25–55	56–70	71–80	81–95	96–99	
Steel:							
Carbon	2,758	92,993	W	16,043	W	W	16,233
Stainless and heat resisting	--	13,027	133	4,718	127	73	380
Alloy (excludes stainless and heat-resisting)	2,999	41,091	1,869	25,104	1,341	975	3,259
Tool	--	2,835	W	471	W	W	W
Cast irons	137,434	179,141	W	22,785	5,801	W	60,460
Superalloys	--	220	W	W	W	112	W
Alloys (excludes alloy steels and superalloys)	W	3,128	--	205	W	43,130	8,370
Miscellaneous and unspecified	5,261	19,533	27,101	684	10,164	19,350	1,287
Total	148,452	351,968	29,103	70,010	17,433	63,640	89,989
Consumer stocks December 31, 1971	76,373	24,103	3,829	4,914	2,025	4,698	8,972

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."
[1] Includes briquets.
[2] Includes magnesium-ferrosilicon and other silicon alloys.

$80 billion by the end of the decade. The 3-inch crystals yield 250 percent more chips than 2-inch crystals. Semiconductor devices were used increasingly in military and industrial applications. Almost every week new products employing the latest advances in electronic device technology appear on the market. Examples are wristwatches that tell time with liquid crystal readout devices or light-cutting diodes, pocket calculators, and display and memories for computers.

Unquestionably, silicon steels are the most important soft magnetic materials in use today. The applications of magnetic steel ranged from a few ounces of ultrathin metallic ribbon in electronic relays and pulse transformers to many tons of large laminations in the heart of large generators. The Bureau of Mines does not collect statistical information on magnetic steel at the present time.

PRICES

The increased price, announced in December 1970, took effect in mid-January 1971 and remained virtually unchanged during the year. The quoted base price for 50 percent ferrosilicon in carload lots, bulk, delivered, was 16 cents per pound of contained silicon. Metallurgical-grade silicon, 98 percent minimum silicon, 0.35 percent maximum iron, was quoted at 25.4 cents per pound at yearend.

The Government 90-day price freeze, that began in August 1971, had no effect on ferrosilicon prices because ferroalloy prices are adjusted on a quarterly basis and are established about 15 days prior to the start of the quarter.

FOREIGN TRADE

Foreign trade in ferrosilicon continued to be active. Exports of ferrosilicon dropped 43 percent, with a net value loss of over $6 million. The main importers of U.S. ferrosilicon were Brazil, 9,462 short tons, followed by India and Canada, 5,056 and 5,045 short tons, respectively. Imports of ferrosilicon for consumption increased 9 percent over those of 1970. Canada, Japan, and Sweden were the main source of imports with a total of 13,641 short tons, while 11 other producing nations supplied the remaining imports.

Table 4.—U.S. exports of ferrosilicon

Year	Short tons	Value (thousands)
1969	6,487	$1,666
1970	44,694	11,887
1971	25,506	5,603

Table 5.—U.S. imports for consumption of ferrosilicon, by grades and countries

Grade and country	1969			1970			1971		
	Short tons		Value (thousands)	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
Over 8 percent but not over 60 percent silicon:									
Canada	15,344	4,515	$1,074	9,450	1,738	$652	6,039	987	$419
France	612	294	181	1,395	670	473	1,388	624	492
Germany, West	77	39	22	402	200	119	276	127	75
Italy	31	15	11	80	38	21	--	--	--
Japan	3,534	1,683	850	2,035	958	595	3,587	1,687	1,111
Norway	3	1	([1])	59	26	18	685	304	213
South Africa, Republic of	64	32	3	--	--	--	--	--	--
Total	19,665	6,579	2,141	13,421	3,630	1,878	11,975	3,729	2,310
Over 60 percent but not over 80 percent silicon:									
Canada	1,379	1,067	261	4,722	3,648	908	791	603	215
China, Republic of (Taiwan)	--	--	--	--	--	--	28	20	7
Denmark	--	--	--	--	--	--	44	26	17
France	2,465	1,624	676	2,676	1,634	1,010	2,836	1,744	1,129
Germany:									
East	--	--	--	28	21	10	--	--	--
West	404	248	120	405	248	128	444	270	162
India	1,925	1,444	269	--	--	--	--	--	--
Japan	661	529	130	--	--	--	50	38	10
Norway	3,471	2,645	453	620	464	92	2,569	1,919	736
South Africa, Republic of	1,410	1,095	203	433	330	69	318	246	63
Sweden	--	--	--	--	--	--	3,114	2,307	541
Yugoslavia	2,101	1,599	295	--	--	--	2,224	1,718	776
Total	13,816	10,251	2,407	8,884	6,345	2,217	12,418	8,891	3,656
Over 80 percent but not over 90 percent silicon:									
Canada	--	--	--	--	--	--	60	51	18
Italy	20	17	4	--	--	--	--	--	--
South Africa, Republic of	113	97	25	99	85	22	14	12	3
Total	133	114	29	99	85	22	74	63	21
Grand total	33,614	16,944	4,577	22,404	10,060	4,117	24,467	12,683	5,987

[1] Less than ½ unit.

WORLD REVIEW

Australia.—Marrangaroon quartzite of New South Wales, a high-silica quartzite containing only 0.2 percent aluminum, met most of the Australian ferrosilicon industry's raw material needs in 1971. Although the Australian ferroalloy industry has adopted rotating furnaces to obtain optimum smelting conditions with minimum air pollution, fixed furnaces are still used to produce ferrosilicon. Consumption of ferrosilicon in Australia in 1971 was approximately 13,000 short tons.

India.—India's estimated demand for ferrosilicon in the 1973-74 fiscal year will be 29,700 short tons. The present combined capacity of its two major domestic producers, Mysore Iron and Steel, Ltd. and Indian Metals and Ferroalloys, Ltd., is 18,700 short tons per year. During 1970–71, production fell far short of demand and India had to import 19,200 short tons of ferrosilicon on an emergency basis. It is estimated by India's steel industry that its demand for ferrosilicon by 1980 will increase to 45,200 short tons annually.

Italy.—A new plant for the production of 148,800 short tons per year of silicon metal, ferrosilicon, and ferrochrome will come into production in Sicily in 1975. No detailed information on financing of the plant or equities were available by yearend.

South Africa, Republic of.—Export and production of ferrosilicon in South Africa has been steadily declining since the peak years around 1964. In 1971 the country remained self-sufficient except for some special high-purity silicon metal grades.

Heavy Media Materials, Ltd. (HYMAT), which was organized in 1968, went into full production in 1971. The plant has a capacity of 5,500 short tons annually and produces atomized, spheroidized, and milled ferrosilicon. Major share holders in HYMAT are African Metals Corp., Ltd. (AMCOR), 52 percent; the South African Iron and Steel Industrial Corp. (ISCOR), 22 percent; and Farbwerke Hoechst A.G., 26 percent. In 1971 Rand Carbide, Ltd., expanded its ferrosilicon operation to 27,600 short tons annually. Of the 27,600 short tons, about 40 percent is slated for export.

Silver

By J. R. Welch[1]

Domestic mine output of silver decreased 10 percent below the 1970 level, primarily because of strikes in the copper industry, but also because of low prices. Total mine production in 1971 was 41.6 million ounces. Silver prices varied, but with the exception of a rally in April when the price increased to 175.20 cents per ounce, a downward trend developed and continued until November 3 when prices reached a low of 128.80 cents. The year finished out with a modest increase in prices, which at year-end reached 138.00 cents per ounce.

U.S. silver consumption for industrial use showed a slight increase over 1970, and silver coinage use increased to 2.5 million ounces owing to the production of the Eisenhower 40-percent silver dollar. Treasury stocks nearly doubled, to 48.0 million ounces, and industrial stocks declined from 82.2 million ounces on December 31, 1970, to 56.2 million ounces on December 31, 1971. Trading activity on the New York Commodity Exchange declined 11 percent. Net imports increased by 11.1 million ounces compared with 1970.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient silver statistics

	1967	1968	1969	1970	1971
United States:					
Mine production thousand troy ounces	32,345	32,729	41,906	r 45,006	41,564
Value thousands	$50,135	$70,191	$75,040	r $79,697	$64,258
Ore (dry and siliceous) produced:					
Gold ore thousand short tons	2,315	2,003	2,002	2,092	1,883
Gold-silver ore do	157	199	216	104	167
Silver ore do	904	701	755	674	673
Percentage derived from—					
Dry and siliceous ores	39	39	36	33	37
Base-metal ores	61	61	64	67	63
Refinery production [1] thousand troy ounces	30,268	r 37,199	r 43,769	r 49,451	37,242
Exports [2] do	70,769	125,761	88,909	27,614	12,224
Imports, general [2] do	55,520	70,709	71,876	62,300	57,962
Stocks Dec. 31:					
Treasury [3] million troy ounces	351	256	104	25	48
Industry [4] thousand troy ounces	83,358	166,356	198,790	210,150	184,670
Consumption:					
Industry and the arts do	171,031	145,293	141,544	128,404	129,146
Coinage do	43,851	36,833	19,407	709	2,474
Price [5] per troy ounce	$1.550+	$2.144+	$1.790+	$1.771−	$1.542−
World:					
Production thousand troy ounces	258,203	275,264	r 295,718	r 303,897	294,709
Consumption: [6]					
Industry and the arts do	346,800	349,600	364,400	357,600	358,000
Coinage do	105,300	89,300	55,700	40,300	19,000

r Revised.
[1] From domestic ores.
[2] Excludes coinage.
[3] Excludes silver in silver dollars.
[4] Includes silver in COMEX warehouses and silver registered to Chicago Board of Trade.
[5] Average New York price.
[6] Free world only.
Source: Handy & Harman.

Total industrial consumption was about the same in 1971 as in 1970. However, use of silver in electrical and electronic products increased 7 percent, use in sterling ware increased 19 percent, and use in commemorative coins and medals increased 17 percent. The main losers were photography, jewelry, and brazing alloys and solders.

Legislation and Government Programs.—There was no legislation pertaining to silver enacted during 1971. Legislation passed on December 31, 1970, provided for minting 150 million 40-percent silver, clad Eisenhower dollars during 1971–75 to be sold at premium prices of $10 for proof coins and $3 for others. The act, Public Law 91–607, also provided for minting cupronickel Eisenhower dollars and Kennedy half-dollars for general circulation. The new coins were made available in 1971. The General Services Administration (GSA) administrator was directed to transfer to the Secretary of the Treasury 25.5 million ounces of silver from the national stockpile, thereby reducing the stockpile to 139.5 million ounces.

In 1971 the Office of Minerals Exploration (OME) of the U.S. Geological Survey negotiated two contracts involving silver totaling $86,300. One of the prospects is located in Park County, Colo., and the other is located in Elko County, Nev. OME also received 10 applications involving silver for assistance under its program, as follows: one in Colorado, one in New Mexico, two in California, one in Pennsylvania, two in Utah, and three in Montana. Silver remains one of the minerals eligible for Government financial assistance of 75 percent of the allowable costs of exploration.

DOMESTIC PRODUCTION

Output of recoverable silver from mines in the United States decreased 3.4 million ounces below that of 1970. Production losses were recorded in Arizona, Montana, and Utah, primarily owing to the copper strike which began July 1 at major byproduct silver producers. Idaho's production was about the same as in 1970 and amounted to 46 percent of the U.S. production. Output of silver in Arizona, Montana, Utah, Colorado, and Idaho combined amounted to 88 percent of the domestic production.

The 25 leading silver producers contributed 84 percent of the total output. Four of the leading producers (1st, 2d, 5th, and 8th) were mining silver ores alone; all the rest were base metal producers. Nine mines produced over 1 million ounces of silver each, and their combined output equaled 61 percent of the total domestic production. Domestic mine output provided about 32 percent of the silver consumed by industry and the arts in the United States.

The Sunshine mine of the Sunshine Mining Co. in Idaho's Coeur d'Alene region led national production with 7,059,132 troy ounces, about 17 percent of the total domestic output for 1971.

In 1971 Hecla Mining Co. of Wallace, Idaho, provided about 15 percent of domestic output and increased its silver production to 6.37 million ounces compared with 6.25 million ounces for 1970. The average selling price for its silver in 1971 was $1.536 per ounce, down from $1.761 in 1970. Hecla's totally owned Lucky Friday mine, the Nation's third largest silver producer, located in Idaho's Couer d'Alene district, produced 3.34 million ounces of silver and substantial amounts of lead, zinc, copper, and gold, by processing 213,394 tons of ore averaging 16.0 ounces of silver per ton. Calculated ore reserves at yearend were 552,000 tons. Development of the new 3,850-foot level was started and partially completed, and the main shaft was deepened to a point 170 feet below the 4,050-foot level. Hecla also operated the Park City district Mayflower mine in Utah under a leasing arrangement with the New Park Mining Co. In the recent past this mine has been one of the large producers in the country, but owing to the depletion of ore reserves productive operations were to be phased out in 1972.

Hecla also shares approximately one-third of the output of the Nation's leading silver producer, the Sunshine mine, and owns a 30-percent interest in the Star-Morning mine. The Bunker Hill Co. owns the other 70-percent interest in this mine, which in 1971, produced 246,053 tons of ore assaying 2.82 ounces of silver, 5.53 percent lead, and 6.72 percent zinc. The Star-Morning unit's No. 4 shaft was deepened to a point 190 feet below the 7,500-foot level. Shaft sinking, to establish the 7,700-foot level, will be started in 1971.

The Galena mine in the Coeur d'Alene district, Idaho, is operated by the American Smelting and Refining Co. (ASARCO). At the Galena mine, under lease from the Callahan Mining Corp., ASARCO produced 3,901,000 ounces of silver by processing 166,296 tons of ore. At the Coeur project being developed by ASARCO, two new levels, the 2,500 and 3,700 foot levels, drifted into ore zones and extended the assured and probable ore reserves to 413,000 tons averaging 20 ounces of silver per ton. ASARCO and Hecla

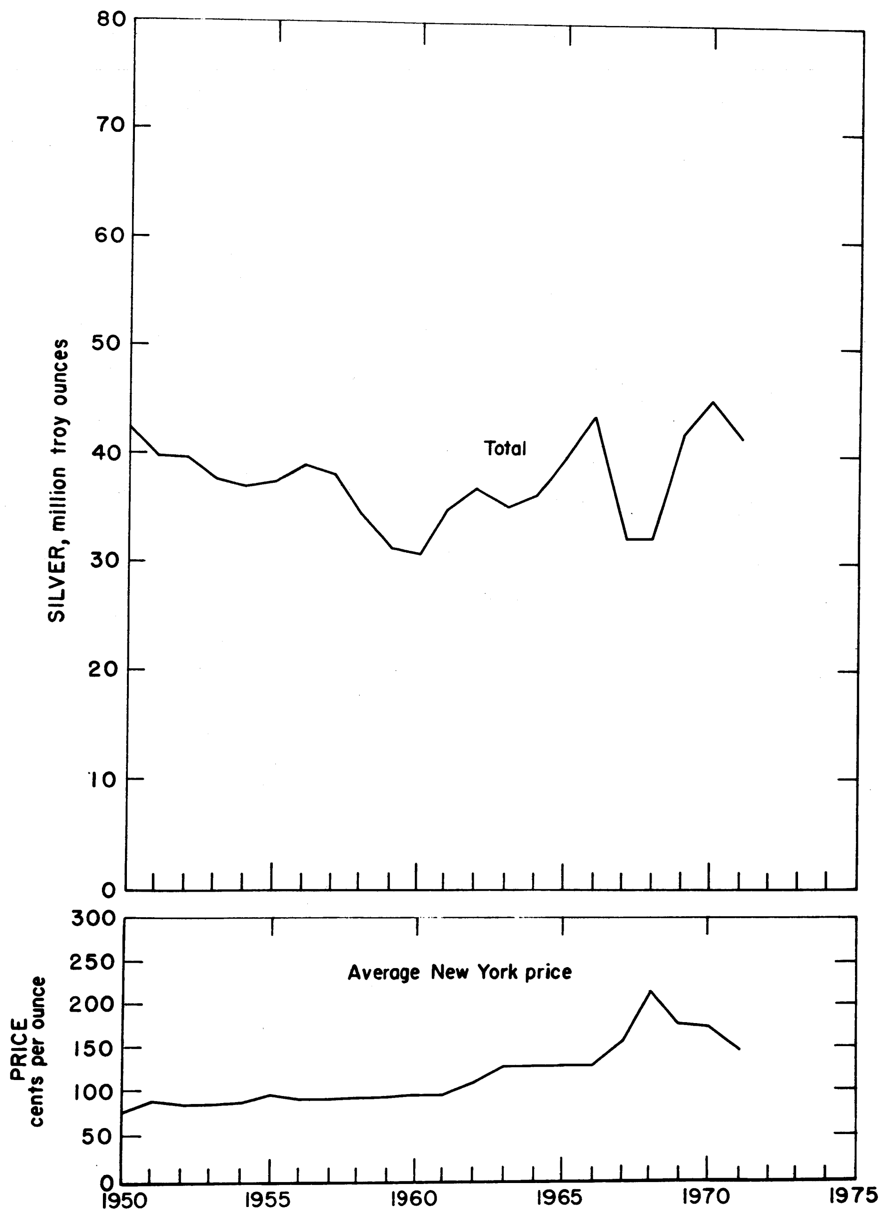

Figure 1.—Silver production in the United States and price per ounce.

closed the Consolidated Silver project, and ASARCO terminated exploration activities at the Camp project.

Kennecott Copper Corp. reported silver production from four U.S. properties at 3.7 million ounces in 1971, compared with 4.3 million ounces in 1970. About 2.7 million ounces were derived as a byproduct of copper; the remainder was a byproduct of lead and zinc.

Bunker Hill Co. produced a total of 3.8 million ounces of silver in 1971, compared with 3.4 million ounces in 1970. About 1.7 million ounces of the total was produced at the Crescent mine. Expansion was continuing at the Crescent mine to be completed in 1973 at which time the production rate should be about 2.8 million ounces per year.

The Anaconda Company produced about 3.9 million ounces of silver from its U.S. properties in 1971. This compares with 5.0 million ounces in 1970. About two-thirds of the total came from Montana mines, and Twin Buttes in Arizona produced most of the balance.

Smelter and refinery reports in 1971 showed that 30.1 million ounces of silver was produced from old scrap and 16.5 million ounces from new scrap, compared with 1970 data of 56.0 million and 24.0 million ounces, respectively. Refinery production, including silver from domestic and imported sources, totaled 115.3 million ounces in 1971 compared with 161.4 million ounces in 1970.

CONSUMPTION AND USES

Consumption data, as measured by sales to the consuming industries, compiled by the Bureau of Mines, show a slight increase compared with 1970. Significant increases were registered in sterling ware, contacts and conductors and in miscellaneous uses. Silver consumed in commemorative medals and other collectors' items contributed to the increase in the miscellaneous category. Declines recorded in major use categories included jewelry, photography, brazing alloys and solders, and batteries. Photographic materials accounted for about 28 percent of the total industrial consumption of silver in 1971; electrical and electronic products, 26 percent; sterling ware, 18 percent; brazing alloys and solders, 9 percent; electroplated ware, 8 percent; and miscellaneous, 4 percent. The remaining 7 percent was used in jewelry, dental and medical supplies, mirrors, bearings, and catalysts.

Continued efficiency in the recovery of silver from process and product waste was an important factor in reducing the quantity of new silver used in the photographic industry. The Department of Defense's program for reclaiming silver from scrap generated by military use has recovered an average of 4 million ounces of the metal annually in the approximately 3 years the present system has been in operation. This reclaimed silver is used in more than 5,000 different items by the Defense Department at substantial savings to the Government.

The Columbia Broadcasting System is producing television cassettes which are being increasingly used in the educational field. The cassettes, which can be played on any television set, are produced by transmitting all the precise electronic information of a movie or television program by an electronic beam to a fine-grain silver halide film. From this master, the desired number of silver halide film cassettes can be made.[2]

Silver powder was produced by an electron beam at the Lewis Laboratory of the National Aeronautics and Space Administration (NASA) in Cleveland, Ohio. The silver is of five-nines fineness, or 99.999 percent pure, and is in the form of round beads. It appears that this can be especially valuable in powder metallurgy, in electronic circuits, and in producing line silver brazing.[3]

A new solution which strips silver by immersion to provide economical recovery of the silver without attacking the base metal has been introduced by Technic Inc. in Chicago, Ill. The new stripping agent permits removal of the silver without electric current from nickel, nickel alloys, copper, and iron.[4]

Other significant new markets were foreseen in commemorative medals, the manufacture of either primary or rechargeable batteries without the use of water,

[2] American Metal Market. V. 78, No. 156, Aug. 13, 1971, p. 11A.
[3] ———. V. 78, No. 156, Aug. 13, 1971, p. 5A.
[4] American Metal Market. V. 78, No. 174, Sept. 9, 1971, p. 15.

and improvement in the production of silver-zinc batteries. Another important contribution is for weather modification. The National Oceanic and Atmospheric Administration has been conducting experiments in Florida using silver iodide to reduce the force of hurricanes.

STOCKS

The Treasury bullion stock outflow in 1971 totaled 2.6 million ounces, most of which (2.5 million ounces) was consumed in U.S. coinage use for the Eisenhower silver dollar. The remainder was the physical delivery of silver sold at the last of the GSA weekly auctions, which ended November 10, 1970.

Yearend Treasury stocks were estimated at 48.0 million ounces in bullion, coin bars, and coinage metal fund silver. New York Commodity Exchange (COMEX) stocks at yearend were 115.45 million ounces, compared with 116.38 million ounces on December 31, 1970. Chicago Board of Trade stocks at yearend were 13.02 million ounces, compared with 11.6 million ounces on December 31, 1970. With addition of reported industrial stocks of about 56.2 million ounces, visible stocks totaled about 232.7 million ounces at yearend. Industrial stocks on December 31, 1970, totaled 81.9 million ounces, compared with the 56.2 million ounces on December 31, 1971.

PRICES

The New York Price of silver as quoted daily by Handy & Harman in cents per troy ounce reached a high for the year of 175.20 on April 8, 1971, declined to 128.80 on November 3, and then rose gradually to end the year at 138.00. At the low level of 128.80, the market was approaching the 125.0-cent price at which the Treasury is required to buy newly mined domestic silver under the provisions of the Coinage Act of 1965.

Prices for spot delivery of silver on the London Market (in U.S. equivalent) ranged from a high of 175.20 cents per ounce on April 8 to a low of 127.13 on November 2, and ended the year at 138.30 cents per ounce.

Futures trading continued on COMEX, with a volume for the year of 6.2 billion ounces, compared with 6.9 billion ounces in 1970. Prices on COMEX ranged from a high of 192.5 cents per ounce for the July 1972 contract reached on April 7, 1971, to a low of 127.4 cents per ounce for the November 1971 contract reached on November 3, 1971. Silver futures trading was also active on the Chicago Board of Trade, where 2.5 billion ounces was traded during 1971 as compared with 1.8 billion ounces in 1970.

FOREIGN TRADE

Exports of silver decreased 56 percent in 1971 to 12.2 million troy ounces. This compares with 27.6 million ounces exported in 1970. About 23 percent of the silver exported went to the United Kingdom, 17 percent went to West Germany, 14 percent went to Switzerland, and 14 percent went to Belgium-Luxembourg. Substantial quantities went to France and Japan. Exports of waste, scrap, and sweepings went mainly to Belgium-Luxembourg and the United Kingdom, and bullion went mainly to the United Kingdom, Switzerland, Japan, West Germany, and France.

Imports of silver totaled 58.0 million ounces, about 7 percent less than in 1970. Canada shipped 32.7 million ounces, about 56 percent; Peru shipped 12.8 million ounces, or about 22 percent; and 24 other countries shipped virtually all of the remaining 12.5 million ounces received. About 22.4 million ounces imported was in the form of refined bullion.

Net imports were 45.8 million ounces, compared with 34.7 million ounces in 1970.

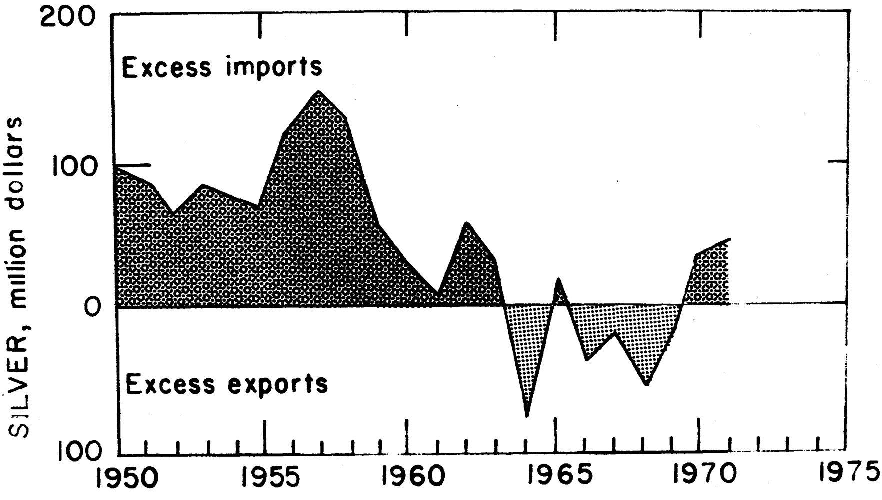

Figure 2.—Net exports or imports of silver, 1950-1971.

WORLD REVIEW

World silver production was estimated at 295 million ounces, approximately 9 million ounces less than in 1970. The major increase in the world was the Canadian gain of 1.7 million ounces. Production decreases were recorded in Mexico, Peru, and the United States. Western Hemisphere output of silver provided slightly less than 62 percent of total world output. About 42 percent of world production of silver came from the North American continent.

World silver consumption in arts and industry was estimated to be about 358 million ounces, up about 0.4 million ounces from that in 1970. Also, as estimated by Handy & Harman's revised figures, coinage requirements for the free world declined to 19.0 million ounces, about 21.3 million ounces less than in 1970. Total free world silver consumption exceeded production by 63.4 million ounces. This production-consumption gap was met, up to November 10, 1970, by sales of U.S. Treasury silver. Since that date the gap has been met by improved secondary recovery and from stocks. It was estimated by Handy & Harman that silver stocks in the hands of investors and speculators amounted to 350 to 400 million ounces.[5]

Australia.—Silver production declined 17 percent to 21.6 million ounces. The leading Australian silver producer is Mount Isa Mines Ltd., which had a 1971 output of nearly 12.0 million ounces, a 20-percent increase over the 1970 production. Mount Isa is also a major lead-zinc-copper producer. The expansion of this copper ore body from producing 100,000 metric tons of copper per year to 150,000 metric tons per year by 1974 is proceeding on schedule.[6]

Canada.—Silver production from Canadian mines increased nearly 4 percent over that of 1970 to 45.9 million ounces. This placed Canada as the leading world producer of silver.

The leading silver producer in Canada and probably the world is the Kidd Creek mine and concentrator of Ecstall Mining Ltd., near Timmins, Ontario, which produced about 28 percent of Canada's total output. This operation, totally owned by Texas Gulf Sulphur Co., had an output of 12.7 million ounces of silver, down slightly from the 13.0 million ounces produced in 1970. In addition to the silver production, this mine is the world's largest producer of lead and zinc, and it also produces copper, cadmium, and other metals. Underground mining facilities at Kidd Creek were under construction, and in 1971 the shaft reached a depth of more than 2,000 feet and a winding decline reached a length of 8,000 feet. Cominco Ltd. produced 5.6 million

[5] Handy & Harman. The Silver Market in 1971, 56th Annual Review. 1972, p. 3.

[6] American Smelting and Refining Company. A Report on the Annual Meeting of Stockholders. Apr. 25, 1972, 21 pp.

ounces at its Trail, British Columbia, smelter, 60 percent of the ore coming from the company's own mines, chiefly the Sullivan. This was 7 percent less than in 1970.

Another silver producer, which was once (1953–67) the largest silver mine in Canada, is the lead-silver-zinc mine of United Keno Hill Mines Ltd. This mine produced 2.9 million ounces of silver in 1971, compared with 2.6 million ounces in 1970.

Honduras.—Silver production at the El Mochito mine of New York and Honduras Rosario Mining Co. was 3.5 million ounces. During the year 311,310 tons of ore was milled, 15 percent more than in 1970. Ore reserves amounted to 2,065,565 tons, averaging 12.6 ounces per ton plus other metals.

The American Smelting and Refining Company's local subsidiary, ASARCO Exploration Co., has invested about $1.25 million in the last 4 years in exploring the San Juancito mine, New York and Honduras Rosario's original mine. In February 1972 ASARCO exercised an option in its contract and withdrew from the joint exploration venture.

Japan.—Mine production of silver was about 11.5 million ounces in 1971. Industrial consumption is estimated to be 46.0 million ounces, slightly lower than in 1970. About 45 percent of the consumption of silver was used in the manufacture of photographic film. The refineries in Japan produced about 30.0 million ounces of refined silver during 1971. Imports of silver in refined and unrefined form totaled about 23.0 million ounces, and exports amounted to less than 0.5 million ounces, most of which went to the United Kingdom.[7] Japanese Government stocks of silver were estimated to be about 16.0 million ounces.

Mexico.—Silver output in Mexico decreased 14 percent, from 42.8 million ounces in 1970 to 36.7 million ounces in 1971. This decrease in production is attributed to a lower price and higher costs resulting in many small operations discontinuing mining.

The American Smelting and Refining Company's subsidiary, ASARCO Mexicana S.A., produced 15.3 million ounces of silver during 1971. This company reported that major mine development work continued at Santa Barbara, San Martin, and Taxco mines. At the La Caridad property work continued in designing a plan for developing this major porphyry copper ore body.[8]

Pure Silver Mines Ltd. (Canada) reportedly continued drifting in high-grade silver-gold ore on the 1,600-foot level of the Cebada mine, one of three mines being developed for production near Guanajuato, Mexico. Pure Silver also holds a 26-percent interest in Tormex Mining Developers, which in turn owns 40 percent of the Encantada lead-silver mine in Mexico. Erection of mine buildings and plant is well underway. Development of sublevels in the mine continues with development ore running from 19 to 31 ounces of silver per ton.[9]

In an attempt to help small and medium-sized producers, who have been hard hit by the continuing drop in world silver prices, the Mexican Government suspended the 25-percent export tax on refined silver. Small and medium-size producers provide about 28 percent of Mexico's total silver output.

Peru.—Cerro de Pasco Corp. produced 19.2 million ounces of silver at its La Oroya smelting and refining facilities. This production compares with 20.8 million ounces produced in 1970. Fifty-seven percent of the production came from purchased ores.

Because of strikes which closed down mining, smelting, and refining operations, Cerro Sales Corp. announced that it was invoking a condition of force majeure effective November 10, 1971. Cerro de Pasco produces copper, lead, zinc, silver, gold, bismuth, and various concentrates from six operating mines in Peru.

TECHNOLOGY

The Bureau of Mines is continuing research on a project entitled "Extraction of Silver and Associated Metals from Refractory Ores and Mine Wastes." Preliminary results to date indicate 85 to 95 percent silver extraction using an SO_2-chloride leach system. Increased depth of mining has created ground control difficulties and aggravated rock burst problems. Since 1961

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[7] Handy & Harman. The Silver Market in 1971, 56th Annual Report. 1972, p. 16.

[8] American Smelting and Refining Company. Annual Report, 1971. P. 16.

[9] The Northern Miner (Toronto). V. 57, No. 36, Nov. 25, 1971, p. 83.

the Bureau of Mines has continued research directed toward a better understanding of hydraulic backfill behavior and it potential to reduce stresses imposed on other support media and to lessen rock burst occurrences in pillar remnants.[10]

More interest is being shown in large low-grade disseminated deposits of precious metals. A Bureau of Mines report presents the results of a comprehensive statistical analysis of assay data obtained from drill hole sampling at the Round Mountain silver prospect in Custer County, Colo. This report compares the consistency of data from rotary and diamond drill holes, from two methods of sample preparation, and from atomic absorption and fire assaying. The methods demonstrated should be useful for the evaluation of low-grade silver deposits and other mineral deposits in similar geological environments.[11]

Two new developments in the use of silver are its use in lead storage battery plates and in the electroplating of stainless steel. Silver in lead storage batteries is said to increase the tensile strength of the plates from 7,000 psi to 15,000 psi, simultaneously doubling the anodic corrosion resistance and operating life of the plate.[12]

[10] Corson, D. R. Field Evaluation of Hydraulic Backfill Compaction at the Lucky Friday Mine, Mullan, Idaho. BuMines RI 7546, 1971, 24 pp.
[11] Koch, George S., Jr. Statistical Analysis of Assay Data From the Round Mountain Silver Prospect, Custer County, Colo. BuMines RI 7486, 1971, 32 pp.
[12] American Metal Market. Batteries, Plating Steel May Boost Use of Silver. V. 79, No. 13, Jan. 19, 1972, p. 11.

Table 2.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1970	1971
January	3,586	3,744
February	3,523	3,522
March	3,772	4,087
April	3,862	3,483
May	3,864	3,459
June	3,646	3,836
July	3,586	2,366
August	3,833	2,780
September	3,804	3,398
October	3,754	3,451
November	3,929	3,706
December	3,847	3,732
Total	45,006	41,564

Table 3.—Twenty-five leading silver-producing mines in the United States in 1971, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
2	Galena	do	American Smelting and Refining Co.	Do.
3	Lucky Friday	do	Hecla Mining Co	Lead ore.
4	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold-silver ores.
5	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
6	Berkeley Pit	Silver Bow, Mont.	The Anaconda Company	Copper ore.
7	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore, lead-zinc tailings.
8	Crescent	do	do	Silver ore.
9	Burgin	Utah, Utah	Kennecott Copper Corp	Lead, lead-zinc ores.
10	Copper Queen-Lavender Pit.	Cochise, Ariz	Phelps Dodge Corp	Do.
11	Twin Buttes	Pima, Ariz	The Anaconda Company	Copper ore.
12	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead-zinc ore.
13	Pima	Pima, Ariz	Pima Mining Co	Copper ore.
14	White Pine	Ontonagon, Mich.	White Pine Copper Co	Do.
15	Star Unit	Shoshone, Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
16	Dayrock	do	Day Mines Inc	Lead ore.
17	Buick	Iron, Mo	Missouri Lead Operating Co	Do.
18	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
19	Sierrita	Pima, Ariz	Duval Sierrita Corp	Copper ore.
20	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
21	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
22	Mission Unit	Pima, Ariz	American Smelting and Refining Co.	Do.
23	Copper Canyon	Lander, Nev	Duval Corp	Do.
24	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
25	Butte Hill Copper Mines.	Silver Bow, Mont.	The Anaconda Company	Do.

Table 4.—Production of silver in the United States in 1971, by State, type of mines, and class of ore, etc., yielding silver, in terms of recoverable metal

	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	728	230	140	--	--	--	--
Arizona	--	[1] 10,158	[1] 5,539	--	--	W	W
California	166	[1] 715	[1] 5,521	W	W	--	--
Colorado	209	--	--	--	--	99,828	2,051,236
Idaho	--	--	--	--	--	557,257	12,808,269
Michigan	--	--	--	--	--	--	--
Missouri	--	--	--	--	--	--	--
Montana	2	739	572	13,765	73,166	15,471	181,590
Nevada	--	--	--	315	4,754	155	2,179
New Mexico	--	--	--	--	--	45	89
South Dakota	--	1,799,678	106,785	--	--	--	--
Utah	--	--	--	152,117	42,632	--	--
Other States [2]	--	71,118	286,886	463	2,328	360	1,462
Total	1,105	1,882,638	405,443	166,660	122,880	673,116	15,044,825
Percent of total silver	(3)	--	1	--	(3)	--	36

Table 4.—Production of silver in the United States in 1971, by State, type of mines, and class of ore, etc., yielding silver, in terms of recoverable metal—Continued

	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	--	--	--	--	--	--
Arizona	135,301,327	6,106,204	3,250	2,253	--	--
California	--	--	W	W	--	--
Colorado	[4] 322,492	[4] 173,222	W	W	W	W
Idaho	26,492	8,840	274,716	3,938,335	973	936
Michigan	6,890,610	670,052	--	--	--	--
Missouri	--	--	8,624,647	1,660,879	--	--
Montana	13,493,171	2,387,897	6,190	50,450	4,027	19,924
Nevada	8,392,460	588,202	197	2,338	W	W
New Mexico	17,587,946	639,478	--	--	--	--
South Dakota	--	--	--	--	--	--
Utah	35,008,400	2,566,223	15,488	170,020	--	--
Other States [2]	222,104	34,796	621	1,172	97,299	4,050
Total	217,245,002	13,174,914	8,925,109	5,825,447	102,299	24,910
Percent of total silver	--	32	--	14	--	(3)

	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	Short tons	Troy ounces of silver
Alaska	--	--	--	--	230	868
Arizona	95,039	28,265	77,179	27,362	135,486,953	6,169,623
California	[4] 87,632	[4] 390,649	--	[5] 47,425	88,347	443,761
Colorado	816,951	1,164,546	--	[5] 535	1,239,271	3,389,748
Idaho	780,970	2,377,873	6,253	5,322	1,646,661	19,139,575
Michigan	--	--	--	--	6,890,610	670,052
Missouri	--	--	--	--	8,624,647	1,660,879
Montana	217	708	17,218	33,248	13,550,798	2,747,557
Nevada	[4] 606	[4] 3,997	--	--	8,393,733	601,470
New Mexico	119,021	142,874	--	--	17,707,012	782,441
South Dakota	--	--	--	--	1,799,678	106,785
Utah	472,082	2,514,802	159	[5] 800	35,648,246	5,294,477
Other States [2]	2,742,796	202,828	--	[5] 23,384	3,134,761	556,906
Total	5,115,314	6,826,542	100,809	138,076	234,210,947	41,564,142
Percent of total silver	--	17	--	(3)	--	100

W Withheld to avoid disclosing individual company confidential data, included with "Other States."
[1] Combined with other dry and siliceous ores to avoid disclosing individual company confidential data.
[2] Includes Illinois, Maine, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Tennessee, and Washington.
[3] Less than ½ unit.
[4] Combined with other base-metal ores to avoid disclosing individual company confidential data.
[5] Includes byproduct silver recovered from tungsten ore in California and North Carolina, from fluorspar ore in Colorado and Illinois, from uranium ore in Utah, and from magnetite-pyrite ore in Pennsylvania.

Table 5.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1967	1968	1969	1970	1971
Alaska	5,787	3,900	2,030	2,189	868
Arizona	4,588,081	4,958,162	6,141,022	7,330,417	6,169,623
California	144,515	597,961	491,927	451,150	443,761
Colorado	1,817,699	1,646,283	2,598,563	2,933,363	3,389,748
Idaho	17,033,330	15,958,715	18,929,697	19,114,829	19,139,575
Kentucky	568	--	--	--	--
Maine	--	[1] 371,745	[1] 319,718	63,227	41,193
Michigan	301,992	472,813	1,009,022	891,579	670,052
Missouri	226,168	340,856	1,442,090	1,816,978	1,660,879
Montana	2,066,464	2,132,571	3,429,314	4,304,326	2,747,557
Nevada	565,755	645,192	884,155	718,011	601,470
New Mexico	157,495	224,866	465,591	781,952	782,441
New York	31,103	27,615	31,755	23,830	17,928
Oklahoma	[2] 279,898	(1)	(1)	[2] 325,887	[2] 362,646
Oregon	31	335	4,749	3,594	3,790
Pennsylvania	(2)	(1)	(1)	(2)	(2)
South Dakota	121,258	137,668	124,497	119,766	106,785
Tennessee	130,078	89,525	78,614	94,770	131,349
Utah	4,874,640	5,120,772	5,953,567	6,029,737	5,294,477
Washington	(2)	(1)	(1)	(2)	(2)
Total	32,344,862	32,728,979	41,906,311	45,005,605	41,564,142

[1] Production of Maine, Oklahoma, Pennsylvania, Washington, and Wyoming (1969) combined to avoid disclosing individual company confidential data.
[2] Production of Oklahoma, Pennsylvania, Washington, Illinois (1971), and North Carolina (1971) combined to avoid disclosing individual company confidential data.

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1971 by States and methods 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)	140
Arizona	149,480	148,999	--	--	2,983,955	6,003,940	481	165,683
California	89	89	--	--	12,097	441,176	(3)	2,419
Colorado	1,239	1,238	993	--	779,629	3,342,041	1	46,505
Idaho	1,647	1,646	--	--	198,374	19,137,708	1	1,867
Michigan	6,890	6,890	--	--	194,532	670,052	--	--
Missouri	8,625	8,625	--	--	722,888	1,660,867	(3)	12
Montana	13,551	13,504	--	--	284,493	2,494,574	47	252,981
Nevada	18,659	18,658	--	--	355,344	586,188	1	15,282
New Mexico	18,520	18,463	--	--	659,893	781,891	57	550
South Dakota	1,800	1,800	--	106,785	--	--	--	--
Utah	36,247	36,080	--	--	905,113	5,087,338	167	207,139
Other States [4]	3,763	3,760	--	--	553,191	551,727	3	5,179
Total	260,510	259,752	993	106,785	7,649,509	40,757,502	758	697,757

[1] Includes some nonsilver-bearing ore not separable.
[2] Excludes tonnage of fluorspar, magnetite-pyrite, and tungsten ores from which silver was recovered as a byproduct.
[3] Less than ½ unit.
[4] Includes Illinois, Maine, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Tennessee, 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
1967	84,290	47,054	0.26	0.15	99.57	0.02
1968	92,021	53,666	.28	.16	99.55	.01
1969	83,775	49,312	.20	.11	99.68	.01
1970	95,287	24,892	.21	.05	99.73	.01
1971	993	106,785	(2)	.26	99.74	(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	1970	1971
Concentrates and ores:		
Domestic	49,451	37,242
Foreign	31,930	31,449
Total	81,381	68,691
Old scrap [1]	56,044	30,075
New scrap	23,999	16,524
Total production	161,424	115,290

[1] Includes coin bullion purchased from GSA and refined to commercial-grade silver.

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

	1970	1971
Electroplated ware	11,437	10,909
Sterling ware	19,116	22,729
Jewelry	5,119	3,447
Photographic materials	38,044	36,073
Dental and medical supplies	1,804	1,485
Mirrors	1,386	1,112
Brazing alloys and solders	14,035	12,085
Electrical and electronic products:		
Batteries	6,342	5,631
Contacts and conductors	25,183	27,954
Bearings	383	355
Catalysts	1,999	1,730
Miscellaneous [1]	3,556	5,636
Total net industrial consumption	128,404	129,146
Coinage	709	2,474
Total consumption	129,113	131,620

[1] Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.

Table 10.—Value of silver exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1969	$156,720	$119,362
1970	49,139	103,757
1971	19,798	82,225

Table 11.—U.S. exports of silver in 1971, by country

(Thousand troy ounces and thousand dollars)

Country	Ore and concentrates		Waste and sweepings		Refined bullion	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	7	$10	--	--	(1)	$1
Belgium-Luxembourg	--	--	1,663	$2,722	--	--
Brazil	--	--	--	--	127	209
Canada	1	2	6	10	523	841
Colombia	--	--	--	--	18	29
France	--	--	--	--	1,501	2,317
Germany, West	--	--	510	869	1,615	2,480
Greece	--	--	--	--	5	7
Israel	--	--	--	--	9	18
Japan	1	2	5	11	1,303	2,218
Korea, Republic of	--	--	--	--	316	576
Mexico	13	22	--	--	--	--
Netherlands	--	--	1	2	--	--
Singapore	--	--	--	--	(1)	1
Spain	--	--	134	219	--	--
Sweden	--	--	31	51	--	--
Switzerland	152	243	--	--	1,507	2,411
United Kingdom	--	--	1,204	2,001	1,570	2,521
Venezuela	--	--	--	--	2	5
Total	174	279	3,554	5,885	8,496	13,634

[1] Less than ½ unit.

Table 12.—U.S. general imports of silver in 1971, 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	196	$288	--	--	--	--	--	--
Australia	1,026	1,539	--	--	--	--	--	--
Austria	5	7		--	--	--	--	--
Belgium-Luxembourg	--	--	--	--	45	$61	--	--
Brazil	--	--	--	--	--	--	65	$94
Canada	15,555	24,087	727	$995	660	1,081	15,733	23,971
Chile	2,237	1,207	--	--	--	--	--	--
Colombia	26	36	--	--	--	--	--	--
France	--	--	--	--	158	323	--	--
Germany, West	--	--	7	7	(1)	1	1	2
Guatemala	150	79	--	--	--	--	--	--
Honduras	2,701	1,633	--	--	400	590	--	--
Japan	--	--	--	--	--	--	480	754
Mexico	1,223	1,728	52	75	--	--	1,986	2,689
Netherlands	9	7	--	--	--	--	--	--
Nicaragua	14	15	--	--	24	37	--	--
Norway	25	31	--	--	--	--	--	--
Panama	--	--	--	--	--	--	9	14
Peru	8,675	11,744	--	--	--	--	4,101	6,432
Philippines	216	345	--	--	--	--	--	--
Salvador	--	--	--	--	12	19	3	4
South Africa, Republic of	499	774	--	--	--	--	--	--
Spain	--	--	1	1	--	--	--	--
Switzerland	--	--	--	--	1	1	8	16
United Kingdom	895	1,483	33	47	--	--	2	3
Venezuela	--	--	2	4	(1)	1	--	--
Total	33,452	45,003	822	1,129	1,300	2,114	22,388	33,979

[1] Less than ½ unit.

Table 13.—World production of silver, by country [1]

(Thousand troy ounces)

Country [2]	1969	1970	1971 p
North and Central America:			
Canada	43,531	44,251	45,950
El Salvador	--	154	215
Haiti e	17	17	17
Honduras	3,905	3,816	3,642
Mexico	42,904	42,836	36,657
Nicaragua	247	217	261
United States	41,906	45,006	41,564
South America:			
Argentina	3,109	2,051	e 2,050
Bolivia [3]	6,013	6,816	e 6,800
Brazil	360	357	624
Chile	3,133	2,393	5,360
Colombia	77	76	67
Ecuador	82	70	e 70
Peru	r 35,886	39,835	38,398
Europe:			
Austria [4]	r 118	176	225
Czechoslovakia e	1,100	1,100	1,100
Finland	625	740	623
France	r 2,396	2,282	e 2,000
Germany:			
East e	4,800	4,800	5,000
West	1,684	1,773	1,800
Greece [4]	258	420	462
Hungary e	6	6	6
Ireland	1,866	2,171	e 2,200
Italy	1,832	1,061	1,222
Poland e	165	180	200
Portugal	339	247	e 250
Romania e	800	800	1,000
Spain [4]	1,823	e 1,640	e 1,640
Sweden	r 6,858	6,109	4,823
U.S.S.R. e	37,000	38,000	39,000
Yugoslavia	3,818	3,417	3,354
Africa:			
Algeria e	100	100	100
Ghana	3	5	--
Kenya	2	--	--
Morocco	861	681	809
Rhodesia, Southern [5]	e 70	71	e 71
South Africa, Republic of	3,335	3,527	3,378
South-West Africa, Territory of [6]	1,273	1,229	1,426
Tanzania	2	1	36
Tunisia	e 43	58	e 58
Zaire	1,896	1,709	1,800
Zambia e [7]	768	768	768
Asia:			
Burma	r 868	960	952
China, People's Republic of e	800	800	800
India	105	50	124
Indonesia	r 341	283	285
Japan	r 10,811	10,795	11,540
Korea:			
North e	700	700	700
South	906	1,494	1,543
Philippines	1,561	1,702	1,940
Taiwan	81	95	73
Oceania:			
Australia	24,457	25,992	21,615
Fiji	38	27	e 27
Papua and New Guinea	17	17	18
New Zealand	22	16	66
Total	r 295,718	303,897	294,709

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, Guatemala, Thailand, Turkey, and several other African countries produced silver, but quantities are insignificant or not reported.

3 Production by the State Mining Company (COMIBOL) plus exports of medium and small (private sector) mines.

4 Smelter and/or refinery production.

5 Output of Inyati mine only.

6 Recoverable content of Tsumeb Corp. Ltd. concentrates, as reported for year ending June 30 of year stated.

7 Includes recovery from copper refinery sludges.

Slag-Iron and Steel

By Harold J. Drake [1]

In 1971, the combined supply of iron and steel slag decreased about 1 percent, reflecting principally a 5-percent decline in the output of iron-blast-furnace slag and a 13-percent increase in the output of steel slag. Demand for iron slag exceeded supply, thus assuring consumption of all production. Demand for steel slag, as in past years, was somewhat less than the output mainly because of the failure to develop potential uses.

Prices of iron and steel slag generally rose through the first 6 months of 1971 but thereafter were relatively stable or, for some kinds, declining. Imports were up about one-fourth, and exports were off about one-fourth.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded		Total	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value [1]	Quantity	Value	Quantity	Value
1970	20,214	$40,066	2,038	$2,069	1,936	r $2,134	1,959	$6,570	26,147	$50,839
1971	20,217	41,203	1,227	1,149	1,787	2,445	1,581	4,887	24,812	49,684

r Revised.
[1] Excludes value of slag used for manufacturing hydraulic cement.
Source: National Slag Association.

Table 2.—Iron-blast-furnace slag processed in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Screened air-cooled		All types	
	Quantity	Value [1]	Quantity	Value [1]
1970				
Ohio	4,286	$9,085	5,429	$11,443
Pennsylvania	4,542	9,676	6,173	13,047
Illinois, Indiana, Michigan	4,599	8,954	5,896	12,022
Other States [2]	6,787	12,351	8,649	r 14,327
Total [3]	20,214	40,066	26,147	r 50,839
1971				
Ohio	4,397	10,209	5,615	12,179
Pennsylvania	4,916	10,681	5,625	12,185
Illinois, Indiana, Michigan	3,737	6,265	4,973	9,145
Other States [2]	7,167	14,048	8,599	16,175
Total [3]	20,217	41,203	24,812	49,684

r Revised.
[1] Excludes value of slag used for manufacturing hydraulic cement.
[2] Alabama, California, Colorado, Kentucky, Louisiana, Maryland, Minnesota, New York, Texas, Utah, and West Virginia.
[3] Data may not add to totals shown because of independent rounding.

Source: National Slag Association.

Table 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1970		1971	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	4,725	18	4,504	18
Truck	20,992	80	19,845	80
Waterway	430	2	463	2
Total	26,147	100	24,812	100

Source: National Slag Association.

DOMESTIC PRODUCTION

Production of iron and steel slag in 1971 totaled 33.3 million short tons valued at $59.4 million, a 1-percent decrease from the production of the preceding year. Iron-blast-furnace slag amounted to 24.8 million tons valued at $49.7 million and steel slag to 8.5 million tons valued at $9.7 million.

Production of screened, air-cooled iron-blast-furnace slag, which in 1971 accounted for 81 percent of the total iron slag production, was virtually unchanged from 1970, whereas production of unscreened, air-cooled slag fell 40 percent. Output of expanded slag was off 19 percent and that of granulated slag, 8 percent.

The principal producing States were Ohio, Pennsylvania, Illinois, Indiana, and Michigan which accounted for two-thirds of the domestic production. A total of 1,549 plant and yard personnel worked 3,427,398 man-hours during 1971 in 56 air-cooled, 17 expanded, and 13 granulated slag plants. The quantity of slag-encrusted magnetic iron recovered at these operations was 3,789,000 tons.

CONSUMPTION AND USES

The construction industry continued to be the major market for slag and, in 1971, consumed more than 95 percent. The remainder was used principally in agriculture and the manufacture of mineral wool.

Consumption of screened, air-cooled iron-blast-furnace slags rose very slightly as increased use was recorded in bituminous construction, concrete block manufacture, and mineral wool production. The largest use category, highway and airport construction, declined as did other concrete applications, railroad ballast, and roofing material. The use of unscreened, air-cooled slag in highway and airport construction was off about 1 million tons, which was equivalent to 70 percent of total consumption of this kind of air-cooled iron slag. Consumption in 1971 of granulated and expanded iron-blast-furnace slags was below the corresponding 1970 levels principally because of decreased usage as construction aggregate.

Consumption of steel slag, continuing the trend of recent years, rose in 1971 as increases were reported in the quantities used as base and fill construction material, railroad ballast, and bituminous mixes. The only significant decline occurred in the use of steel slag as a base material for paving.

Table 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1970				1971			
	Screened		Unscreened		Screened		Unscreened	
	Quantity	Value	Quantity	Value	Quantity	Value [1]	Quantity	Value
Aggregate in—								
Portland cement concrete construction:								
Structures	2,075	$4,405	--	--	1,986	$4,385	--	--
Pavements	418	919	--	--	413	974	--	--
Bituminous construction (all types)	3,838	7,819	--	--	4,091	8,445	--	--
Highway and airport construction [1]	8,291	17,057	1,475	$1,550	7,856	16,117	429	$554
Manufacture of concrete block	371	730	--	--	469	951	--	--
Railroad ballast	3,420	4,682	--	--	3,174	4,866	--	--
Mineral wool	351	705	35	27	369	809	42	33
Roofing slag:								
Cover material	628	1,443	--	--	328	1,115	--	--
Granules	76	530	--	--	63	488	--	--
Sewage trickling filter medium	65	126	--	--	36	62	--	--
Agricultural slag, liming	7	14	--	--	8	17	--	--
Other uses	674	1,636	528	492	1,424	2,974	756	562
Total	20,214	40,066	2,038	2,069	20,217	41,203	1,227	1,149

[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 uses

(Thousand short tons and thousand dollars)

Use	1970				1971			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value [1]	Quantity	Value	Quantity	Value [1]	Quantity	Value
Highway construction and fill (road, etc.)	1,121	$1,639	--	--	997	$1,547	--	--
Agricultural slag, liming	121	187	--	--	74	156	--	--
Manufacture of cement (all types)	412	r NA	--	--	297	NA	160	NA
Lightweight concrete	--	--	48	$156	--	--	26	$72
Aggregate for concrete-block manufacture	151	208	1,781	6,033	96	294	1,351	4,653
Other uses	131	100	130	381	323	448	44	162
Total	1,936	r 2,134	1,959	6,570	1,787	2,445	1,581	4,887

r Revised. NA Not available.

[1] Excludes value of granulated and expanded slag used for hydraulic cement manufacture.

Source: National Slag Association.

Table 6.—Steel slag sold or used by processors in the United States, in 1971, by uses [1]

(Thousand short tons and thousand dollars)

Use	1970		1971	
	Quantity	Value	Quantity	Value
Railroad ballast	840	$981	855	$1,041
Highway base or shoulders	2,371	2,476	2,635	2,651
Paved-area base	1,346	1,343	1,115	1,150
Miscellaneous base or fill	1,419	1,651	2,053	2,196
Bituminous mixes	496	764	529	842
Agricultural	77	490	99	630
Other uses	990	1,127	1,202	1,209
Total	7,539	8,832	8,488	9,719

[1] Excludes tonnage returned to furnace for charge material.

PRICES

Prices of iron and steel slag, except those for screened, air-cooled iron slag, were lower in 1971 than in 1970. In terms of average unit values, the price of screened, air-cooled and granulated slags was up $0.06 and $0.27 per ton, respectively, and that for expanded and steel slags was off $0.26 and $0.02 per ton, respectively.

Table 7.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by uses

(Per short ton)

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1970	1971	1970	1971	1970	1971	1970	1971
Aggregate in:								
Portland cement concrete construction	$2.14	$2.23	--	--	--	--	--	--
Bituminous construction (all types)	2.04	2.06	--	--	--	--	--	--
Highway and airport construction [1]	2.06	2.05	$1.05	$1.29	$1.46	$1.55	--	--
Manufacture of concrete block	1.97	2.02	--	--	r 1.98	3.06	$3.39	$3.43
Lightweight concrete	--	--	--	--	--	--	3.25	3.00
Railroad ballast	1.37	1.53	--	--	--	--	--	--
Mineral wool	2.01	2.19	.77	.78	--	--	--	--
Roofing slag:								
Cover material	2.30	3.39	--	--	--	--	--	--
Granules	6.97	7.72	--	--	--	--	--	--
Sewage trickling filter medium	1.94	1.72	--	--	--	--	--	--
Agricultural slag, liming	2.00	2.09	--	--	1.55	2.00	--	--
Other uses	2.43	2.08	.93	.74	.76	1.38	2.93	2.88

r Revised.
[1] Other than in portland cement and bituminous construction.

Source: National Slag Association.

FOREIGN TRADE

U.S. exports of iron and steel slag in 1971 amounted to 21,729 tons valued at $982,639, a level well below that of 1970. Sharply reduced shipments to European countries were only partially offset by increased shipments to Canada and Bermuda. U.S. imports, all of which came from Canada, rose 23 percent in quantity and 15 percent in value to 2,324 tons valued at $27,050.

Table 8.—U.S. exports and imports for consumption of slag, dross and scaling from the manufacture of iron and steel

Country	1970		1971	
	Short tons	Value	Short tons	Value
Imports: Canada	1,891	$23,521	2,324	$27,050
Exports:				
Australia	1	405	--	--
Bahamas	107	978	--	--
Belgium-Luxembourg	18,869	4,048,869	4,377	837,611
Bermuda	--	--	7,493	22,193
Brazil	4	1,327	--	--
Canada	4,587	84,840	9,478	71,806
Chile	145	14,531	6	840
Colombia	--	--	173	38,192
France	--	--	45	2,700
Germany, West	2,260	110,546	--	--
Japan	616	21,067	--	--
Korea, Republic of	--	--	40	2,882
Mexico	3	376	--	--
Netherlands	2,195	101,179	23	3,080
Netherlands Antilles	100	1,200	--	--
Philippines	182	1,660	--	--
Taiwan	--	--	25	650
United Kingdom	--	--	31	1,965
Venezuela	45	864	38	720
Total	29,114	4,387,842	21,729	982,639

Sodium and Sodium Compounds

By Charles L. Klingman [1]

The combined production of sodium carbonate and sodium sulfate in the United States increased only 0.5 percent in 1971 over that of 1970; this was almost equivalent to the decline between 1969 and 1970. When compared to the usual economic indicators, such as the gross national product (GNP), these figures indicate that the sodium industry has not kept up with the overall economic advancement of the Nation.

DOMESTIC PRODUCTION

In 1971, total production of natural and manufactured soda ash increased less than one percent over that of 1970 to 7,153,000 tons. Natural soda ash, obtained primarily from Wyoming trona deposits, continued its historic increases of about 10 percent per year to reach 2,878,000 tons in 1971, or 40.2 percent, of the total soda ash production.

By contrast, Solvay-processed soda ash has decreased every year since 1966. The 1971 level was 4,275,000 tons, 3.2 percent less than that of 1970. The Olin Corp. completed the final shutdown of its Solvay soda ash plant at Saltville, Va., in 1971, and the PPG Co. announced the imminent shutdown of its Solvay soda ash plant in Barberton, Ohio. Both companies gave stricter State limitations on permissible chlorides in plant effluents and poor economic position relative to the naturally occurring soda ash from Wyoming as reasons for the closings.

Meanwhile the plants at Green River, Wyo., which make soda ash from trona deposits, continue to expand their operations. The Stauffer Chemical Co., the Allied Chemical Corp., and the FMC Corp. each added about 500,000 tons per year to their present production capacities.

[1] Physical scientist, Division of Nonmetallic Minerals.

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]	
	Quantity	Quantity	Value
1967	4,849	1,726	$40,539
1968	4,596	2,043	42,104
1969	4,540	2,495	50,922
1970	4,414	r 2,678	56,320
1971	p 4,275	2,878	60,774

p Preliminary. r Revised.
[1] Current Industrial Reports. Inorganic Chemicals. U.S. Department of Commerce, Bureau of the Census.
[2] Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3] Soda ash and trona (sesquicarbonate).

A proposed dam on the Green River in Wyoming and the consequent formation of a new lake has been studied to anticipate its effect on the trona mining operations in the area. The mine operators continued to object to the building of the dam in spite of a consultant's report that the lake would not create any serious problems. A new deposit of trona has been discovered in the Unita Basin of northeastern Utah. A new $20 million plant to extract soda ash and other chemicals by solar evaporation from Searles Lake, Calif., is being built by Hooker Chemical Co., a subsidiary of the Occidental Petroleum Corp. Completion is scheduled for fall, 1972.

The oil shale deposits on government land in Colorado have valuable underlying beds of nahcolite, 100 pounds of which can be readily converted to 63 pounds of soda ash. The Department of the Interior leased four 2400-acre tracts in this area in July, 1971, for sodium mining only. It is estimated that commercial mining of the nahcolite can begin in about 2 years.

Natural soda ash was produced by four companies at five plants in two states as shown in the following tabulation of producers:

Company	Plant Location	State	Source of Sodium
American Potash and Chemical Corp	Trona	California	Dry lake brine.
Stauffer Chemical Co	do	do	Do.
Allied Chemical Corp	Green River	Wyoming	Underground trona.
FMC Corporation	do	do	Do.
Stauffer Chemical Co	do	do	Do.

Metallic sodium, which is a coproduct of the electrolysis of molten salt, was manufactured by three companies at five plants in five different states as shown by the following tabulation of producers:

Company	Plant location	State
E. I. du Pont de Nemours & Co., Inc.	Niagara Falls	New York.
Do	Memphis	Tennessee.
Ethyl Corp	Baton Rouge	Louisiana.
Do	Houston	Texas.
Reactive Metals Inc	Ashtabula	Ohio.

Metallic sodium production declined 10.6 percent in 1971 to 153,075 pounds. This is the lowest production of metallic sodium since that of 1965. The decline was due, at least in part, to a reduced requirement for tetraethyl and tetramethyl lead, antiknock compounds in automotive gasoline. Metallic sodium is used in the preparation of these compounds that are now considered promoters of atmospheric pollution from automotive exhausts.

A major new supplier of natural sodium sulfate, the Great Salt Lake Chemical Corp., with a designed capacity of 150,000 tons per year, apparently had not yet attained full production during 1971.

Total production of sodium sulfate (salt cake) decreased 0.5 percent in 1971 to 1,355,000 tons. High-purity sodium sulfate increased 2.8 percent, but the low-purity product decreased 3.2 percent. A significant factor in the reduced demand for low-purity salt cake has been a slump in the production of pulp and paper in which about 67 percent of the sodium sulfate supply is utilized.

Natural sodium sulfate, obtained from brine, has been taking an increasing portion of the total sodium sulfate market for the past 20 years. In 1971 the natural product amounted to 51 percent of the total, compared with 25 percent in 1950.

Natural sodium sulfate was produced by four companies at five plants in three states, as shown in the following listing of producers:

Company	Plant location	State	Source
Stauffer Chemical Co	Trona	California	Dry lake brine.
U.S. Borax & Chem. Co	Boron	do	Open pit mining.
Ozark-Mahoning Co	Brownfield	Texas	Subterranean brine.
Do	Seagraves	do	Do.
Great Salt Lake Minerals & Chem. Corp	Ogden	Utah	Salt lake brine.

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)	
	Low purity [3] (99 percent or less)	High purity	Quantity	Value
1967	696	668	637	$10,710
1968	758	725	700	12,729
1969	731	744	672	12,427
1970	761	r 601	598	10,932
1971	p 737	p 618	688	11,008

p Preliminary. r Revised.
[1] All quantities converted to 100 percent Na_2SO_4 basis.
[2] Current Industrial Reports. Inorganic Chemicals. U.S. Department of Commerce, Bureau of the Census.
[3] Includes glauber salt.

CONSUMPTION AND USES

The consumption and use pattern of sodium and its compounds showed minor changes in 1971. About 40 percent of the soda ash produced was used in the making of glass; 23 percent in the making of chemicals; about 6 percent in the production of pulp and paper; and the remainder was consumed in miscellaneous uses such as water treatment, aluminum production, and in the manufacture of soap and detergents.

About 67 percent of the sodium sulfate output was used in the production of Kraft paper. The remaining output was divided among glass, ceramics, detergents, stockfeeds, dyes, textiles, and medicines.

Metallic sodium continued to be used primarily in the manufacture of tetraethyl or tetramethyl lead in spite of a small reduction of the use of lead in gasoline. Titanium producers utilized metallic sodium to reduce titanium tetrachloride to metallic titanium.

The predicted high usage of sodium nitrilotriacetate as a substitute for phosphates in detergents has not developed as expected.

PRICES

Market prices quoted at yearend for sodium carbonate, sodium sulfate, and metallic sodium were as follows:

		1970	1971 [1]
Sodium carbonate (soda ash, 58 percent Na_2O):			
Light, paper bags, carlots, works	per 100 pounds	$2.35	$2.35
Light, bulk, carlots, works	do	1.65	1.65
Dense, paper bags, carlots, works	do	2.40	2.40–2.45
Dense, bulk, carlots, works	do	1.65	1.65–1.80
Sodium sulfate (100 percent Na_2SO_4):			
Technical detergent, rayon-grade, bags, carlots, works	per ton	40.00	40.00
Technical detergent, rayon-grade, bulk, works	do	34.00	34.00
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	.26	.30
Fused, lots of 18,000 pounds and more, works	do	.24½	.26½–.27½
Bulk, tank, works	do	.18¾	.18¾

[1] Chemical Marketing Reporter, current prices of chemicals and related materials, v. 200, No. 26, Dec. 27, 1971, pp. 22–33.
[2] Delivered east of the Mississippi River.

FOREIGN TRADE

In 1971, exports of sodium carbonate increased 30 percent over those of 1970 to the highest amount in history, 437,000 tons. This was 6.1 percent of the sodium carbonate production, compared with 4.7 percent in 1970. About 40 percent of the total exports went to Canada, 16 percent to Argentina, and 9 percent to Venezuela. Other countries that received over 5 percent of the export were New Zealand, Mexico, Republic of South Africa, and the Philippines.

Imports of sodium sulfate in 1971 were the same as those of 1970, 269,000 tons. Exports of sodium sulfate, however, increased from 55,000 to 66,000 tons. The net import of sodium sulfate (imports less exports) amounted to 13 percent of the sodium sulfate consumption. About 45 percent of the sodium sulfate imports were received from Belgium and Luxembourg, 42 percent from Canada, 5 percent from West Germany, 4 percent from East Germany, and 4 percent from the Netherlands.

There was a favorable balance of trade in sodium compounds for 1971. The value of exports exceeded the value of imports by $12.6 million.

Tariff rates for sodium compounds in effect at the beginning of 1971 and 1972 are shown in the following tabulation:

	Tariff: Dollars per Short Ton	
	January 1, 1971	January 1, 1972
Sodium carbonate:		
Calcined (soda ash)	$3.00	$2.40
Hydrated and sesquicarbonate	3.00	2.00
Sodium sulfate:		
Crude (salt cake)	Free	Free
Anhydrous	0.30	0.25
Crystallized (glauber salt)	.60	.50

Table 3.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1969	324	$10,326	91	$2,644
1970	336	12,007	55	1,668
1971	437	15,400	66	1,825

Table 4.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	264	$4,477	22	$324	286	$4,808
1970	243	4,224	26	529	269	4,753
1971	236	4,108	33	559	269	4,667

[1] Includes glauber salt as follows; 1969, 153 tons ($6,935); 1970 and 1971 none.

WORLD REVIEW

Argentina.—The construction of a large industrial complex at Bahia Blanca, reported in the 1970 yearbook, has apparently been cancelled. For the present, this prohibits large potential caustic soda and soda ash production and leaves the country, still dependent upon imports of these commodities.[2]

Bulgaria and Hungary.—The Governments of Bulgaria and Hungary have agreed to coordinate their soda production efforts. Between 1971 and 1975, Hungary is scheduled to supply soda manufacturing equipment to Bulgaria, and, in return, Bulgaria is to ship 120,000 tons per year of soda to Hungary.[3]

Canada.—A new manufacturer of sodium sulfate, Kaiser Strontium Products, Ltd., of Point Edward, Nova Scotia, started operations in 1971 with a production capacity of 35,000 tons per year.[4]

Japan.—Japan is said to have produced 1,250,000 tons of soda ash in 1971 and has

[2] U.S. Embassy, Buenos Aires. State Department Airgram. No. A–130, Mar. 20, 1972, pp. 1–3.

[3] Chemical Age (London). Hungarian-Bulgarian Soda Link-Up. V. 100, No. 2648, Apr. 17, 1970, p. 24.

[4] Mining Annual Review. Mining Journal (London). Sodium Sulfate. June 1971, p. 253.

planned to increase this figure to 1,350,000 tons per year in the future. It is probable that the increasing demand for soda ash will require importation of up to 224,000 tons from the United States by 1975.[5]

In 1971, Japan set up voluntary controls on the export of certain commodities, which included caustic soda and sodium sulfide. The controls include shipment to all destinations and will regulate the quantity and price of all shipments.[6]

Mexico.—Information on 1970 Mexican sodium production is given below in short tons:

Caustic soda	198,000
Soda ash	403,000
Sodium sulfate	198,000

Exports of sodium sulfate totaled 33,000 tons in 1970.[7]

Turkey.—A new soda ash plant was being built at Mersin, South Anatolia, Turkey, by a French-Polish team. The plant is to have a production capacity of 150,000 tons per year and is due to begin production in 1972.[8]

The 1970 production of sodium sulfate in Turkey was 18,000 tons.[9]

U.S.S.R.—Russian soda ash production increased 4 percent in 1971 to 3.82 million tons.[10]

TECHNOLOGY

A new type of fuel cell or battery, which has been devised by Lockheed Missiles and Space Co., utilizes a highly alkaline metal such as sodium or lithium for an electrode. The innovation is said to increase the electrical power per pound from 10 to 100 times over a conventional lead-acid battery. Such batteries may be used in pollution-free electric automobiles of the future.[11]

A large, fully commercial, sulfur dioxide absorption unit, which utilizes regenerable sodium sulfite as a reagent, is in operation at Paulsboro, N.J. Tail gas from a sulfuric acid plant flowing at 45,000 cubic feet per minute has its SO_2 content lowered from 4500 to 6000 parts per million units to 200 to 300 parts per million units by the process. The sodium sulfite reacts with the sulfur dioxide to form sodium bisulfite, which can be thermally regenerated to its original form. The sulfur dioxide is recycled through the sulfuric acid plant.[12]

The U.S. Food and Drug Administration has been notified by the Hebrew University-Hadassah medical school in Jerusalem that the common food preservative, sodium nitrite, may cause brain damage in laboratory rats. The material is also believed to pass from mother rats to their offspring and may cause excessive deaths and poor growth of the survivors.[13]

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[5] Japan Chemical Review. Outlook for 1972—Soda Products. December, 1971, p. 80.
[6] U.S. Embassy, Tokyo. State Department Airgram. No. A-567, July 21, 1971 (items No. 30 and 34 on p. 2, of enclosure No. 4).
[7] U.S. Embassy, Mexico. State Department Airgram. No. A-375, July, 1971, p. 7.
[8] European Chemical News. Polimex and Krebs Link for Turkey Soda Ash Unit. V. 20, No. 493, Aug. 13, 1971, p. 18.
[9] U.S. Embassy Ankara. State Department Airgram. No. 10. A-62, Mar. 21, 1972.
[10] European Chemical News. U.S.S.R. Production Advances in 1971. V. 21, No. 518, Feb. 4, 1972, p. 6.
[11] Chemical and Engineering News. Lockheed Develops New Fuel Cell. V. 50, No. 9., Feb. 28, 1972. p. 57.
[12] Chemical Engineering. SO_2 Absorbed From Tail Gas With Sodium Sulfite. V. 78, No. 27, Nov. 29, 1971, pp. 43–45.
[13] Chemical and Engineering News. Sodium Nitrite Hazard. V. 49, No. 44, Oct. 25, 1971, p. 26.

Stone

By Harold J. Drake [1]

Production of stone in 1971 totaled 876 million tons valued at $1.6 billion. Although volume was up only slightly from that of 1970, total value increased about 9 percent. Output of dimension stone rose about 5 percent in quantity and declined 2 percent in value; output of crushed stone was up 1 and 10 percent in quantity and value respectively.

The increase in volume was limited by a softness in demand in some segments of the construction industry. Both public and private nonresidential construction showed little real growth, which offset somewhat the gains recorded in residential construction. In addition, declines in building permits in some major consuming centers in 1969 and 1970 were reflected in reduced output of stone in 1971. The increase in the total value of stone in 1971 was primarily due to construction costs that steadily increased until the middle of August, at which time the Government introduced a nationwide price and wage freeze. Costs and prices of stone were then stabilized for the remainder of the year.

Legislation and Government Programs.—The U.S. Tariff Commission instituted an investigation under Section 301(b)(1) of the Trade Expansion Act of 1962 (TEA) in response to a petition filed by the National Association of Marble Producers. The purpose of the investigation was to determine whether certain dimension marble, travertine, and articles thereof were, as a result, in major part of concessions granted thereon under trade agreements, being imported into the United States in such increased quantities as to cause, or threaten to cause, serious injury to the domestic industry or industries producing like or directly competitive products. A public hearing was held June 15–16, 1971, and on September 13, 1971, the Commission reported to the President, the results of the investigation.[2]

The Commission was equally divided in its findings with regard to injury to the domestic industry. Under Section 330(d) TEA, the Commission was required to transmit the findings of each group to the President, who could then consider the findings of either group to be the findings of the Commission. The President accepted the view that the industry was threatened with serious injury but declined to impose increased tariffs on imported marble and travertine. The President instead, in order to make domestic producers and fabricators more competitive vis-a-vis their foreign counterparts, decided to eliminate the duty on all unfinished and some semifinished marble and travertine imports, which are vital to the U.S. industry. In addition, the President decided to permit firms and workers producing marble and travertine products for structural uses to apply for trade adjustment assistance. Firms certified by the Secretary of Commerce as eligible to receive adjustment assistance may receive loans and loan guarantees, technical assistance, and certain tax relief. Workers certified by the Secretary of Labor as eligible may receive cash adjustment allowances, counseling, training, and relocation allowances if needed.

The U.S. Department of Transportation issued a report on usage factors per million dollars of major highway construction [3] of the various aggregate materials used in highway construction. The Department estimated that aggregates account for 21 to 31 percent of the cost of all materials and

[1] Physical scientist, Division of Nonmetallic Minerals.

[2] U.S. Tariff Commission. Marble and Travertine Products. TC Pub. 420, September 1971, 87 pp.

[3] U.S. Department of Transportation. Highway Construction Usage Factors for Aggregates, 1968–69–70. August 1971, 5 pp.

supplies and between 10 and 14 percent of the total construction cost exclusive of right-of-way and engineering costs. The usage factors are intended to aid commercial pit and quarry operators and others to estimate future aggregate requirements for expanded highway construction programs.

The Federal Metal and Nonmetallic Mine Safety Act has been in effect since 1966, and the development of safety standards under it is still occurring. In 1971, more than 50 new mandatory standards went into effect. These standards, and those of earlier years, are enforced principally by the Bureau of Mines through a program of inspection and closure of mine areas found not in compliance. Many States were developing plans that would allow them to carry out inspection and enforcement. Such plans require Department of the Interior approval and do not preclude Bureau of Mines inspections, safety evaluations, and mine closures.

The impact of surface mining on the environment continued to concern environmentalists and the aggregate mining industry. Problems of air and water pollution, land reclamation, damage from blasting, and diminution of esthetic values were under study, and many aggregate producers were taking positive steps to eliminate them. Because of these problems, numerous bills have been introduced in Congress to regulate surface mining. None of the bills were enacted into law in 1971.

One of the most pressing problems facing aggregate producers is the restoration of mined-out land. Planned restoration involving progressive rehabilitation of the landscape during mining operations is probably the ideal solution.[4] Restoration at the end of the life of quarries entails a major outlay of capital, which may be beyond the financial capability of many quarry operators. A number of U.S. producers are engaged in land reclamation concurrent with their mining operations. American Aggregates Corp. Greeneville, Ohio, a pioneer in land restoration of exhausted quarries, now turns mined-out areas into recreational, residential, or commercial developments that may yield to the company more than did the aggregate production. Other mining companies are also discovering unexpected benefits from planned utilization of reclaimed land.

Environmental consideration became paramount to Elmhurst-Chicago Stone Co., Elmhurst, Ill., when urban encroachment engulfed its aggregate producing facilities.[5] The company continued to operate by reducing dust, noise, and blasting vibration. Dust was controlled by covering all outside conveyors, using dust collectors on screening operations, and by using a street sweeper on roads and in loading areas. In the quarry, roads were oiled and sprinkled. The company also determined the maximum blasting vibration that did not cause damage and then seismographically monitored each shot to insure that it was well below this vibration level.

[4] Clouston, J. Brian. The Role of the Landscape Architect in Quarrying. Quarry Managers' J., v. 55, No. 2, February 1971, pp. 39–44.
[5] Rock Products. Quarry Thrives in Urban Area. V. 75, No. 2, February 1972, pp. 58–60.

Table 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
Shipped or used by producers:					
Dimension stone	2,011	2,060	1,867	1,565	1,648
Value	$95,472	$98,441	$98,547	$95,157	$93,375
Crushed stone	783,581	817,537	861,021	867,628	874,068
Value	$1,144,772	$1,219,469	$1,326,047	$1,374,441	$1,508,016
Total stone [2]	785,592	819,597	862,889	r 869,193	875,716
Value [2]	$1,240,244	$1,317,911	$1,424,594	$1,469,598	$1,601,391
Exports (value)	$11,156	$9,969	$10,223	$10,396	$11,488
Imports for consumption (value)	$19,823	$24,629	$30,548	$35,674	$33,643

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

DIMENSION STONE

DOMESTIC PRODUCTION

Production of dimension stone in 1971 increased about 5 percent in quantity and declined 2 percent in value from the 1970 levels. The increase in production is attributed to a decline in the volume of imports of dimension stone. Production totaled 1.6 million tons valued at $93 million.

Output of dimension granite in 1971 was marked by little change in volume from 1970 and a 15-percent decline in value. Output of limestone and dolomite was off 3 percent in quantity and up 1 percent in value. A 19-percent increase in output of marble in 1971 was accompanied by a 35-percent increase in value. Production of sandstone, quartz, and quartzite was up 21 percent in volume but down 5 percent in value. Slate production was nearly unchanged from 1970, but some unspecified varieties of dimension stone recorded sizable production gains.

CONSUMPTION AND USES

Apparent consumption of dimension stone, continuing the trend of recent years, declined in value to $118.4 million, a level 2 percent below that of 1970. Consumption of domestically produced dimension stone was off about 2 percent and that of imported stone decreased 3 percent. Domestic producers supplied about three-fourths and foreign producers supplied about one-fourth of the U.S. market for dimension stone.

In terms of value, apparent consumption of granite, which normally accounts for about two-fifths of total consumption, totaled $46.2 million, off about 14 percent. Consumption of marble totaled $30.2 million, compared with $26.4 million in 1970. Consumption of limestone and siliceous stone, such as sandstone and quartzite, which are supplied mainly by U.S. producers, was higher by 1 and lower by 5 percent, respectively, from the 1970 levels. Increases in use were recorded for slate and other kinds of stone.

Monumental granite is believed to be the largest use category, in terms of value, of dimension stone. Domestic consumption of dressed monumental granite is estimated to have exceeded $60 million in 1971. The bulk of the quantities consumed was produced by independent fabricators purchasing both foreign and domestic rough granite. Use of dressed architectural stone of all types in 1971 was valued at an estimated $60 million.

PRICES

Average values for dimension stone in 1971, as reported to the Bureau of Mines, are listed as follows, in dollars per ton:

	Building		Monumental, rough and dressed	Flagging
	Rough	Dressed		
Granite	$22.23	$54.76	$85.83	--
Marble	43.64	267.56	--	--
Limestone	20.08	51.35	--	$12.29
Sandstone	16.93	44.88	--	--
Slate	--	180.36	--	28.30
Miscellaneous	16.67	68.42	--	--

FOREIGN TRADE

U.S. exports of dimension stone rose about 6 percent to $3.9 million. About two-fifths was dolomite shipped mainly to Venezuela, Chile, and Canada. Approximately 30 percent consisted of undifferentiated monumental, building and paving stone, the great bulk of which went to Japan and Italy. The remainder consisted mainly of marble shipments to Canada and small quantities of slate, also to Canada.

U.S. imports of dimension stone declined slightly in 1971 to $29 million. Of total imports, marble accounted for about 43 percent; granite, 26 percent; slate, 12 percent; and travertine, 9 percent. The remainder consisted of limestone, quartzite, and unspecified dimension stone and products thereof. Imports of granite, nearly all of which was monumental, paving, and building stone, were off 6 percent, those of marble and travertine off 5 percent each. Imports of slate, limestone, and some unspecified stone registered small increases.

Imports of dressed monumental, paving and building stone totaled $15.6 million in 1971, compared with $17.1 million in 1970. Principal items in 1971 were 6.7 million square feet of marble slabs and paving tiles valued at $6.7 million and 745,601 cubic feet of dressed granite valued at $6.1 million. Imports of marble breccia, and onyx manufactures totaled $5.6 million.

Italy and Portugal supplied the great bulk of the marble and travertine imports. Canada and Italy accounted for most of the imported granite, which consisted almost entirely of monumental, paving, and building stone. Numerous other countries supplied the remainder in small quantities.

WORLD REVIEW

Burma.—Production of dimension marble has been below expectations in recent years. The industry, established with Italian assistance, consists of two quarries at Lawpita and a small processing plant at Loikaw. The plant is equipped with two gang saws, three polishing machines, and a number of other cutting and shaping machines. Plant output, currently several thousand square feet per year of marble flooring, is sold locally.

Italy.—The principal kinds of dimension stone produced in Sardinia in recent years were granite and marble.[6] Annual production is believed to exceed 50,000 tons, most of which comes from the Province of Cagliari. The principal granite-producing districts are Gallura in the north and Santa Antioco in the southwest. Santa Antioco is also the site of important marble deposits, as is Mount Gonare. Planned expansion of dimension stone production is contingent on improvement and modernization of production facilities.

Mozambique.—Granite production in 1970, the latest year for which detailed statistics are available, totaled 705,000 short tons valued at $1.1 million. Granite was produced by six operators in the Zambezia district, by 16 in the Mocambique district, and by one in the Vila Pery district. Exports to the United States in 1970, totaled 2,039 cubic feet of granite blocks.

Sweden.—Production of dimension stone in 1970, totaled 180,000 short tons, of which 57,000 tons were black to green granite and 47,500 tons were sandstone blocks. The remainder comprised quartzite, marble, limestone, other granite, and gneiss.

TECHNOLOGY

Rapid expansion of industrialization in recent years has resulted in deterioration not only of stone art works but of many buildings built with stone.[7] Sulfur dioxide is believed to be the most potent cause of decay in building and monumental stone. Chemical reactions between industrial waste gases and varieties of dimension stone should be carefully evaluated in order to insure the selection of the proper stone to use.

CRUSHED STONE

DOMESTIC PRODUCTION

Production of crushed stone in 1971 totaled 874 million tons valued at $1.5 billion, compared with 868 million tons valued at $1.4 billion in 1970. Output of crushed limestone and dolomite was up slightly, output of granite and siliceous rock was up 7 and 28 percent, respectively. Production of crushed marble, shell, traprock, and other stone declined somewhat. Production of marl was nearly double that of 1970.

Changing methods of transportation through the years have had a profound impact on the crushed stone industry.[8] Not only have these changes sharply increased demand for crushed stone, they have led to greater mechanization, new management techniques, new and improved machinery and mining methods, and to the establishment of use standards and specifications. The National Crushed Stone Association was formed in 1918 to unite and give guidance to crushed stone producers in order that they might successfully overcome the many problems facing them. In another vein, economic transportation of crushed stone and other mineral commodities to consuming areas is of vital importance.[9] In the future, forms of transportation that require a high labor input and whose maintenance and replacement are high have to be held to a minimum. Conveyor systems must become more efficient, and they will be augmented increasingly by overland transport of solid materials by pipelines.

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[6] Industrial Minerals. Sardinia's Ornamental Stone. No. 50, November 1971, pp. 24–25.

[7] De Gast, A. A., and M. Sensupta. Environmental Deterioration and Evaluation for Dimension Stone. Can. Min. and Metal. Bull., v. 65, No. 717, January 1972, pp. 54–58.

[8] Carter, William L. Crushed Stone-Transportation Advances Expand Demand. Rock Products, v. 74, No. 10, October 1971, pp. 90–94, 164.

[9] Robinson, C. W. What's Ahead in Transportation. Min. Eng., v. 23, No. 12, December 1971, pp. 40–43.

Methods needing further study include air transport and the use of air-cushioned vehicle systems to transport minerals.

The cost of transporting crushed stone by water is significantly less than that for rail or truck.[10] In certain cases, it is more economic to locate a manufacturing plant in a consuming center on a navigable waterway and ship the crushed stone to it. It may also be more economic to supply a plant, located at a depleted quarry, with crushed stone transported by boat rather than abandoning the entire operation.

Development of measuring methods, standards and monitoring systems are essential to the control of dust in mining operations.[11] Current measuring techniques are being studied and improved, and many companies are moving towards nearly complete elimination of dust. When Kentucky Stone Co., Russellville, Ky., replaced its old crushed stone plant, elimination of dust was a major goal.[12] All screens, conveyors, bins, hoppers, and chutes were covered and a high-volume, dry-filter system installed to collect dust. Water sprays, sometimes containing dust-control chemicals, were used at conveyor feed points, the quarry drill, stockpiles, and other points that could not be adequately covered. The use of dust-suppressant compounds was one company's answer to stringent anti-pollution regulations.[13] The chemical suppressant, which coats and agglomerates dust particles to prevent them from becoming airborne, is applied at feeding and discharging points and at screening operations. To meet Hawaii's antipollution regulations, Pacific Cement and Aggregates Co., Halawa, Hawaii, uses dust suppression systems on all drills and conveyor transfer points in addition to paving some areas and constantly wetting others.[14] Noise is suppressed with mufflers on engines and soundproofing coatings applied to bins, transfer chutes, and baffles.

Articles on noise pollution in the aggregate industry and a description of a sanitary landfill operation conducted concurrently with aggregate production were published.[15] [16] [17]

Processed rubble may become an abundant source of natural aggregates for the construction industry.[18] Those areas faced with aggregate depletion and those where aggregate resources are made unavailable by zoning restrictions and environmental control regulations may have to rely on recycling rubble generated by the deliberate destruction of pavements and buildings. Another type of recycling in the mining industry is the use of mined out underground areas for storage, office, and factory operations.[19] Virtually no upkeep of the underground facilities is required, the danger of fire is minimal, and the cost to control the internal climate is considerably less.

Portable plants continued to be an important ancillary facility utilized by producers to solve a number of problems. In one operation, a portable plant was used to process stone from a cluster of quarries.[20] In another, cooperation between an aggregate producer and a highway contractor led to the purchase and use of a large portable unit that supplied crushed stone to both.[21] The contractor supplied the raw materials from road cuts and was reimbursed for shooting and hauling the rock to the plant site. A portable primary crusher combined with movable field conveyors was used to supply a stationary plant when the quarrying operations moved away from the stationary plant.[22] A portable agricultural stone plant system consisting of a portable crusher and a portable secondary drying and grinding plant was

[10] Holm, A. R. and B. R. Bowman. Great Lakes Water Transportation Offers Lower-Cost Shipping. Rock Products, v. 74, No. 11, November 1971, pp. 42–45.

[11] Cochrane, T. S. Routine Dust Measurements and Standards. Can. Min. and Metal. Bull., v. 65, No. 717, January 1972, pp. 46–50.

[12] Trauffer, Walter E. Kentucky Stone Co.'s New Dustless Plant. Pit and Quarry, v. 64, No. 6, December 1971, pp. 70–75.

[13] Rock Products. Dust Suppressant Clears the Air at General Crushed Stone Plant. V. 74, No. 8, August 1971, p. 63.

[14] Rock Products. CP&A Keeps Dust and Noise to a Minimum at Halawa. V. 74, No. 4, April 1971, pp. 56–58.

[15] Hosking, Paul C. In-Plant Noise: Unwanted Byproduct of Cement Manufacture. Rock Products, v. 74, No. 8, August 1971, pp. 55, 84–85.

[16] Levine, Sidney. Sanitary Landfill Operation Teams With Aggregate Production. Rock Products, v. 74, No. 9, September 1971, pp. 57–59.

[17] Stearn, Enid W. Noise the Newest Pollutant. Rock Products, v. 74, No. 8, August 1971, pp. 49–54.

[18] Marek, Charles R., Bob M. Gallaway, and Robert E. Long. Look at Processed Rubble.—It's a Vital Source of Aggregates. Roads and Streets, v. 114, No. 9, September 1971, pp. 82–85.

[19] Yearich, Bob. After-Use of Limestone Mines. Quarry Managers' J., v. 55, No. 12, December 1971, pp. 413–416.

[20] Levine, Sidney. Portable Plant Works Permanent Quarries on "Cluster" Concept. Rock Products, v. 74, No. 6, June 1971, pp. 78–79.

[21] Herod, Sandy. Portables Aid Producer in Construction Service. Pit and Quarry, v. 64, No. 2, August 1971, pp. 93–95.

[22] Rock Products. Southeastern Materials Quarries With Portable Primary Crusher. V. 74, No. 9, September 1971, pp. 60–61, 96.

utilized to supply areas in Florida and Georgia where demand did not justify the installation of permanent plants.[23] The problems of reducing massive limestone to a fine powder cheaply and efficiently was solved in a unique way by constructing a self-contained movable crushing plant that included a complete dust collection system, control room, and a separate movable electrical room.[24] A substantial saving in the cost of production was achieved by this type of operation. A cost analysis of crushed-stone-producing operation indicates that the entire operating system from blasting to secondary crushing must be analyzed in order to lower overall costs.[25] The analysis shows that mobile crushers often lead to the elimination of much of the costly truck maneuvering and waiting time.

CONSUMPTION AND USES

Consumption of crushed stone in 1971 totaled 874 million tons valued at $1.5 billion, which represents increases in quantity and value of 1 and 10 percent, respectively, over that of 1970. Consumption of limestone and dolomite, at 628 million tons valued at 1 billion dollars, was only slightly above that in 1970. Consumption of crushed granite increased 7 percent in quantity and 18 percent in value; the value of crushed traprock consumed in 1971 rose 9 percent not withstanding a 2-percent decline in volume. Sharp gains in consumption were recorded for marl, sandstone, quartz, and quartzite. Shell consumption declined slightly, as did that for other types of crushed stone.

Use of crushed stone by the construction industry recorded modest gains in 1971. Aggregate use, which accounts for nearly 55 percent of crushed stone consumption, was up about 2 percent, and the gain in the quantities used in the manufacture of cement amounted to 5 percent. Use of crushed stone as dense-graded road-base stone, the largest use category, increased about 1 percent. Other large uses recording gains included manufactured fine aggregate, and lime manufacture. Declines in consumption were reported for agricultural stone, riprap, railroad ballast, flux stone, and others.

Plant expansion to meet increased demand was reported by many companies. Productive capacity was increased 30 percent, processing efficiency raised, and quality control improved at one plant.[26] Reduction of labor requirements by 55 percent and secondary blasting by 65 percent were some of the achievements of an El Paso, Tex., aggregate producer,[27] and a Hillsboro, Ohio, producer increased capacity 50 percent in addition to installing central control, simultaneous wet and dry processing, a wet and dry dust-control system, and increased flexibility within the individual processing stages.[28] Continuous modernization and expansion allowed some companies to meet steadily broadening markets[29], and judicious stockpiling gave other companies a high degree of flexibility in meeting ever-changing consumption patterns.[30]

PRICES

Quotations in Engineering News-Record for carload lots of 1½-inch crushed stone in 1971, exclusive of discounts, ranged from $6.00 per ton in Minneapolis to $1.65 per ton in Birmingham. The average price reported for 15 major cities was $3.37 per ton. Prices for ¾-inch crushed stone ranged from $6.00 per ton in Minneapolis to $1.65 per ton in Birmingham. The average price for 16 major cities was $3.41 per ton.

Prices per ton for industrial fillers and extenders, as reported in the American Paint Journal, were as follows:

Silica, amorphous, ultrafine-ground	$69.00
Silica, crystalline	$20.50–45.40
Whiting, precipitated, surface-treated	$48.00
Whiting, dry-ground, 325 mesh	$14.25–19.00
Whiting, precipitated, U.S.P	$50.00–117.00
Whiting, precipitated, technical	$33.00–44.00
Whiting, natural, water-ground	$39.00

[23] Trauffer, Walter E. Dixie's New High-Volume Portable Agstone Operation. Pit and Quarry, v. 64, No. 4, October 1971, pp. 83–86, 110.

[24] Durie, W. Cameron. Portable Crusher Aids Efficiency at PC&A Quarry. Rock Products, v. 74, No. 8, August 1971, pp. 69–71.

[25] Andreas, A. Mobile Crushing Plants.—Key to Continuous Haulage? Rock Products, v. 74, No. 9, September 1971, pp. 83–84, 86.

[26] Herod, Sandy. New York Operation Produces Pulverized Limestone Materials. Pit and Quarry, v. 64, No. 5, November 1971, pp. 64–66, 96.

[27] Pit and Quarry. El Paso Rock Modernizes Pit and Plant Systems. V. 64, No. 5, November 1971, pp. 81–83, 112.

[28] Herod, Sandy. Ohio Quarry Firm Builds Versatile Plant. Pit and Quarry, v. 64, No. 4, October 1971, pp. 70–75.

[29] Rock Products. Easy Route to Output. V. 74, No. 8, August 1971, pp. 64–66.

[30] Robertson, Joseph L. Stockpile Inventory Sets Product Schedule. Rock Products, v. 74, No. 11, November 1971, pp. 50–53.

FOREIGN TRADE

Exports of crushed stone totaled 2.4 million tons valued at $7.6 million in 1971, increases of 12 and 13 percent, respectively, over the levels of the preceding year. About 75 percent of the exports consisted of limestone, and 25 percent was of unspecified types of stone. The great bulk of crushed stone exports were shipped to various countries in North America, but Canada was by far the principal market.

Imports of crushed stone declined 15 percent in quantity and 21 percent in value to 2.5 million tons valued at $3.7 million. The volume of crushed limestone was off 6 percent and that of other crushed stone was off 26 percent. Imports of dry-ground whiting rose 32 percent to 18,017 tons, whereas imports of precipitated chalk whiting declined slightly to 1,699 tons.

WORLD REVIEW

Australia.—Production of limestone, notwithstanding plentiful deposits, accounts for about 20 percent of total crushed stone output.[31] Limestone does not occur as close to consuming centers as does basaltic rock which is, therefore, much more commonly used as an aggregate in construction. Total crushed stone output generally amounts to about 55 million tons per year. Principal uses are in concrete, construction, and paving. Limestone is used, in descending order of importance, in cement manufacture, steel production, concrete, lime, agriculture and others.

Ireland.—Dublin is the locale for the establishment of one of Western Europe's largest crushed stone quarry complexes.[32] Completion date for the project was the spring of 1972 and total output is expected to reach 2.5 million tons a year. Production units include a concrete plant and an asphalt plant and units to produce crushed stone, mortar, macadam, and other related products.

Sweden.—Underground mining of sandstone for use as aggregate or as a constituent of building materials was proven feasible.[33] Because the sandstone bed was thin and had a weak roof, a system of long and comparatively narrow rooms divided by pillars was chosen to exploit the deposit. Efficient use of labor and equipment was achieved by the intense application of production engineering techniques. A favorable labor contract contributed materially to cost control.

United Kingdom.—The black-top industry, including its aggregate-producing segment, was examined in detail with emphasis on the organization of and factors that currently effect the industry.[34] In recent years, the total market has sharply increased, but the net return on the large sums of capital invested in the industry has fallen. Changes in manufacturing techniques, a radical reduction in the number of specifications, and new surface application techniques were among the suggestions made to improve the returns.

TECHNOLOGY

The need for well-performing pavement structures is being met through improved knowledge of factors that influence pavement performance and a greater emphasis on analytical design procedures.[35] Principal variables that must be taken into consideration when designing pavements are traffic characteristics, raw materials, type of construction, and environmental characteristics of the area. Quality control of materials production and construction and the use of a total system concept are probably the most important goals of pavement designers. Improved base course performance is dependent on improved testing and understanding of the raw materials used.[36] The design of flexible pavements requires a high degree of engineering judgment particularly with regard to the selection of materials and thicknesses of the various layers.

Crushing of aggregate rock using underwater electric sparks gave mixed results.[37] Products have better shapes and size distri-

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[31] Hoskins, K. C. The Use of Limestone in Australia. Limestone, v. 8, No. 29, 1971, pp. 13, 41–45.

[32] The Quarry Managers' Journal. New Roadstone Quarry Near Dublin. V. 55, No. 11, November 1971, p. 402.

[33] Gising, Bjorn. Underground Extraction of Sandstone. Quarry Managers J., v. 54, No. 4, April 1970, pp. 117–122.

[34] Beckett, J. M. Problems and Opportunities of the Black-Top Industry. Quarry Managers J., v. 55, No. 11, November 1971, pp. 371–378.

[35] Goodwin, William A. Pavement Design—Where Are We Today? Limestone, v. 8, No. 29, Fall 1971, pp. 16, 47–49, 51.

[36] Bloem, D. L., and R. D. Gaynor. The Case for Graded Aggregate Base course. Cement, Lime and Gravel, v. 46, No. 5, May 1971, pp. 124–125.

[37] Carley-Macauly, K. W., and J. W. Hitchon. Electrohydraulic Crushing of Aggregates. Quarry Managers' Journal, v. 55, No. 8, August 1971, pp. 261–270.

bution than those from conventional crushing but the cost is higher. Waste limestone was converted to salable ground products using a roller mill equipped with air heater, automatic controls, and dust collection devices.[38]

A wide range of earthmoving units are available for quarrying operations and the selection of the right machine results from an analysis of the quarrying method desired, the type of stone involved, and the volume of output desired.[39] Although the trend in recent years has been to rubber tired front-end loaders, the new faster and more maneuverable power shovels perform well in quarry operations.[40] A cost comparison of ripping versus blasting in quarrying indicated that it was more economical to rip.[41] Prevention of unnecessary repairs to trucks and other quarry vehicles was accomplished by fairly strict adherence to a servicing schedule.[42]

Improper use of ammonium nitrate fuel oil (ANFO) explosives that result in poor fragmentation may offset the lower cost of these blasting agents.[43] It is suggested that the use of a high-energy bottom charge can result in significant cost savings to quarry operators. Although ANFO is much safer to handle than many other types of explosives, problems arise particularly when it is purchased in bulk.[44]

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[38] Rock Products. Roller Mill System Converts Waste Stone to Salable Products. V. 74, No. 6, June 1971, pp. 63, 91.

[39] Rock Products. Which Earthmoving Units Will Meet Your Needs? V. 74, No. 10, October 1971, pp. 127–134.

[40] Wedertz, R. L. The Power Shovel in the Quarry. Rock Products, v. 74, No. 10, October 1971, pp. 126, 182–184.

[41] Roshet, W. J. Will Quarry Ripping Work for You. Rock Products, v. 74, No. 9, September 1971, pp. 16–67.

[42] Vincent, R. M. 100-Hour Service Schedule Keeps Trucks Operating. Rock Products, v. 74, No. 8, August 1971, pp. 75, 88.

[43] Borg, David G. How Blasting Techniques Affect Overall Cost. Rock Products, v. 74, No. 4, April 1971, pp. 77–78.

[44] Dannenberg, Joe. How To Solve Blasting Materials-Handling Problems. Rock Products, v. 74, No. 9, September 1971, pp. 63–65.

Table 2.—Stone shipped or used by producers in the United States by State
(Thousand short tons and thousand dollars)

State	1970		1971	
	Quantity	Value	Quantity	Value
Alabama [1]	19,882	$37,166	17,773	$34,413
Alaska	6,470	10,014	2,658	5,066
Arizona	3,511	7,094	2,873	5,848
Arkansas	15,284	22,786	17,116	35,677
California	r 41,080	r 61,630	43,336	86,255
Colorado	3,552	8,076	3,785	7,933
Connecticut	8,338	16,915	7,193	15,649
Florida	[1] 43,089	[1] 61,302	42,816	64,332
Georgia	26,635	59,200	30,669	69,897
Hawaii [1]	6,332	15,538	6,056	14,357
Idaho	[1] 4,240	[1] 6,368	4,149	6,118
Illinois	55,776	86,502	[1] 61,991	[1] 106,084
Indiana	25,818	45,215	26,233	48,218
Iowa	25,305	41,119	[1] 25,389	[1] 44,977
Kansas	15,161	22,406	[1] 14,908	23,697
Kentucky	29,311	[1] 45,208	[1] 32,514	[1] 52,296
Louisiana [1]	9,059	11,660	9,688	14,139
Maine	W	[1] 2,311	1,133	2,913
Maryland	16,015	32,783	15,912	34,770
Massachusetts	[1] 8,008	[1] 24,349	7,816	23,582
Michigan	41,687	49,501	40,705	49,240
Minnesota	4,579	[1] 7,000	5,838	14,346
Mississippi	W	W	848	938
Missouri	39,726	[1] 57,285	41,099	[1] 64,772
Montana	[1] 6,501	[1] 6,896	W	W
Nebraska	4,265	7,378	4,174	7,892
Nevada	1,860	2,722	2,531	3,800
New Hampshire	W	[1] 845	429	3,433
New Jersey [1]	15,160	40,567	13,469	36,057
New Mexico [1]	3,100	4,030	2,913	5,337
New York	37,616	68,118	37,778	73,418
North Carolina	30,363	54,121	30,917	58,026
North Dakota	103	126	W	W
Ohio	47,244	81,506	46,891	88,372
Oklahoma	18,177	23,701	19,449	27,125
Oregon	13,439	20,948	13,794	26,708
Pennsylvania	[1] 66,119	120,187	64,467	118,469
Rhode Island	W	W	[1] 3	[1] 422
South Carolina	9,710	[1] 14,734	11,047	17,852
South Dakota	1,979	13,375	2,199	8,874
Tennessee	35,374	50,013	32,369	48,665
Texas	45,557	64,422	41,168	[1] 62,144
Utah	1,650	4,320	2,556	5,335
Vermont	1,514	19,088	2,498	28,135
Virginia	35,415	60,477	34,643	63,482
Washington	13,701	19,100	12,436	20,489
West Virginia	[1] 9,740	[1] 16,722	9,880	[1] 18,066
Wisconsin	17,577	25,167	15,568	25,105
Wyoming	1,266	2,758	2,894	4,789
Undistributed	2,906	16,850	9,145	23,882
Total [2]	r 869,193	r 1,469,598	875,716	1,601,391
Pacific Island Possessions	678	1,375	723	1,726
Puerto Rico	7,296	13,947	12,130	29,847
Virgin Islands	514	2,226	2,236	W

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed" (excluding possessions).
[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	
1967	63,073	$133,664	68,483	$116,913	2,232	$35,245	569,463	$799,687	22,026	$33,334
1968	70,506	148,333	73,117	125,476	2,559	32,372	603,740	873,634	20,268	28,563
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	628,796	961,013	21,713	31,035
1971	92,956	201,616	75,318	160,582	1,717	34,860	628,625	1,031,441	18,537	30,088
	Calcareous marl		Sandstone, quartz, and quartzite		Slate		Other stone [2]		Total [3]	
1967	1,227	$1,084	27,249	$60,494	1,260	$14,615	30,580	$45,208	785,592	$1,240,244
1968	1,211	1,166	27,010	63,416	1,273	14,412	19,914	30,539	819,597	1,317,911
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	r 28,925	r 39,738	r 869,193	r 1,469,598
1971	3,459	4,504	30,729	84,630	1,234	13,810	23,143	39,860	875,716	1,601,391

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	1970 Short tons	1970 Cubic feet	1970 Value	1971 Short tons	1971 Cubic feet	1971 Value
GRANITE						
Rough:						
Architectural	43	497	$1,255	60	651	$1,987
Construction [1]	55	692	535	56	687	592
Monumental	200	2,386	17,160	194	2,248	11,067
Other rough stone [2]	3	25	17	([3])	5	27
Dressed:						
Cut	54	630	10,109	W	W	W
Sawed [4]	7	87	875	11	128	991
House stone veneer	7	74	602	6	72	492
Construction	19	234	1,774	18	228	1,425
Monumental	25	298	7,317	33	385	8,416
Curbing	159	1,870	5,762	151	1,818	5,579
Flagging	W	W	W	1	12	W
Paving blocks	W	W	W	W	W	W
Other dressed stone [5]	5	55	111	44	530	7,963
Total [6]	577	6,847	45,517	575	6,764	38,538
LIMESTONE AND DOLOMITE						
Rough:						
Architectural	161	2,081	3,402	219	2,939	4,681
Construction [1]	67	830	714	43	526	581
Flagging [7]	18	225	150	17	212	209
Other rough stone	6	77	39	W	W	W
Dressed:						
Cut	76	996	5,897	59	792	5,558
Sawed	47	611	2,194	38	515	1,755
House stone veneer	68	871	2,048	61	800	1,881
Construction [8]	13	154	453	21	259	356
Flagging [9]	1	18	30	2	22	38
Other dressed stone	27	335	W	7	93	65
Total [6]	482	6,197	14,926	468	6,159	15,122
MARBLE						
Rough:						
Architectural	10	111	456	11	126	480
Construction [1]	r 3	r 33	r 72	W	W	W
Dressed:						
Cut	23	274	7,659	25	285	8,949
Sawed	8	92	1,485	8	90	1,376
House stone veneer, Construction, Monumental	[10] 20	237	3,381	32	374	6,799
Total [6]	63	746	13,053	75	875	17,604
SANDSTONE, QUARTZ, AND QUARTZITE						
Rough:						
Architectural	43	562	673	34	441	599
Construction [1]	83	1,132	1,178	40	504	654
Flagging [11]	18	223	W	W	W	1,739
Dressed:						
Cut	58	764	3,873	68	942	3,187
Sawed [12]	56	732	2,161	50	668	2,227
Flagging [13]	30	372	1,067	18	240	689
Other uses not listed or unspecified	4	52	1,706	142	1,791	1,063
Total [6]	291	3,837	10,658	352	4,586	10,157
SLATE						
Roofing slate [14]	22	--	1,842	25	--	2,250
Millstock:						
Structural and sanitary	18	--	3,137	18	--	3,153
Blackboards, etc. [15]	2	--	652	4	--	815
Total	20	--	3,789	22	--	3,968
Flagging	39	--	1,160	37	--	1,047
Other uses not specified	18	--	1,897	13	--	1,511
Total [6]	99	--	8,688	96	--	8,777
OTHER STONE [16]						
Rough:						
Architectural	W	W	30	6	70	77
Construction [1]	27	337	365	30	214	523
Other rough stone [17]	W	W	W	W	W	W

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

(Thousand)

Kind of stone and use	1970 Short tons	1970 Cubic feet	1970 Value	1971 Short tons	1971 Cubic feet	1971 Value
OTHER STONE[16]—Continued						
Dressed:						
Cut [18]	r 2	r 27	$169	1	8	$117
Construction [19]	5	76	W	W	W	W
Flagging	W	W	W	W	W	154
Total [20]	43	543	2,044	67	640	2,875
TOTAL STONE						
Rough:						
Architectural	259	3,287	$5,839	331	4,232	$7,840
Construction [1]	239	3,086	2,908	183	2,101	2,515
Monumental	200	2,391	17,173	195	2,254	11,083
Flagging	34	428	903	132	1,666	1,904
Other rough stone [21]	10	128	100	3	38	66
Dressed:						
Cut	212	2,685	27,661	194	2,524	25,536
Sawed	89	1,162	5,946	81	1,062	5,548
House stone veneer	111	1,401	4,411	100	1,291	4,044
Construction	36	446	2,081	42	523	1,861
Roofing (slate) [14]	22	--	1,842	25	--	2,250
Millstock (slate)	20	--	3,789	22	--	3,968
Monumental	32	378	9,302	49	571	13,715
Curbing	161	1,886	5,822	170	2,049	5,991
Flagging	81	516	2,522	68	388	2,067
Miscellaneous uses [22]	58	506	4,857	53	503	4,889
Total [6]	1,565	18,299	95,157	1,648	19,201	93,275

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes irregular shaped stone and rubble.
[2] Includes flagging and other unspecified rough stone.
[3] Less than ½ unit.
[4] Includes other uses not listed or unspecified.
[5] Includes figures where symbol W appears to avoid disclosing individual company confidential data.
[6] Data may not add to totals shown because of independent rounding.
[7] Data includes small amounts of monumental and other rough stone (1971 only).
[8] To avoid disclosing confidential data, figure shown includes value data for other dressed stone not listed (1970 only).
[9] Data includes small amount of dressed monumental stone.
[10] Data combined to avoid disclosing confidential data; also includes flagging, other dressed stone not listed and 1971 rough construction figures where symbol W appears.
[11] Data includes small amounts of other rough stone and monumental (1970); also, figures where W appears are withheld to avoid disclosing confidential data and are included with "Other uses not listed or unspecified."
[12] Includes dressed stone used for house stone veneer and construction.
[13] Includes stone for curbing.
[14] Includes minor amount of slate used for house stone veneer.
[15] Includes slate for electrical purposes and billiard table tops.
[16] Produced by the following States in 1971, in order of value of output and with number of quarries: Virginia (2), Illinois (1), California (10), Maryland (4), New Jersey (1), Hawaii (2), Pennsylvania (2), Oregon (2), Arizona (2), New Mexico (2), and Washington (3).
[17] Includes minor amount of rough stone used for flagging.
[18] Includes sawed stone and house stone veneer.
[19] Includes stone used for structural and sanitary purposes.
[20] To avoid disclosing individual company confidential data, figures indicated by symbol W are included in "Total", for other stone.
[21] Includes small amount of 1971 data for unspecified uses of rough stone.
[22] Data includes stone used for paving blocks, structural and sanitary purposes (excluding slate), and other unspecified uses.

Table 5.—Granite (dimension stone) shipped or used by producers in the United States in 1971, by State

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
California	8	5,111	$345	Rhode Island	1	2,572	$422
Georgia	28	188,513	6,243	South Carolina	5	11,519	468
Massachusetts	7	97,294	3,437	South Dakota	6	35,643	5,654
Missouri	1	1,798	346	Washington	1	82	W
New York	4	16,455	733	Wisconsin	9	6,493	1,886
Oklahoma	5	4,131	417	Other States [1]	52	204,960	18,589
Oregon	2	272	W				
				Total [2]	129	574,843	38,538

W Withheld to avoid disclosing individual confidential data; included with "Other States."
[1] Includes quarries in Colorado (3), Connecticut (3), Maine (2), Maryland (1), Minnesota (15), New Hampshire (2), North Carolina (14), Pennsylvania (2), Texas (2), and Vermont (8).
[2] 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 1971, by State

State	Active quarries [1]	Short tons	Value (thousands)	State	Active quarries [1]	Short tons	Value (thousands)
Illinois	1	3,505	$60	Ohio	5	6,960	$84
Indiana	20	300,275	9,753	Oklahoma	3	1,820	29
Kansas	7	W	503	Virginia	1	821	W
Michigan	3	735	26	Wisconsin	29	72,208	1,350
Minnesota	6	12,666	1,677	Other States [2]	15	62,413	1,566
Nebraska	2	5,966	75				
New York	1	500	W	Total [3]	93	467,869	15,122
				Puerto Rico	3	142,000	441

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 (3), Colorado (1), Iowa (5), Missouri (1) and Texas (4).
[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 1971, by State

State	Active quarries [1]	Short tons	Value (thousands)	State	Active quarries [1]	Short tons	Value (thousands)
Arizona	42	9,954	$185	Pennsylvania	17	42,101	$943
Arkansas	4	5,741	132	Tennessee	4	8,076	356
Colorado	23	8,327	159	Utah	4	1,447	70
Connecticut	3	4,210	62	West Virginia	1	260	W
Missouri	1	820	33	Wisconsin	7	2,180	96
Montana	1	29	W	Wyoming	1	376	W
New York	7	29,333	1,610	Other States [2]	25	162,762	2,413
Ohio	17	76,082	4,098				
				Total	157	351,698	10,157

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 California (3), Georgia (2), Indiana (3), Kansas (1), Maryland (4), Massachusetts (1), Minnesota (1), New Jersey (1), New Mexico (1), North Carolina (2), Virginia (4), and Washington (2).

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1970 and 1971, by kind of stone and use

(Thousand short tons and thousand dollars)

Kind of stone and use	1970		1971	
	Quantity	Value	Quantity	Value
CALCAREOUS MARL [1]				
Agricultural purposes [2]	178	$181	217	$593
Surface-treatment aggregates	3	2	--	--
Cement manufacture	[3] 1,558	[3] 1,372	1,821	1,721
Other uses [4]	--	--	1,420	2,191
Total [5]	1,739	1,554	3,459	4,504
GRANITE				
Agricultural purposes [6]	W	875	W	1,609
Concrete aggregate (coarse)	16,127	24,465	19,337	28,945
Bituminous aggregate	11,945	20,326	15,159	29,527
Macadam aggregate	2,820	4,207	3,623	6,601
Dense-graded road-base stone	28,162	46,072	28,853	49,217
Surface-treatment aggregate	4,477	7,172	5,216	9,107
Unspecified construction aggregate and roadstone	12,609	19,569	7,307	11,240
Riprap and jetty stone	2,275	4,621	3,118	5,623
Railroad ballast	4,513	6,356	5,388	8,108
Filter stone	W	W	133	319
Fill	W	W	165	168
Other uses [7]	3,205	4,131	4,081	12,613
Total [5]	86,133	137,795	92,381	163,078
LIMESTONE AND DOLOMITE				
Agricultural purposes [6]	37,945	70,483	32,058	62,450
Concrete aggregate (coarse)	95,879	154,730	96,373	155,818
Bituminous aggregate	42,312	70,082	47,591	83,730
Macadam aggregate	24,573	37,390	27,617	43,542
Dense-graded road-base stone	124,897	171,019	130,515	195,178
Surface-treatment aggregate	35,567	52,550	34,070	55,445
Unspecified construction aggregate and roadstone	57,694	89,118	56,570	92,735
Riprap and jetty stone	11,560	14,277	11,016	16,725
Railroad ballast	6,387	8,583	6,153	8,925
Filter stone	747	1,636	378	620
Manufactured fine aggregate (stone sand)	3,116	5,100	4,507	7,442
Terrazzo and exposed aggregate	82	767	116	1,366
Cement manufacture	95,946	104,928	100,770	119,853
Lime manufacture	25,989	47,440	27,361	52,460
Dead-burned dolomite	1,990	3,262	1,565	2,808
Ferrosilicon	714	1,032	997	W
Flux stone	29,462	45,262	24,234	38,823
Refractory stone	374	1,023	949	W
Chemical stone for alkali works	4,215	7,533	3,033	7,226
Special uses and products [8]	877	4,385	975	3,900
Mineral fillers, extenders and whiting	2,698	17,250	2,891	21,368
Fill	3,706	2,727	1,426	1,201
Glass	1,156	3,823	1,452	5,644
Other uses [9]	8,541	19,284	10,722	31,079
Uses not specified	8,886	12,406	4,816	7,981
Total [5]	625,313	946,087	628,157	1,016,318
MARBLE				
Agricultural purposes [6]	72	247	60	175
Concrete aggregate (coarse)				
Dense-graded road-base stone				
Unspecified construction aggregate and roadstone				
Riprap and jetty stone	[10] 446	2,418	410	1,380
Filter stone				
Manufactured fine aggregate (stone sand)				
Terrazzo and exposed aggregate	157	2,436	160	2,580
Mineral fillers, extenders and whiting	966	14,564	[11] 1,010	[11] 13,121
Other uses	[12] 53	[12] 803	W	W
Uses not specified	27	213	W	W
Total [5]	1,722	20,681	1,641	17,256
SANDSTONE, QUARTZ, AND QUARTZITE [13]				
Concrete aggregate (coarse)	2,709	4,313	2,790	5,634
Bituminous aggregate	2,282	4,886	2,489	4,385
Macadam aggregate	429	578	349	457
Dense-graded road-base stone	8,082	12,902	8,017	14,718
Surface-treatment aggregate	510	1,110	793	2,088
Unspecified construction aggregate and roadstone	2,871	5,123	3,842	8,197
Riprap and jetty stone	2,008	4,039	1,068	2,791
Railroad ballast	608	893	610	890
Filter stone	28	80	17	60

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1970 and 1971, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1970		1971	
	Quantity	Value	Quantity	Value
SANDSTONE, QUARTZ, AND QUARTZITE[13]—Continued				
Manufactured fine aggregate (stone sand)	293	$456	245	$1,010
Terrazzo and exposed aggregate	75	1,370	56	1,006
Cement manufacture	698	1,053	610	1,063
Ferrosilicon	[14] 337	[14] 1,473	294	1,105
Flux stone	870	3,370	1,333	5,335
Refractory stone	255	2,503	255	3,379
Special uses and products [8]	[15] 50	[15] 303	[15] 42	[15] 199
Glass	W	W	967	4,082
Other uses [16]	1,662	4,075	1,605	5,114
Uses not specified	W	W	4,996	12,960
Total [5]	23,768	48,526	30,378	74,473
SHELL				
Concrete aggregate (coarse)	3,962	4,903	6,406	8,858
Dense-grade road-base stone	5,277	6,983	2,600	2,755
Unspecified construction aggregate and roadstone [17]	1,943	3,507	1,842	3,900
Cement manufacture	4,343	6,060	4,859	7,218
Other uses [18]	6,188	9,583	2,830	7,357
Total [5]	21,713	31,035	18,537	30,088
TRAPROCK				
Concrete aggregate (coarse)	9,702	20,894	9,153	25,139
Bituminous aggregate	12,047	25,059	11,282	24,260
Macadam aggregate	2,982	5,241	1,801	3,703
Dense-graded road-base stone	14,467	22,588	14,478	24,796
Surface-treatment aggregate	9,042	13,314	3,956	7,046
Unspecified construction aggregate and roadstone	20,305	42,112	22,234	44,224
Riprap and jetty stone	1,983	3,704	3,056	6,087
Railroad ballast	1,496	2,430	989	1,589
Filter stone	W	W	87	W
Manufactured fine aggregate (stone sand)	162	W	196	W
Fill	1,941	1,651	398	W
Other uses [19]	3,089	9,399	7,673	23,437
Total [5]	77,217	146,391	75,303	160,281
OTHER STONE				
Concrete aggregate (coarse)	869	1,498	1,127	2,703
Bituminous aggregate	2,453	4,797	2,567	5,014
Macadam aggregate	145	226	203	364
Dense-graded road-base stone	7,161	8,383	4,919	7,706
Surface-treatment aggregate	1,301	1,761	818	1,199
Unspecified construction aggregate and roadstone	4,065	5,082	5,753	9,651
Riprap and jetty stone	r 9,019	r 11,334	3,170	4,914
Railroad ballast	2,027	1,968	1,538	1,287
Mineral fillers, extenders and whiting	65	65	W	W
Fill	1,107	1,120	W	W
Other uses [20]	670	1,331	1,559	2,299
Uses not specified	W	131	1,422	1,847
Total	r 28,881	r 37,693	23,076	36,985
TOTAL STONE				
Agricultural purposes [6]	38,985	74,786	33,705	69,066
Concrete aggregate (coarse)	129,532	211,411	135,440	227,641
Bituminous aggregate	71,554	126,013	79,088	146,916
Macadam aggregate	31,085	47,674	33,593	54,666
Dense-graded road-base stone	188,094	268,017	190,342	296,117
Surface-treatment aggregate	50,938	75,971	45,507	76,277
Unspecified construction aggregate and roadstone	98,802	163,565	96,969	168,624
Riprap and jetty stone	r 26,859	r 37,998	21,428	36,140
Railroad ballast	15,032	20,229	14,678	20,799
Filter stone	838	1,828	618	1,320
Manufactured fine aggregate (stone sand)	4,081	8,298	5,513	10,367
Terrazzo and exposed aggregate	317	4,583	337	4,985
Cement manufacture	102,573	113,485	108,115	129,971
Lime manufacture	27,580	49,657	30,380	56,562
Dead-burned dolomite	2,050	3,652	1,565	2,808
Ferrosilicon	991	2,115	1,290	2,899
Flux	30,332	48,632	25,567	44,158
Refractory	629	3,526	1,204	6,745
Chemical stone for alkali works	4,215	7,533	r 3,033	7,226
Special uses and products [8]	920	4,658	1,017	4,099
Mineral fillers, extenders and whiting	3,896	32,310	5,116	37,155
Fill	6,820	5,587	3,279	3,351
Glass	1,688	5,533	2,420	9,726

See footnote at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1970 and 1971, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1970		1971	
	Quantity	Value	Quantity	Value
TOTAL STONE—Continued				
Other uses [21]	16,895	$37,041	16,989	$54,275
Uses not specified	12,925	20,342	16,875	36,123
Total [5]	r 867,628	r 1,374,441	874,068	1,508,016

r Revised. W Withheld to avoid disclosing individual company confidential data.

1 Produced by the following States in 1971, in order of tonnage: South Carolina, Florida, Virginia, Texas, Michigan, Mississippi, California, Indiana, North Carolina, Minnesota, and Nevada.

2 Includes marl used in agricultural limestone, and agricultural marl and other soil conditioners and nutrients; 1971 data also includes stone used in poultry grit and mineral food, and other fillers.

3 Data includes small amount of fill and minor amounts of unspecified uses.

4 Data includes stone used in dense-graded road-base stone, lime manufacture, and unspecified uses.

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

6 Includes agricultural limestone, agricultural marl and other soil conditioners, and poultry grit and mineral food.

7 Includes stone used in manufactured fine aggregate, terrazzo, cement, drain fields, roofing aggregate, unspecified uses, and any data represented by the symbol W in granite; 1971 data also includes stone used in other fillers.

8 Includes stone used for abrasives and mine dusting.

9 Data include stone used in building products, chemicals, sugar refining, paper manufacture, roofing aggregate other uses in smaller quantities, and any data represented by symbol W in limestone and dolomite.

10 Data combined to avoid disclosing confidential data.

11 Includes a minor amount of stone used in roofing aggregate and any data represented by the symbol W in marble.

12 Data include some stone used in roofing aggregate and other uses in smaller quantities.

13 Includes ground sandstone, quartz, and quartzite.

14 Includes small amount of dead-burned dolomite.

15 1970 data include stone used in asphalt filler; 1971 data represents abrasives only.

16 Includes stone used for agricultural purposes, roofing aggregate, fill, dam construction (1970), other uses in small quantities, and any data represented by symbol W in sandstone, quartz, and quartzite.

17 Includes stone used in surface-treatment aggregate; 1970 data also include bituminous and macadam aggregate, and a smaller amount of riprap and jetty stone.

18 Includes stone used in agricultural purposes, lime manufacture, asphalt filler, other fillers (1971) and uses not specified (1970).

19 Data include stone used in agricultural lime, asphalt and other fillers, drain fields, roofing aggregate, uses not specified, and any data represented by the symbol W in traprock.

20 Includes stone used for agricultural purposes, cement, roofing aggregate, other uses in smaller quantities, and data represented by the symbol W in other stone.

21 Data include stone used in roofing aggregate, building products, chemicals, expanded slate, and other uses in smaller quantities.

Table 9.—Number and production of crushed-stone quarries in the United States, by size of operation

Annual production (short tons)	1970			1971		
	Number of quarries	Production		Number of quarries	Production	
		Thousand short tons	Percent of total		Thousand short tons	Percent of total
Less than 25,000	1,656	14,840	1.7	1,872	15,827	1.8
25,000 to 49,999	538	19,205	2.2	597	21,367	2.4
50,000 to 74,999	352	21,824	2.5	341	21,139	2.4
75,000 to 99,999	267	22,697	2.6	233	19,903	2.3
100,000 to 199,999	614	87,295	r 10.1	528	75,968	8.7
200,000 to 299,999	278	68,090	r 7.9	308	76,174	8.7
300,000 to 399,999	224	76,819	r 8.9	238	82,898	9.5
400,000 to 499,999	159	71,582	r 8.3	147	65,838	7.5
500,000 to 599,999	102	55,869	6.4	99	53,974	6.2
600,000 to 699,999	71	46,266	5.3	78	50,291	5.8
700,000 to 799,999	59	43,647	5.0	49	36,559	4.2
800,000 to 899,999	49	41,901	4.8	54	45,692	5.2
900,000 and over	181	r 297,594	r 34.3	185	308,439	35.3
Total [1]	4,550	r 867,628	100.0	4,729	874,068	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	1970		1971	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	r 633,940	73	646,509	74
Rail	89,646	11	86,610	10
Waterway	79,572	9	71,154	8
Other	27,341	3	25,340	3
Unspecified	37,128	4	44,455	5
Total [1]	r 867,628	100	874,068	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 1971, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	81	$379	North Carolina	23,960	$41,546
Arkansas	4,953	W	Rhode Island	261	W
California	5,919	12,584	South Carolina	8,362	13,594
Colorado	490	759	Virginia	10,532	18,826
Georgia	24,167	38,849	Washington	886	W
Massachusetts	1,447	3,395	Wisconsin	1,080	995
Minnesota	W	775	Wyoming	553	W
Montana	W	162	Other States [1]	7,415	26,535
New Jersey	2,274	4,680	Total [2]	92,381	163,078

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Idaho, Maryland, Michigan, Missouri, Nevada, New Hampshire, New York, Oregon, Pennsylvania, Texas, and Vermont.
[2] 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 1971, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	435	W	Oregon	11,899	$23,019
California	2,555	$6,630	Pennsylvania	4,176	7,694
Colorado	382	W	South Dakota	3	6
Connecticut	6,511	12,706	Virginia	3,552	7,126
Hawaii	4,533	10,818	Washington	9,283	14,081
Idaho	802	1,764	Wyoming	193	W
Maryland	3,624	7,754	Other States [1]	12,588	32,347
Massachusetts	4,204	9,299			
Michigan	9	14	Total	75,303	160,281
Minnesota	50	145	American Samoa	1	5
New Jersey	10,504	26,878	Virgin Islands	2,236	W

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alaska, Maine, Missouri, Montana, New Hampshire, New Mexico, New York, North Carolina, Texas, Vermont, and Wisconsin.

Table 13.—Limestone and dolomite (crushed and broken) shipped or used by producers in the United States in 1971, by State and use

(Thousand short tons and thousand dollars)

State	Agriculture [1]		Aggregates		Riprap		Railroad		Fluxing stone		Miscellaneous and undistributed		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	679	$1,162	8,429	$11,360	W	W	W	W	451	$1,112	5,914	$,8190	15,473	$21,824
Alaska	--	--	--	--	W	W	--	--	--	--	W	W	W	W
Arizona	W	W	W	W	--	--	--	--	175	387	1,374	2,496	1,548	2,884
Arkansas	519	1,175	3,145	5,742	W	W	W	W	W	W	3,406	4,372	7,070	11,288
California	89	428	W	W	--	--	--	--	W	W	23,187	43,686	23,275	44,115
Colorado	--	--	W	W	W	W	W	W	W	W	2,623	5,708	2,623	5,708
Connecticut	45	W	W	W	--	--	--	--	W	W	149	1,385	194	1,385
Florida	720	2,468	32,023	47,689	--	--	W	W	--	--	7,934	9,898	40,676	60,055
Georgia	W	W	3,147	5,694	W	W	W	W	--	--	2,220	4,968	5,366	10,662
Hawaii	W	98	700	2,386	W	W	--	--	--	--	486	562	1,186	3,045
Idaho	--	--	--	--	--	--	--	--	--	--	W	W	W	W
Illinois	4,113	6,643	45,618	73,433	637	$919	752	$1,157	758	1,105	5,468	10,740	57,346	93,997
Indiana	1,845	3,270	20,015	30,442	248	767	459	645	29	46	3,303	3,129	25,899	38,298
Iowa	1,870	4,305	18,297	32,977	254	492	W	W	W	W	4,967	7,203	25,389	44,977
Kansas	629	947	9,897	16,214	142	287	W	W	--	--	3,681	4,779	14,349	22,227
Kentucky	1,779	3,046	21,920	36,313	3,409	4,677	312	425	W	W	3,938	6,506	31,358	50,969
Maine	W	W	W	W	--	--	--	--	--	--	W	2,221	W	2,221
Maryland	W	W	6,893	12,493	W	W	W	W	W	W	2,919	6,642	9,812	19,135
Massachusetts	W	W	W	W	--	--	--	--	W	W	919	5,014	919	5,014
Michigan	481	533	10,026	13,355	595	696	W	W	10,740	14,392	17,663	17,369	39,504	46,344
Minnesota	241	491	4,278	5,942	32	68	W	W	W	W	588	1,043	5,138	7,544
Mississippi	W	W	W	W	W	W	--	--	--	--	738	717	738	717
Missouri	3,277	5,675	22,508	33,536	1,898	1,969	W	W	W	W	12,560	21,864	40,244	63,044
Montana	--	--	W	W	--	--	--	--	W	W	1,326	2,195	1,326	2,195
Nebraska	181	787	2,274	4,441	W	W	--	--	--	--	1,713	2,589	4,168	7,817
Nevada	--	--	W	W	--	--	--	--	W	W	1,361	W	1,361	W
New Jersey	W	W	145	W	--	--	--	--	W	W	W	W	W	W
New Mexico	--	--	1,515	2,988	W	W	--	--	W	W	739	1,460	2,254	4,448
New York	451	1,669	22,975	43,507	511	1,035	228	432	W	W	9,545	11,464	33,710	58,108
North Carolina	W	W	W	W	W	W	--	--	--	--	5,649	9,860	5,649	9,860
North Dakota	--	--	--	--	W	W	--	--	--	--	W	W	W	W
Ohio	1,654	3,081	27,589	43,051	558	773	750	1,077	3,567	5,824	11,141	23,623	45,258	77,428
Oklahoma	W	W	7,652	10,685	109	192	W	W	--	--	10,200	14,198	17,961	25,075
Oregon	W	W	W	W	--	--	--	--	W	W	W	W	W	W
Pennsylvania	1,620	4,392	32,654	54,964	165	278	196	308	3,787	7,500	14,941	24,297	53,362	91,740
Rhode Island	W	W	--	--	--	--	--	--	W	W	W	W	W	W
South Carolina	W	W	W	W	--	--	--	--	--	--	W	W	W	W
South Dakota	--	--	816	1,075	W	W	W	W	--	--	610	546	1,426	1,621
Tennessee	1,391	1,907	26,577	38,288	123	206	W	W	W	W	4,061	6,551	32,152	46,952
Texas	327	453	20,758	32,171	457	710	632	826	487	659	9,064	11,495	31,725	46,314
Utah	W	W	W	W	--	--	--	--	W	W	1,731	3,878	1,731	3,878
Vermont	W	W	W	W	W	W	--	--	--	--	767	W	767	W
Virginia	1,218	2,691	11,944	18,126	23	36	170	240	393	826	4,552	7,821	18,299	29,740
Washington	8	W	--	--	--	--	--	--	W	W	856	1,231	865	1,231
West Virginia	93	222	3,608	6,543	W	W	779	1,020	W	W	4,665	8,690	9,145	16,475
Wisconsin	616	1,336	12,631	16,489	W	W	W	W	W	W	396	1,041	13,644	18,866

Wyoming	--	--	32	91	W	W	W	W	--	--	1,473	2,175	1,505	2,266
Total [2]	23,846	46,779	378,066	599,995	9,161	13,105	4,278	6,130	20,387	31,851	188,827	301,606	624,417	999,468
Undistributed	8,212	15,677	14,670	26,453	1,855	3,620	1,875	2,795	3,847	6,972	3,594	16,850	3,740	16,850
Pacific Island Possessions	--	--	722	1,721	--	--	--	--	--	--	--	--	722	1,721
Puerto Rico	--	--	7,386	14,164	--	--	--	--	--	--	2,276	1,692	9,662	15,856

W Withheld to avoid disclosing individual 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 1971, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Louisiana	9,688	$14,139
Texas	5,985	8,482
Other States [1]	2,863	7,467
Total [2]	18,537	30,088

[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 1971, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
California	54	W
Indiana	29	$26
Michigan	119	111
Mississippi	111	222
Other States [1]	3,146	4,145
Total	3,459	4,504

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Florida, Minnesota, Nevada, North Carolina, 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 1971, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	447	$1,077	Pennsylvania	4,637	$9,985
Arkansas	4,932	8,416	South Dakota	716	1,540
California	4,572	9,977	Texas	2,405	5,510
Colorado	131	473	Utah	W	148
Georgia	33	W	Virginia	965	1,797
Illinois	3,429	10,233	West Virginia	719	1,550
Montana	156	W	Wyoming	283	266
New York	455	1,314	Other States [1]	4,259	14,047
North Carolina	49	W			
Ohio	1,550	6,762	Total [2]	30,378	74,473
Oregon	641	1,378			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alabama, Connecticut, Idaho, Kansas, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nevada, New Hampshire, New Mexico, Oklahoma, Tennessee, Vermont, Washington, 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 1971, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	2,363	$3,497	Rhode Island	W	$21
California	6,784	11,421	South Dakota	19	54
Colorado	W	179	Texas	W	1,159
Hawaii	338	494	Utah	706	863
Kentucky	1,156	1,327	Vermont	64	121
Maryland	W	402	Washington	1,240	W
New Mexico	585	757	Other States [1]	7,061	11,991
North Dakota	7	20			
Oregon	828	1,471	Total [2]	23,076	36,985
Pennsylvania	1,927	3,209	Puerto Rico	2,321	13,406

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Arizona, Arkansas, Connecticut, Georgia, Idaho, Illinois, Kansas, Louisiana, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nevada, New Hampshire, New York, North Carolina, Oklahoma, Virginia, West Virginia, Wisconsin, and Wyoming.
[2] 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	
1969	93	$1,809	$863	1,382	$3,189	284	$3,569	$793
1970	77	1,454	877	1,755	3,459	388	3,288	1,318
1971	87	1,639	905	1,822	3,751	585	3,871	1,322

Table 19.—U.S. imports for consumption of stone and whiting, by class

Class	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)
Granite:				
Monumental, paving and building stone:				
Rough ---------- cubic feet --	189,198	$1,147	706,289	$1,395
Dressed, manufactured ---------- do ----	442,794	6,807	745,601	6,111
Not manufactured and not suitable for monumental, paving or building stone --- short tons --	656	13	811	11
Other, n.s.p.f ----------	--	141	--	132
Total ----------	--	8,108	--	7,649
Marble, breccia, and onyx:				
In block, rough or squared ---------- cubic feet --	37,465	389	23,752	268
Sawed or dressed, over 2 inches thick ----- do ----	15,560	129	6,660	65
Slabs and paving tiles ---------- superficial feet --	7,328,874	7,283	6,700,271	6,732
All other manufactures ----------	--	5,532	--	5,565
Total ----------	--	13,333	--	12,630
Travertine stone:				
Rough, unmanufctured ---------- cubic feet --	12,582	56	3,520	15
Dressed, suitable for monumental, paving and building stone ---------- short tons --	111,966	2,726	24,845	2,599
Other, n.s.p.f ----------	--	34	--	52
Total ----------	--	2,816	--	2,666
Limestone:				
Monumental, paving, and building stone:				
Rough ---------- cubic feet --	300	(1)	175	(1)
Dressed, manufactured ---------- short tons --	1,032	51	1,026	102
Crude, not suitable for monumental, paving, or building stone ---------- do ----	19,250	78	19,689	70
Other, n.s.p.f ----------	--	47	--	26
Total ----------	--	176	--	198
Slate:				
Roofing ---------- square feet --	5,109	4	6,100	1
Other, n.s.p.f ----------	--	3,092	--	3,412
Total ----------	--	3,096	--	3,413
Quartzite ---------- short tons --	137,529	739	58,612	411
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures ----------	--	307	--	308
Stone, unmanufactured ---------- short tons --	6,145	107	7,289	232
Building stone, rough ---------- cubic feet --	3,799	5	2,790	5
Building stone, dressed ---------- short tons --	1,389	67	347	33
Other ----------	--	1,802	--	1,764
Total ----------	--	2,288	--	2,342
Stone, chips, spall, crushed or ground:				
Marble, breccia, and onyx chips ----- short tons --	10,284	197	7,923	142
Limestone, chips and spalls, crushed or ground do ----	1,649,484	2,943	1,551,929	2,207
Stone chips and spalls and stone crushed or ground, n.s.p.f ---------- do ----	1,286,758	1,523	949,458	1,320
Slate chips and spalls and slate crushed or ground do ----	54	4	235	2
Total ----------	2,946,580	4,667	2,509,545	3,671
Whiting:				
Whiting, dry, ground, or bolted ------ short tons --	13,623	325	18,017	520
Chalk whiting, precipitated ---------- do ----	1,714	126	1,699	143
Total ----------	15,337	451	19,716	663
Grand total ----------	--	35,674	--	33,643

(1) Less than ½ unit.

Sulfur and Pyrites

By Roland W. Merwin [1] and Ted C. Briggs [2]

Sulfur prices declined to the lowest point in more than 20 years, reaching distress levels for the Frasch industry, the basic source of U.S. supply. This was the result of a worldwide oversupply, the principal causes being very large increases in Canadian production recovered from sour natural gas, increased Polish Frasch production, and worldwide increases in byproduct sulfur production. The oversupply situation was assessed as being basic in nature, rather than cyclic, and was expected to continue over both the short- and long-term ranges.

The U.S. production of sulfur in all forms increased slightly. Production of Frasch sulfur registered a small decline as a result of adverse market conditions and increased producers' stocks, while there was an increase in the nondiscretionary production of recovered elemental sulfur. The production of sulfur in other forms declined somewhat. Exports of sulfur increased in the face of strong competition in foreign markets but at the expense of much lower unit and total values. Imports decreased, both from Canada and Mexico, despite lower prices for sulfur from these sources. The apparent domestic consumption of sulfur in all forms increased slightly. Shipments of sulfur in all forms by domestic producers increased substantially because of increases in exports and domestic consumption and a decline in imports. However, the total value of shipments of sulfur in all forms decreased from $218.5 million in 1970 to $176.6 million in 1971, reflecting a continued deterioration of the sulfur price structure. The average net shipment value f.o.b. mine or plant for Frasch and recovered elemental sulfur, which accounted for 90 percent of the total shipments of sulfur in all forms in 1971, was $17.50 per long ton in 1971, $23.15 in 1970, $27.38 in 1969, and $40.14 per ton in 1968.

[1] Mining engineer, Division of Nonmetallic Minerals.
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Table 1.—Salient sulfur statistics
(Thousand long tons, sulfur content)

	1967	1968	1969	1970	1971
United States:					
Production:					
Native	7,014	7,460	7,146	7,082	7,025
All forms	9,136	9,739	9,540	9,551	9,572
Exports, sulfur	2,193	1,602	1,551	1,433	1,536
Imports, pyrites and sulfur	1,639	r 1,754	1,795	1,667	1,427
Stocks Dec. 31: Producer, Frasch and recovered sulfur	1,954	2,790	3,461	4,038	4,311
Consumption, apparent, all forms [1]	9,251	8,988	9,171	9,134	9,180
World:					
Production:					
Sulfur, elemental	17,948	19,477	20,785	21,749	22,516
Pyrites	9,989	9,591	9,432	10,242	9,830

r Revised.
[1] Measured by quantity sold, plus imports, minus exports.

DOMESTIC PRODUCTION

Native Sulfur.—Native sulfur accounted for 73 percent of the domestic production of sulfur in all forms. All of it was produced from Frasch mines in Texas and Louisiana. No sulfur ore production was reported during the year.

In 1971, 14 Frasch mines produced sulfur; one of these was closed during the year. The producers and mines in Louisiana were Freeport Minerals Co. at Garden Island Bay, Grand Isle, Grande Ecaille, and Lake Pelto; Jefferson Lake Sulphur Co. at Lake Hermitage; and Texas Gulf Sulphur Co. at Bully Camp. The producers and mines in Texas were Atlantic Richfield Co. at Fort Stockton; Duval Corp. at Pecos; Jefferson Lake Sulphur Co. at Long Point Dome; Pan American Petroleum Corp. at High Island (closed in May); and Texas Gulf Sulphur Co. at Boling Dome, Fannett Dome, Moss Bluff Dome, and Spindletop Dome.

Production of domestic Frasch sulfur continued to decline during 1971, being 1 percent less than in 1970, and 6 percent lower than the alltime peak production in 1968. This reflected the efforts of producers to overcome the current oversupply of this product.

Approximately 74 percent of domestic Frasch sulfur production was for domestic consumption, and 22 percent for export. The remaining 4 percent was accounted for by increases and adjustments in producers' stocks.

There was a continuing tendency to concentrate production in the larger low-cost mines to counteract the adverse effects of low sulfur prices. During 1969, nine producers operated 21 mines. By yearend 1971, this was reduced to five producers operating 13 mines. Based on their production during the calendar years prior to closing, these eight closures (two in 1969, five in 1970, and one in 1971) represented an apparent reduction in production potential of 985,000 tons per year, or 14 percent of the average annual production rates for all mines during 1969–71.

The 13 mines remaining in operation at the end of 1971 increased their production over that of 1969 by 640,000 tons, or 10 percent; and over that of 1970 by 202,000 tons, or 3 percent. Five of the mines showed increases in their production rates over those during 1970, and the other eight registered decreases. The five largest mines, with production rates in excess of ½ million tons per year each, accounted for 71 percent of the total Frasch sulfur output for the year. Four medium-sized mines, with production rates of more than 250,000 tons per year each, contributed an additional 20 percent of the year's production. The remaining 9 percent of the output came from five smaller mines, one of which closed during the year.

Ten mines, operated by the Duval Corp., Freeport Minerals Co., and Texas Gulf Sulphur Co. accounted for most of the production. Only a relatively small portion of the output was obtained from the other

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Thousand long tons)

	1968		1969		1970		1971	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:								
Frasch-process mines	7,458	7,458	7,146	7,146	7,082	7,082	7,025	7,025
Other mines	3	2	--	--	--	--	--	--
Total	--	7,460	--	7,146	--	7,082	--	7,025
Recovered elemental sulfur	1,359	1,354	1,422	1,414	1,457	1,449	1,595	1,586
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,315	430	1,583	517	r 1,642	r 537	1,585	518
Pyrites	872	362	821	334	845	339	808	316
Other forms [1]	163	133	150	129	165	144	150	127
Grand total	--	9,739	--	9,540	--	r 9,551	--	9,572

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]
1967	2,956	4,059	7,014	7,682	$251,670
1968	3,203	4,255	7,458	6,645	268,146
1969	3,289	3,857	7,146	6,551	176,659
1970	3,446	3,636	7,082	6,419	151,779
1971	3,408	3,616	7,025	6,756	118,245

[1] Data may not add to totals shown because of independent rounding.
[2] F.o.b. mine or plant.

Table 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States [1]
(Long tons)

Year	Production		Shipments		
	Gross weight	Sulfur content	Gross weight	Sulfur content	Value (thousands)
1967	568	284	568	284	$3
1968	3,125	1,563	3,125	1,563	46
1969	--	--	--	--	--
1970	--	--	--	--	--
1971	--	--	--	--	--

[1] California, Nevada, and Utah.

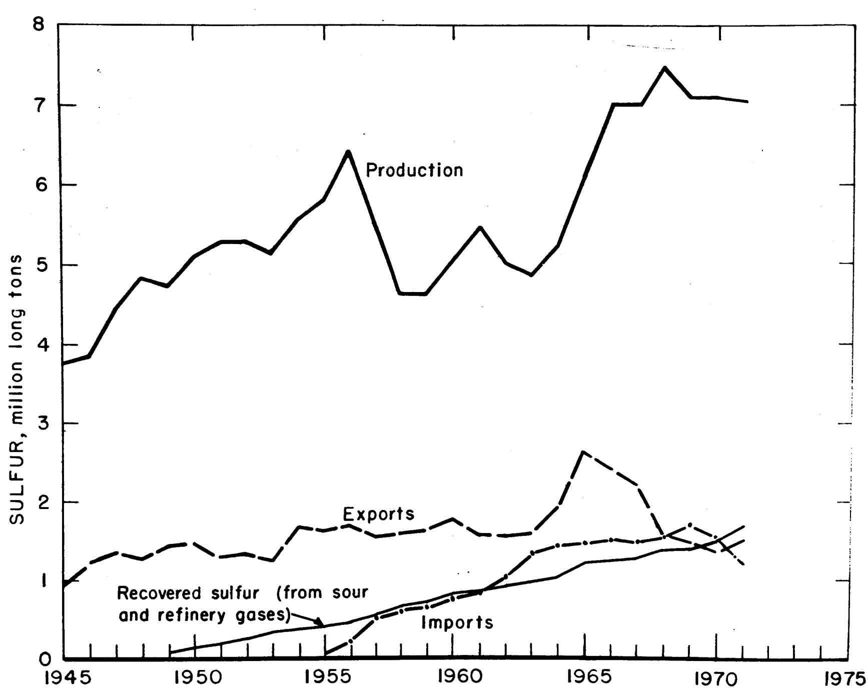

Figure 1.—Domestic Frasch and recovered sulfur production, and imports for consumption and exports of native sulfur.

three producers, operating four mines. By yearend, this was reduced to two companies with three mines.

Producers' shipments of Frasch sulfur increased by 5 percent over those in 1970 as a result of improved demands for domestic consumption and export. However, the total value of the shipments, f.o.b. mine, decreased by 22 percent because of a worldwide oversupply and price-cutting by foreign producers, both abroad and in the domestic market. The average reported shipment value, f.o.b. mine, was only $17.50 per ton as compared with $23.65 per ton in 1970, an abrupt decrease of 26 percent.

Recovered Sulfur.—Elemental recovered sulfur accounted for 17 percent of the total domestic production of sulfur in all forms. It was produced at 106 plants in 24 States. The 10 largest of these plants accounted for 67 percent of the total, and the combined production of the five leading States amounted to 78 percent of the total. Statistics on shipments of recovered sulfur and value for 1971 are as follows:

State	Quantity (long tons)	Value (thousands)
Arkansas	31,127	$579
California	243,375	5,239
Colorado	1,719	9
Florida	3,861	W
New Jersey	52,689	1,542
New Mexico	24,190	294
New York	3,940	W
Oklahoma	1,114	11
Pennsylvania	20,769	438
Texas	770,432	10,336
Wyoming	41,208	709
Other States [1]	378,309	8,326
Total	1,572,733	27,483

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

[1] Combined to avoid disclosing individual company confidential data; includes Delaware, Illinois, Indiana, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, North Dakota, Ohio, and Virginia.

The production was nondiscretionary, as a byproduct from natural gas and petroleum refining operations. As such, it was produced and marketed regardless of demand or price, and generally sold in close proximity to the points of production. Approximately 60 percent was produced at refineries, or at satellite plants treating refinery gases, and 40 percent at natural gas treatment plants.

Production and shipments of this product in 1971 reached alltime highs, with an increase of 9 percent and 8 percent, respectively, over those in 1970. However, the total value of the shipments decreased by 11 percent because of the depressed state of the Frasch sulfur market and competition from Canadian sources in the northern areas of the Nation. The average reported shipment value, f.o.b. plant, was only $17.47 per ton as compared with $21.00 per ton in 1970, a decrease of 17 percent.

The five largest producers of recovered sulfur were Amoco Production Co., Getty Oil Co., Gulf Oil Corp., Shell Oil Co., and Stauffer Chemical Co. Together, their 23 plants accounted for 47 percent of recovered sulfur production.

Byproduct Sulfuric Acid.—The contained sulfur in byproduct sulfuric acid produced at copper, lead, and zinc roasters and smelters during 1971 amounted to 5 percent of the total domestic production of sulfur in all forms. It was produced at 18 plants in 13 States. Six acid plants operated in conjunction with copper smelters, and 12 plants operated as accessories to lead and zinc roasting and smelting operations. The five largest acid plants accounted for 62 percent of the production, and the combined production of five States amounted to 75 percent of the total.

Total production was 4 percent less than in 1970 because of strikes and other adverse conditions affecting the nonferrous smelting industry. The total value of shipments was approximately $21.3 million, or 10 percent less than in 1970, reflecting difficulties in the marketing of this product.

The five largest producers of byproduct sulfuric acid were American Smelting and Refining Co., Kennecott Copper Corp., New Jersey Zinc Co., Phelps Dodge Corp., and St. Joe Minerals Corp. Together, their 10 plants produced 74 percent of the production during 1971.

Pyrites, Hydrogen Sulfide and Sulfur Dioxide.—The contained sulfur in these products accounted for 5 percent of the total domestic production of sulfur in all forms during 1971. Pyrites was produced at six mines in five States; hydrogen sulfide at five plants in two States; and sulfur dioxide at one plant. Output was 8 percent less than in 1970. The value of these combined products was approximately $9.5 million, or 22 percent less than in 1970. Both of these decreases reflected the distressed state of the sulfur industry.

Table 5.—Recovered sulfur produced and shipped in the United States
(Thousand long tons and thousand dollars)

Year	Production		Shipments		
	Gross weight	Sulfur content	Gross weight	Sulfur content	Value [1]
1967	1,270	1,268	1,286	1,284	$40,984
1968	1,359	1,354	1,278	1,273	49,696
1969	1,422	1,414	1,408	1,400	41,037
1970	1,457	1,449	1,471	1,463	30,725
1971	1,595	1,586	1,582	1,573	27,483

[1] F.o.b. mine or plant.

Table 6.—Byproduct sulfuric acid [1] (100-percent basis) produced in the United States
(Short tons)

Year	Copper plants [2]	Lead and zinc plants [3]	Total
1967	348,497	900,170	1,248,667
1968	483,108	989,973	1,473,081
1969	685,775	1,086,938	1,772,713
1970	747,784	r 1,090,817	r 1,838,601
1971	803,284	971,946	1,775,230

r Revised.
[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter in 1967–68. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

The five largest producers of these products were Bethlehem Mines Corp. (pyrites), Phillips Petroleum Co. (hydrogen sulfide), Shell Oil Co. (hydrogen sulfide), Standard Oil Co. of California (hydrogen sulfide), and Cities Service Co. (pyrites and sulfur dioxide). Together, the three mines and five plants accounted for 96 percent of the contained sulfur produced in the form of these products.

CONSUMPTION

The apparent consumption of sulfur, in all forms, increased slightly from that of 1970 and was 1 percent less than the all-time peak consumption in 1967. This stable level of consumption reflected a continued weakness in the fertilizer trade. There were indications that this condition was beginning to improve during 1971.

Sulfur for domestic consumption was obtained mainly from domestic sources: Frasch, 57 percent; recovered, 17 percent; and combined byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 10 percent. The remaining 16 percent of the sulfur was obtained by substantial imports of Frasch and recovered sulfur and by minor imports of pyrites.

Domestic producers of elemental sulfur increased their apparent sales to domestic consumers: Frasch producers by 234,000 tons, or 5 percent over those in 1970; and recovered sulfur producers by 110,000 tons, or 8 percent. The reported sale or use of byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide by domestic producers in the domestic market declined by 58,000 tons, or 6 percent. Imports of elemental sulfur and pyrites for domestic consumption decreased by 240,000 tons, or 14 percent.

Approximately 90 percent of sulfur consumption was in the form of sulfuric acid. The manufacture of fertilizers accounted for approximately 50 percent of all sulfur consumption. Together, plastic and synthetic products, paper products, paints, nonferrous metals production, and explosives accounted for approximately 24 percent of demand. The remaining 26 percent was used for a large number of relatively small individual end uses.

The approximate distribution of consumption was: Southern States, 66 percent; North-Central States, 13 percent; Western States, 12 percent; and Northeastern States, 9 percent.

Table 7.—Apparent consumption of native sulfur in the United States
(Thousand long tons)

	1967	1968	1969	1970	1971
Apparent sales to consumers	r 7,682	r 6,647	6,551	6,419	6,756
Imports	724	r 784	745	539	447
Total	r 8,406	r 7,431	7,296	6,958	7,203
Exports:					
Crude	2,043	1,549	1,549	1,429	1,532
Refined	150	53	2	4	4
Total	2,193	1,602	1,551	1,433	1,536
Apparent consumption (sales plus imports minus exports)	r 6,213	r 5,829	5,745	5,525	5,667

r Revised.

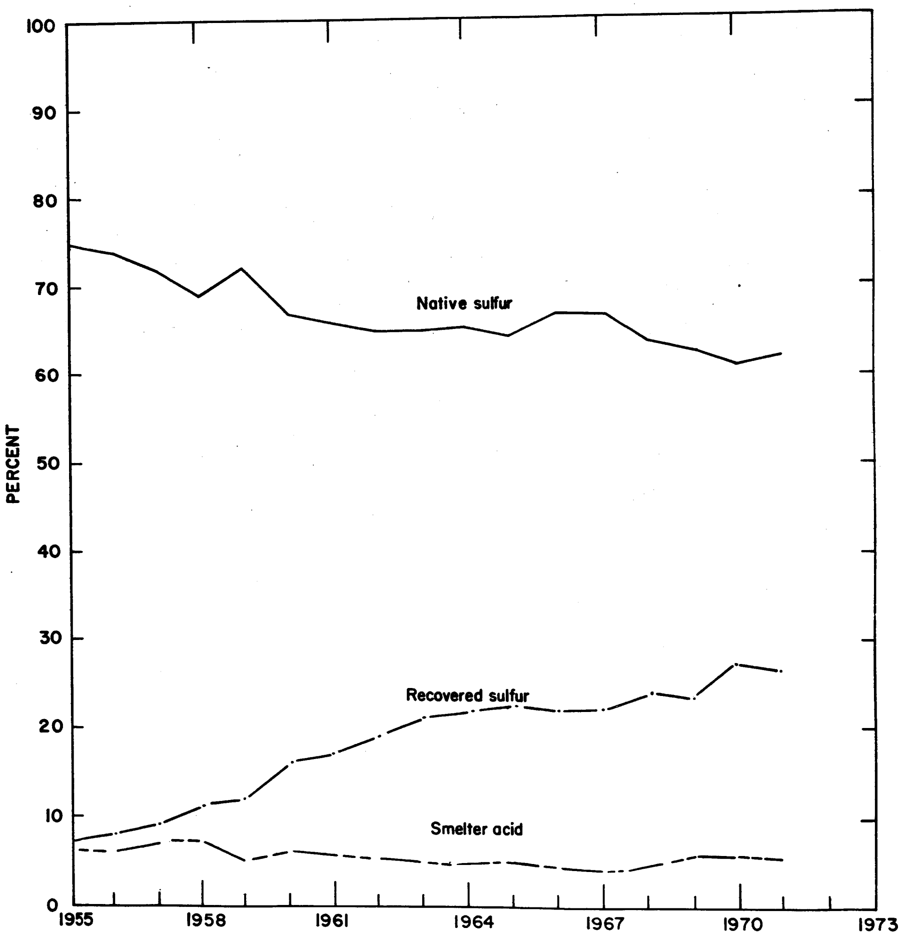

Figure 2.—Sulfur supply sources as a percent of total apparent consumption based on sulfur content.

Table 8.—Apparent consumption of sulfur in all forms in the United States [1]
(Thousand long tons)

	1967	1968	1969	1970	1971
Native sulfur	r 6,213	r 5,829	5,745	5,525	5,667
Recovered sulfur:					
Sales	r 1,284	r 1,273	1,400	1,463	1,573
Imports	750	830	929	998	850
Pyrites:					
Sales	355	362	334	339	316
Imports e	165	140	120	130	130
Smelter acid	364	430	517	r 537	518
Other forms [2]	120	124	126	142	126
Total	r 9,251	r 8,988	9,171	r 9,134	9,180

e Estimated. r Revised.
[1] Crude sulfur or sulfur content.
[2] Includes consumption of hydrogen sulfide and liquid sulfur dioxide.

STOCKS

At yearend, producers' stocks of Frasch sulfur totaled 4,214,313 long tons, an increase of 261,352 tons, or 7 percent, over the stocks on hand at the end of 1970. These stocks were the largest since the yearend of 1964. Yearend stocks of recovered sulfur were 97,115 tons, as compared with 84,819 tons for the previous year. The combined yearend stocks amounted to approximately a 6-month supply, based on the normal domestic and export demands for domestically produced Frasch and recovered sulfur.

PRICES

Firmly based price quotations were not available during the year. Most sales of elemental sulfur, generally in the form of molten sulfur, are made ex-terminal near the points of major 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. It stated that delivered prices at the beginning of the year were: Gulf Coast region, $23 to $25 per long ton; Tampa, Fla., $26 to $27; along the Atlantic Seaboard, $27 to $31; and in the North-Central region about $24 per ton. At yearend these prices were reported as follows: Gulf Coast region, $23 to $26 per ton; Tampa, Fla., $25; Atlantic Coast region from $31 in the south to $36 in New England; and North-Central region about $24 per ton.

FOREIGN TRADE

The United States regained its position as a net exporter of sulfur in all forms. In 1971, exports of elemental sulfur exceeded imports of elemental sulfur and sulfur contained in pyrites by 109,000 long tons. In 1970, imports of sulfur in these forms exceeded exports by 234,000 tons. The improvement in the export-import balance reflected strenuous efforts on the part of domestic producers to maintain their competitive position in the domestic and world markets in the face of strong foreign competition and low price levels.

Exports were almost entirely in the form of elemental Frasch sulfur. The tonnage of elemental sulfur exported during 1971 was 7 percent greater than in 1970. However, the total value decreased by 16 percent, with an average reported value of $18.18 per ton in 1971 and $23.16 per ton in 1970. Together, Belgium and the Netherlands received 60 percent of these exports, mainly for transshipment to other European Economic Community (EEC) countries. Brazil, with 14 percent, was the third largest customer. Exports to the United Kingdom were very low, reflecting a virtual loss of this formerly important customer to foreign competition.

Imports of sulfur consisted mainly of recovered sulfur from Canada and Frasch sulfur from Mexico, both of which were considerably lower in 1971 than in 1970. The total quantity of elemental sulfur imported was 16 percent less than in 1970, and the total value decreased by 26 percent. The average reported value in 1971 was $19.60 per ton, whereas in 1970 the average was $22.22.

Estimated imports of pyrites from Canada in 1971 were 260,000 tons, containing 130,000 tons of sulfur, approximately the same as during 1970. (U.S. Bureau of Census data do not include all shipments.)

Acting under the provisions of the Antidumping Act, the U.S. Government investigated the sales of Mexican elemental sulfur within the United States. On April 2, 1971, the Bureau of Customs, U.S. Department of the Treasury, announced that it had received information indicating a possibility that elemental sulfur from Mexico was being sold at less than fair value and that it was instituting an inquiry.[3] On

[3] U.S. Department of the Treasury, Bureau of Customs. Elemental Sulfur From Mexico, Antidumping Proceeding Notice. Federal Register, v. 36, No. 66, Apr. 6, 1971, p. 6526.

Table 9.—U.S. exports and imports for consumption of sulfur
(Thousand long tons and thousand dollars)

Year	Exports: Elemental, Frasch or sulfur recovered by any process		Exports: Processed, ground, screened, refined, sublimed, precipitated, colloidal, rolled flowers, and insoluble		Imports	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	1,549	$57,449	2	$334	1,675	$57,222
1970	1,429	33,096	4	955	1,537	34,149
1971	1,532	27,844	4	1,019	1,297	25,419

Table 10.—U.S. exports of sulfur, by country

Destination	Elemental, Frasch or sulfur recovered by any process: 1970		1971		Processed, ground, screened, refined, sublimed, precipitated, colloidal, rolled flowers, and insoluble: 1970		1971	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
Argentina	27,628	$579	8,906	$171	59	$29	38	$18
Australia	31,665	977	60,897	1,410	247	82	399	56
Belgium-Luxembourg	51,400	1,122	352,677	5,287	62	6	26	3
Brazil	229,102	5,223	213,929	4,161	248	104	375	143
Canada	54,414	1,593	37,921	1,012	900	122	307	45
Canary Islands	--	--	6,500	135	--	--	--	--
Chile	9	(1)	8,100	151	--	--	--	--
France	--	--	15,402	254	19	4	53	15
Germany, West	2,827	142	2,349	59	824	229	523	161
India	--	--	131	5	83	39	170	74
Ireland	92,620	2,061	79,500	1,385	--	--	--	--
Israel	32,929	715	11,925	228	87	24	72	21
Italy	33,220	604	28,735	586	12	4	98	16
Japan	948	33	401	14	70	25	411	119
Mexico	2,727	111	894	40	221	79	340	103
Netherlands	614,759	13,316	566,191	10,195	47	5	--	--
New Zealand	60,373	1,769	17,585	423	19	8	31	5
Philippines	196	8	--	--	79	42	97	49
South Africa, Republic of	15,073	308	27,810	521	48	5	107	11
Spain	--	--	4,000	83	10	1	15	2
Switzerland	9,000	189	16,500	313	--	--	--	--
Trinidad and Tobago	16,716	488	--	--	--	--	--	--
Tunisia	--	--	48,235	903	--	--	--	--
United Kingdom	131,325	3,203	15,621	297	67	20	--	--
Uruguay	6,278	159	4,574	101	3	2	--	--
Venezuela	1,023	37	1,045	37	181	41	159	35
Other	14,823	459	1,998	73	489	84	525	143
Total	1,429,055	33,096	1,531,826	27,844	3,775	955	3,746	1,019

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of sulfur, by country

Country	1970		1971	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	11	$1	--	--
Canada	998,008	14,005	849,700	$10,320
Germany, West	61	15	147	31
Japan	--	--	3	1
Mexico	538,985	20,115	447,101	15,065
Philippines	118	9	--	--
U.S.S.R.	--	--	(1)	2
United Kingdom	22	1	(1)	(1)
Venezuela	276	3	--	--
Total	1,537,481	34,149	1,296,951	25,419

1 Less than ½ unit.

November 2, 1971, it issued a Withholding of Appraisement notice directed against imports of elemental sulfur from Mexico on the basis that there were reasonable grounds to believe or suspect that selling prices were below those allowed by the Antidumping Act.[4] The investigation was continuing at yearend. A positive finding, and subsequent determination of injury to industry by the U.S. Tariff Commission, could result in the imposition of duties retroactive to the date of the Withholding of Appraisement notice.

The major sulfur producing and consuming nations exhibited their concern with the worldwide sulfur oversupply situation and its effect on international trade in sulfur. The Provincial Government of Alberta, Canada, and agencies of Mexico, Poland, and France discussed plans for the stabilization of the sulfur market. Subsequently, Alberta announced plans for stockpiling by producers, and Mexico outlined plans for control of production and sales and proposed an increase in export prices. These efforts appeared to be directed toward a form of international control. However, they became ineffective when Alberta cancelled plans for stockpiling. U.S. Government representatives attended two International meetings on sulfur in which delegates from the major producing and consuming nations discussed the problems of oversupply. Independently, the Governments of the United States and Canada studied the possibility of research and development efforts leading to new uses for sulfur as a viable solution to the problem of oversupply.

WORLD REVIEW

Canada.—Canadian production of sulfur from natural gas containing high percentages of hydrogen sulfide (sour gas) increased at an average growth rate of 28 percent per year during the last 10 years. This high growth rate is expected to continue into 1973 and then level off somewhat. The sulfur was produced as a byproduct of natural gas production. The increased demand for natural gas was mainly responsible for the involuntary sulfur production in Canada. Canadian inventories of sulfur in 1971 were approximately 6 million tons and are projected to be 24 million tons by the end of 1975 and 50 million tons by 1980. The huge Canadian production and stockpiles had a profound influence on sulfur prices, with a drop in f.o.b. plant prices (Alberta) from an average of $37.50 per ton in mid-1968 to $6.41 per ton in mid-1971. The sulfur surplus promised to be long-lasting; therefore, much interest has developed in finding new uses and markets.

Twenty companies operated 35 plants to remove sulfur from sour gas. The combined capacity was 15,093 tons per day. Eight new plants or plant expansions were underway, which will add another 8,461 tons of capacity.[5]

4 U.S. Department of the Treasury, Bureau of Customs. Elemental Sulfur From Mexico, Withholding of Appraisement Notice. Federal Register, v. 36, No. 215, Nov. 6, 1971, p. 21364.

5 Vroom, Alan H. Sulphur Utilization. A Challenge and an Opportunity. Nat. Res. Council of Canada, Ottawa, Ontario, NRC 12241, 2d ed., October 1971, 80 pp.

The International Nickel Co. of Canada, Ltd. cancelled plans for the construction of a 700,000-ton-per-year sulfuric acid plant at Copper Cliff, Ontario. The acid plant was to have been an addition to the existing acid capacity of 875,000 tons per year and was to have served to meet the air-quality objectives of the Ontario Government. The objectives will instead be met by cutting back on the quantity of pyrrhotite treated in the iron ore plant. The company was continuing construction of a 1,250-foot stack to diffuse smelter gases.[6]

Germany, West.—Norddeutsche Erdgasaufbereitungs Gesellschaft m.b.H. of Nienburg was making a major expansion of its sour natural gas processing plant at Voigtei, near Sulingen. The sour gas comes from fields in the Weser-Ems gasfields. The expansion will increase recovered sulfur capacity from 360 tons per day to over 1,000 tons per day. Another large new plant of 1,000-tons-per-day capacity was planned for Gewerkschaft Brigitta at Grossenkneten near Oldenburg. By 1975 the two plants will be producing almost 600,000 tons per year of recovered sulfur, or about five times the current West German output from natural gas and crude oil.[7]

Iran.—The large Shahpur and Kharg sulfur recovery complexes were made fully operational. The Shahpur complex is situated on an 80-acre site about a mile from the port of Bandar Shahpur and about 100 miles south of the Masjid-i-Suleiman gasfield. The sour-gas input to the plant contains about 25 percent hydrogen sulfide, 12 percent carbon dioxide, and 63 percent methane. The gas is first processed to remove hydrogen sulfide by using a process licensed by Societé des Nationale Pétrolés d'Aquitaine and constructed by Ralph M. Parsons. The hydrogen sulfide stream goes to a Claus sulfur-recovery unit with an annual capacity of 495,000 tons of elemental sulfur. The molten recovered sulfur is sprayed into one of three 40,000-ton vats and is allowed to solidify. The production units can be easily tripled if future demand exceeds present production. Also, facilities for shipping molten sulfur may be added at some later stage.

The Kharg Island complex uses byproduct sour gas from oil production as the plant feed. The sour gas contains about 12 percent hydrogen sulfide. The sulfur recovery unit was designed by Pan American Petroleum, Inc., a subsidiary of Standard Oil Co. of Indiana. The capacity is 198,000 tons per year.

In addition to the large plants described above, there were a number of smaller plants operating in 1971. Iran had an export potential of approximately 600,000 tons per year from a total national capacity of 800,000 tons per year. Africa, Japan, Australia, Southeast Asia, and India were the potential markets for the Iranian sulfur.[8]

Iraq.—Frasch mining of the large salt dome sulfur deposits at Mishraq was scheduled to start. Drilling of 64 wells and the erection of surface installations was carried out by Centrozap, a Polish engineering concern. Initial production was expected to be between 250,000 and 300,000 tons per year of sulfur.[9]

The $28 million sulfur recovery plant at Kirkuk was scheduled to start regular production with a daily rate of 200 tons of sulfur. The plant was designed by the Italian firm, Techint, and was built by the Anglo-American combine of Parsons Power Gas.[10]

Mexico.—Exploradora de Istmo, S.A., started operation of a new Frasch sulfur mine at Texistepec on the Isthmus of Tehuantepec. Texas Gulf Sulphur had a 34-percent interest, Commission de Fomento Minero had a 33-percent interest, and a Mexican industrial group controlled the remaining 33 percent.[11]

New Zealand.—Gulf Resources & Chemical Corp. and Fletcher Holdings Ltd. took over American Cyanamid's option on the Taupo sulfur deposits. Development of the deposits will depend on the outcome of test bores and subsequent trials. At present, 6 million tons of recoverable sulfur have been proved. The sulfur-containing ore was found mixed with silt at depths of 100 to 150 feet below the surface of Lake

[6] The International Nickel Co. of Canada, Ltd. Press Information. May 20, 1971, 2 pp.
[7] Sulphur (London). New Plants and Projects. West Germany. No. 92, January–February 1971, p. 17.
[8] Sulphur (London). Iran Emerges as Major Brimstone Exporter. No. 94, May–June 1971, pp. 32–36.
[9] Sulphur (London). New Plants and Projects. Iraq. No. 92, January–February 1971, p. 18.
[10] Canada Commerce. Trade Lines. Iraq Starts to Produce Sulphur. November 1971, p. 60.
[11] Mining Engineering. TGS Mexican Subsidiary Has a Newly Opened Sulfur Mine. V. 23, No. 4, April 1971, p. 14.

Table 12.—Elemental sulfur: World production, by country

(Thousand long tons)

Country [1]	1969	1970	1971 p
Native sulfur:			
Frasch:			
Mexico	1,606	1,276	1,160
Poland	1,300	e 1,600	e 1,700
United States	7,146	7,082	7,025
Total	10,052	9,958	9,885
From sulfur ores:			
Argentina	34	34	e 34
Bolivia (exports)	36	16	9
Chile	97	106	104
China, People's Republic of e	118	118	118
Colombia e	26	29	30
Ecuador	5	6	e 6
Indonesia e	1	1	1
Iran [2]	1	2	2
Italy	53	47	36
Japan [3]	201	101	64
Mexico	26	24	23
Poland	650	e 1,067	e 1,078
Taiwan	5	6	5
Turkey	r 21	26	24
U.S.S.R. e	1,102	1,102	1,171
Total	r 2,376	2,685	2,705
Total native sulfur	r 12,428	12,643	12,590
Other elemental sulfur: Recovered:			
Austria [4]	3	e 3	e 3
Belgium [4]	r 8	10	8
Brazil [5]	7	9	9
Bulgaria [5]	5	5	e 5
Canada [6]	r 3,814	4,341	4,810
China, People's Republic of e [5] [7]	128	128	128
Colombia e [5]	4	4	4
Egypt, Arab Republic of [5]	1	e 1	e 1
Finland	110	113	100
France [8]	r 1,714	1,706	1,778
Germany:			
East	108	108	e 108
West [4]	127	173	181
Hungary	2	3	e 3
Iran e [5]	39	39	e 39
Israel e	8	8	10
Italy [4]	69	79	e 84
Japan [9]	r 142	235	338
Kuwait	15	47	36
Mexico [8]	57	59	64
Netherlands [4]	31	32	33
Portugal	r 4	3	3
Saudi Arabia e	4	5	5
South Africa, Republic of e [5]	12	16	25
Spain [10]	5	6	e 6
Sweden [11]	5	5	e 5
Taiwan [5]	r 3	4	5
Trinidad	4	4	e 4
U.S.S.R. e	472	472	502
United Kingdom [12]	42	37	43
United States	1,414	1,451	1,586
Total other elemental sulfur	r 8,357	9,106	9,926
Grand total	r 20,785	21,749	22,516

e Estimate. p Preliminary. r Revised.

[1] In addition to countries listed, Uruguay produces less than 500 tons of sulfur annually as a byproduct of petroleum refining.

[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] Includes in part H_2S converted directly into sulfuric acid.

[5] From petroleum refining.

[6] From natural gas, petroleum, tar sands, and smelting of sulfide ores.

[7] From sulfide ores.

[8] From natural gas.

[9] From petroleum refineries only. Excludes an unreported quantity recovered from sulfide ores, which is included above (see footnote 3).

[10] From distillation of petroleum, lignite, and from the reduction of SO_2 gas.

[11] From oil shale.

[12] Includes sulfur recovered from petroleum refineries, and from other unspecified sources.

Table 13.—Pyrites (including cupreous pyrites): World production, by country
(Thousand long tons)

Country [1]	1969 Gross weight	1969 Sulfur content	1970 Gross weight	1970 Sulfur content	1971 p Gross weight	1971 p Sulfur content
North America:						
Canada (pyrrhotite)	336	r 153	324	e 147	284	e 128
United States [2]	W	W	W	W	W	W
Europe:						
Bulgaria	r 158	66	154	65	e 148	e 63
Czechoslovakia	351	e 148	e 354	e 149	e 354	e 149
Finland	841	387	948	489	847	383
France	84	e 34	84	e 34	e 84	e 34
Germany:						
East e	138	57	138	57	138	57
West	630	262	545	238	e 545	e 238
Greece	242	112	266	116	211	95
Italy	r 1,450	r 653	1,543	694	1,494	636
Norway	754	346	735	377	769	353
Poland e	221	87	221	87	197	79
Portugal	523	235	468	206	552	248
Romania	e 354	e 138	794	e 341	e 827	e 354
Spain	2,436	1,131	2,693	1,253	2,391	1,117
Sweden	487	246	566	318	653	e 313
U.S.S.R. e	3,445	1,821	3,937	2,067	2,425	2,165
Yugoslavia	268	e 113	349	e 147	272	130
Africa:						
Algeria	45	20	32	15	e 32	e 15
Morocco (pyrrhotite)	385	116	286	86	434	113
South Africa, Republic of	824	e 330	854	e 342	738	295
Asia:						
China, People's Republic of e	1,772	787	1,968	886	1,968	900
Cyprus	912	430	915	418	769	370
Japan	2,919	1,344	2,599	1,229	2,326	1,095
Korea, North e	492	197	492	197	492	197
Philippines	198	93	270	125	e 300	e 138
Taiwan	38	e 14	39	e 15	45	e 19
Turkey	128	61	90	43	58	26
Oceania: Australia	r 118	r 51	210	101	e 250	e 120
Total	r 20,549	r 9,432	21,874	10,242	19,603	9,830

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Pyrites is produced in Cuba, but there is too little information to estimate production. Pyrites is also produced in Southern Rhodesia, but production figures have been withheld by the Government.
[2] Sold and used.

Rotokawa, about 9 miles from Taupo. If the trials are successful, the sulfur will be produced by using the Frasch process. Production cost could be lowered by obtaining water for the process from local geothermal springs.

New Zealand imported about 240,000 tons of sulfur in 1971, most of which was consumed in the manufacture of fertilizer.[12]

Poland.—Poland started shipping liquid sulfur to West European markets from new storage and handling facilities near the port of Gdansk. Eventually the facilities will include ten 5,000-ton-capacity tanks for holding liquid sulfur and solid storage for up to 750,000 tons. The new equipment provides special 50-ton-capacity tank cars to deliver liquid sulfur to the port. Each sulfur train will consist of between 30 and 36 tank cars. Seventy-six steam heating points have been installed in the transport system to deal with possible solidification of sulfur in the cars during the winter months. The terminal can accommodate large vessels. Depth alongside the quay was about 26 feet at the liquid-sulfur loading area and 36 feet at the solid loading area. The liquid-loading pipeline had a capacity of 600 tons per hour, and 1,000 tons per hour of solid sulfur can be loaded with a conveyor belt system. A 5,500-ton liquid sulfur carrier was acquired and additional vessels will go into service as markets for the sulfur develop.[13]

Spain.—A pyrites deposit was discovered near the Axnal Collar mines of the Sociedad Andaluza in the Province of Huelva. No assessment of the total extent of the

[12] Industrial Minerals. New Zealand. Sulphur Project Nearer Fruition. No. 49, October 1971, pp. 31–32.
[13] Sulphur (London). The New Sulphur Terminal at Gdansk. No. 92, January–February 1971, pp. 25–26.

deposits has yet been made, but preliminary estimates indicated 2 million tons of ore could be treated annually.[14]

Sweden.—A direct route for removing sulfur from residual fuel oil will be used at the Shell Oil Co.'s 98,000-barrel-per-day refinery in Kappartrans near Gothenburg. The hydrodesulfurization unit will have a daily throughput capacity of 400 tons of residual oils which may have a sulfur content of 4 percent. Startup date will be in 1973.[15]

United Kingdom.—Production of sulfuric acid in the first quarter of 1971 amounted to 843,670 tons, for an increase of 3.6 percent over the same period in 1970. Of the total, 812,493 tons were manufactured by the contact process and 31,177 tons by chamber and tower. The industry operated at 82.3 percent of capacity. Consumption increased 7.3 percent to 960,996 tons, including 60,504 tons of imported acid and 39,528 tons of recovered acid.[16]

TECHNOLOGY

A Soviet sulfuric acid process was developed that promises to challenge conventional contact sulfuric acid flow schemes. The process is said to be simpler and more trouble free than conventional contact sulfuric acid flow schemes, and it uses a novel tail-gas treatment system to obtain high conversion efficiencies. Hot gas is passed directly from the raw material roaster to the converter. Capital investment is reduced by eliminating several stages from the conventional flow scheme. In addition, power cost and water consumption are reduced, while steam production can be increased. It was reported that the simplicity of the process reduces operation and maintenance costs. The Soviet process can handle hot sulfur dioxide gases from roasting pyrites, lead, zinc, copper ores or anhydrite, but shows no advantage over conventional processes when elemental sulfur is used.

The tail gas is scrubbed by a countercurrent flow of 50 percent sulfuric acid and the bulk of the remaining sulfur dioxide is absorbed. The acid is pumped through a catalyst vessel to oxidize sulfur dioxide to sulfur trioxide, which is absorbed into the circulating acid. Overall sulfur dioxide recovery of 99.7 percent for the whole plant was stated to be economically attainable.[17]

A new paving material called "Thermopave" was under development by Shell Canada Ltd. The material is a thermal-setting mixture of sand, petroleum residue, and sulfur. Advantages are that the material is fast setting and has good overall strength and resistance to deformation. Also, the sulfur permits the use of inexpensive low-grade sand rather than more expensive crushed rock, and the paving material can be laid over weak subgrades without rolling. Shell Canada expects "Thermopave" to be competitive in cost with conventional pavement; however, more laboratory and field work is needed for commercial development.[18]

A $350,000 research contract for recovering elemental sulfur from flue gases was granted to Westvaco Corporation by the Environmental Protection Agency (EPA). In the Westvaco process sulfur dioxide and sulfur trioxide in flue gas are absorbed on fluidized carbon. The sulfur oxides and residual oxygen in the gas form sulfuric acid which is held in the carbon pores. Sulfur is produced by reducing the sulfuric acid with hydrogen in a reaction catalyzed by the carbon. In a pilot test the process recovered 90 to 100 percent of the sulfur dioxide in the feed gas; however, the company stated that it will be 3 to 5 years before the process can be commercialized.[19]

A mixture of alkali metal carbonates, molten at 800° F, was used to absorb sulfur dioxide from industrial and powerplant stack gases in a process developed by North American Rockwell's Atomic's International Division under a contract with EPA. In the process alkali sulfites and sulfates are formed and converted in a stripping unit to hydrogen sulfide by interac-

[14] Mining Magazine. Spanish Pyrites Discovery. V. 124, No. 5, May 1971, p. 402.

[15] Chemical and Engineering News. Sulfur in Oil. V. 49, No. 44, Oct. 25, 1971, p. 23.

[16] Industrial Minerals (London). United Kingdom First Quarter Sulphuric. No. 45, June 1971, p. 34.

[17] Chemical Engineering. Soviet Process Slashes Sulfuric-Acid-Making Cost. V. 78, No. 6, Mar. 8, 1971, pp. 81–83.

[18] Oilweek. Shell Develops Sulphur Paving Material. V. 22, No. 41, Nov. 29, 1971, p. 25.

[19] Chemical Week. A New Process for Recovering Elemental Sulfur. V. 108, No. 8, Feb. 24, 1971, pp. 71–72.

tion with carbon monoxide and hydrogen. The regenerated carbonates are recycled. Elemental sulfur or sulfuric acid are the final recovered products and cost of the removal process can be partially offset by their sale.[20]

Tennessee Valley Authority (TVA) pollution control engineers completed the installation of an oxidizing unit in a pilot plant that uses a limestone slurry as the sulfur dioxide absorbent. The unit converts some of the calcium sulfite reaction product to calcium sulfate, thereby making separation of the waste solid for disposal an easier task. The problem with limestone-slurry systems in the past has been that as the concentration of calcium sulfite builds up, it tends to crystallize into thin platelets that do not readily settle out. Otherwise, operation of the system is satisfactory and the bulk of the sulfur dioxide is removed.

TVA's pilot pollution control unit takes flue gas containing about 2,500 parts per million sulfur dioxide from a coal-fired powerplant. The flue gas goes to a venturi scrubber to remove particulates and then to a cross flow scrubber. The gas makes contact with a descending aqueous slurry of calcium carbonate mixed with calcium sulfite and calcium sulfate. The effluent slurry is split into two streams. One goes to a calcium carbonate makeup unit and is then circulated back to the absorption scrubber, while the other stream passes to the oxidizer unit where air blowing through it converts the sulfite to sulfate. The precipitated calcium sulfate is removed and the aqueous fraction returned to the system.[21]

The Bureau of Mines reported that several solid sorbents were compared for their effectiveness in removing sulfur dioxide from flue gases. The materials were tested for the rate of sorption and capacity at about 300° C and for the rate of regeneration around 700° C in thin beds and in 4-inch-diameter fluidized beds. Rates of material loss were also estimated. The sorbents tested included three samples of alkalized alumina—two samples of sodium carbonate-impregnated alumina and one proprietary sample of porous silica impregnated with copper and iron compounds. The results showed that all the alkalized aluminas had good sorption capacities and rates, required high-temperature regeneration, and suffered excessive material loss; the sodium carbonate-impregnated aluminas had high sorption rates but barely adequate capacities, required high-temperature regeneration, and suffered excessive material losses; and the copper-iron impregnated silica suffered only slight material loss and could be regenerated at a relatively low temperature, but the sorption rate and capacity were too small. None of the sorbents met all the arbitrary performance criteria that were established.[22]

Because of increasing concern with air pollution, the Bureau of Mines has developed a hydrometallurgical procedure to obtain elemental sulfur from chalcopyrite ($CuFeS_2$) by means of the following reaction: $CuFeS_2 + 3FeCl_3 = CuCl + 4FeCl_2 + 2S$. Under optimum conditions, 99.6 percent of the copper and 71.6 percent of the iron were extracted in 2 hours from a typical mill concentrate, containing 75 percent $CuFeS_2$ and 15 percent pyrite (FeS_2). At the same time, 68.2 percent of the sulfur in the concentrate was oxidized to the elemental form. The leach was highly selective; gangue minerals, including pyrite, were not attacked, thus accounting for the relatively low recoveries of iron and sulfur.[23]

The Bureau of Mines developed a citrate process for recovering sulfur dioxide (SO_2) from smelter and other industrial gases as elemental sulfur. In the citrate process, gas containing 1 to 3 percent SO_2 by volume was washed to remove particulate matter and SO_3 and cooled to about 50° C. The gas was then passed upward through a packed absorption tower countercurrent to a downward flow of a citrate solution containing citric acid and Na_2CO_3. Over 90 percent of the SO_2 was absorbed by the citrate solution. The SO_2 loaded solution was reacted with H_2S in a stirred, closed vessel to precipitate the absorbed SO_2 as sulfur. Residence time in the reaction vessel was about 10 minutes, and the slurry temperature was about 50° C. The

[20] Chemical and Engineering News. SO_2 Removal. V. 49, No. 6, Feb. 8, 1971, p. 52.
[21] Chemical and Engineering News. Air Pollution: Limestone Removes SO_2. V. 49, No. 22, May 31, 1971, pp. 6–7.
[22] Russell, James H., Jack I. Paige, and Danton L. Paulson. Evaluation of Some Solid Oxides as Sorbents of Sulfur Dioxide. BuMines RI 7582, 1971, 27 pp.
[23] Haver, F. P., and M. M. Wong. Recovering Elemental Sulfur From Nonferrous Minerals. Ferric Chloride Leaching of Chalcopyrite Concentrate. BuMines RI 7474, 1971, 20 pp.

slurry of citrate solution and sulfur was thickened and the thickener underflow was centrifuged to recover stripped citrate solution for recycle with the thickener overflow to the absorption tower. The sulfur product was heated in an autoclave at 130° C and 35 pounds per square inch to melt the sulfur and recover residual citrate solution for recycle. Two-thirds of the molten sulfur was then converted to H_2S for use in the sulfur precipitation reaction by vaporizing the sulfur and reacting the sulfur vapor with natural gas and steam in the presence of an alumina catalyst.[24]

The Bureau of Mines conducted a research project in which a high-sulfur bituminous coal suspended in coal tar was hydrodesulfurized in a method for providing large amounts of low-sulfur fuel. High yields of low-sulfur fuel oil were obtained. The feed contained 30 percent coal of 3.4 percent sulfur suspended in tar of 0.6 percent sulfur. For process conditions of 4,000 pounds per square inch, gage and 450° C, the yield of whole liquefied product was 94 percent of the whole feed; the product had 9 percent benzene-insoluble residues and only 0.3 percent sulfur. Most of the sulfur was in the insoluble residues and was organic. By separating the insoluble residues, the whole product gave a 91-percent yield of benzene-soluble fuel oil having only 0.09 percent sulfur. For the milder conditions of 2,000 pounds per square inch, gage and 450° C, the whole liquefied product was 93 percent of the and 0.4 percent sulfur. By separating the residues, this product gave an 87-percent yield of fuel oil having only 0.14 percent feed and had 13 percent insoluble residues sulfur. Commercially, part of the separated product oil would be recycled to suspend the feed coal instead of using the tar. Thus, the net product oil for fuel use would derive entirely from coal and is expected to have sulfur at least as low as reported above.[25]

The Aquitaine Company of Canada investigated the technology of a pipeline to transport sulfur some 20 miles from its Ram River Processing Plant to rail facilities. For the test, a 1,400-foot pilot pipeline loop capable of circulating 5,000 long tons per day of sulfur was constructed near Rainbow Lake, Alberta. Initial results showed that a pipeline can be maintained at the optimum temperature economically by the use of an asbestos-polyurethane insulation system and electrical heating by the patented "Skin Electric Current Tracing System" (SECT). Although pilot project testing is still in progress, it is believed by the company that a long-distance buried pipeline for transmission of sulfur is technically and economically feasible.[26]

The first United States interabsorption sulfuric acid facility was constructed at the Warners' complex of American Cyanamid Co. at Linden, N.J. The designers of the new 700-ton-per-day facility expect lower sulfur dioxide emissions than any other plant operating at the present time in the United States. The plant has a mist-elimination system to control the emission of acid fumes and mist particles. In addition to pollution abatement features, efficiency of the new plant is expected to increase from 98 to 99.5 percent. Sulfur dioxide, after passing through a waste heat boiler, will be fed to the converter at a concentration between 10 and 11 percent sulfur dioxide. After passing through three catalyst stages, there will be a 90 percent conversion to sulfur trioxide. The gas stream will be cooled and introduced into the interpass absorption tower where the sulfur trioxide will be dissolved in recirculating sulfuric acid. Following the inter-absorption stage, the gas will be reheated and fed through the final converter pass. The additional sulfur trioxide formed during this pass will be removed in a final absorption tower before the remaining gas is vented to the atmosphere.[27]

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[24] Rosenbaum, J. B., D. R. George, Laird Crocker, W. J. Nissen, S. L. May, and H. R. Beard. The Citrate Process for Removing SO_2 and Recovering Sulfur From Waste Gases. Pres. at AIME Environmental Quality Conference, Washington, D.C., June 7–9, 1971, 26 pp. (Available from J. B. Rosenbaum, Bureau of Mines, Salt Lake City, Utah.)

[25] Akhtar, Sayeed, Sam Friedman, and Paul M. Yavorsky. Low-Sulfur Fuel Oil From Coal. BuMines Tech. Progress Rept. 35, July 1971, 11 pp.

[26] Cartwright, D. J., and R. D. Waymouth. Liquid Sulphur Transmission by Pipeline. Pres. at the 22d Ann. Tech. Meeting of the Petroleum Society of CIM, paper No. 7619, June 2–5, 1971, 12 pp.

[27] Sulphur (London). Monsanto Inter-Absorption Process Incorporated in Cyanamids Warners Complex. No. 93, March–April 1971, pp. 46–47.

Talc, Soapstone, and Pyrophyllite

By J. Robert Wells [1]

Mines in the United States produced talc, soapstone, and pyrophyllite (collectively termed the talc-group minerals) at an unprecedented rate in 1971, setting a mark for total tonnage that was 1 percent above any previously recorded and more than one-third higher than the level of a decade ago. Substantially higher mine output in Alabama, Georgia, New York, Texas, and Washington, and slightly higher output in Arkansas and Oregon more than offset significant decreases in California, Montana, and North Carolina. Vermont and Virginia recorded marginal declines; Nevada and Pennsylvania dropped out of the list of producing States, the first such absence since 1953 for Pennsylvania and even longer (since 1940) for Nevada. In U.S. foreign trade, the domestic talc industry more than pulled its weight in 1971, supplying for export eight times the tonnage and seven times the value of the year's talc-group imports.

Legislation and Government Programs.—The Defense Materials Inventories prepared by General Services Administration (GSA) showed that Government holdings as of December 31, 1971, included 1,204 short tons of talc (steatite, block or lump), with a market value of $391,300, and 3,900 short tons of talc (steatite, ground), valued at $21,400. Of the block or lump steatite, 1,004 short tons was listed as excess inventory, as was also the entire quantity of ground material. No sales of these materials were made during calendar year 1971. The Stockpile Storage Division, GSA, revised rules governing storage of the stockpiled talc (steatite, block or lump) and talc (steatite, ground). Significant changes included provision for use of approved respirators to protect workmen handling the ground material from the hazard of inhalation of finely divided, air-borne talc dust, a possible cause of pulmonary fibrosis.

The Office of Minerals Exploration, Geological Survey, offered to provide loans of up to 50 percent of approved exploration costs on eligible deposits of strategic-grade block steatite talc, but no loans for that purpose were made in 1971. The allowable depletion rates for talc, established by the Tax Reform Act of 1969 and unchanged through 1971, were 22 percent on production of block steatite of domestic origin and 14 percent on foreign production of this material, which rate also applied to production of all other classes of talc from all sources.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Mine production	903	958	1,029	1,028	1,037
Value	$6,871	$6,656	$7,508	$7,773	$7,634
Sold by producers	824	886	985	948	979
Value	$20,488	$22,968	$26,294	$25,980	$26,936
Exports [1]	66	66	69	105	136
Value [1]	$3,450	$3,521	$3,713	$5,739	$4,844
Imports for consumption	15	24	20	30	17
Value	$653	$973	$749	$1,294	$745
World: Production	4,369	4,796	5,162	5,387	5,392

[1] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

Talc, soapstone, and pyrophyllite were produced in the United States in 1971 from 54 mines in 13 States—talc from 38 mines in nine States (Alabama, California, Georgia, Maryland, Montana, New York, North Carolina, Texas, and Vermont); soapstone from seven mines in six States (Arkansas, California, Oregon, Texas, Virginia, and Washington); and pyrophyllite from nine mines in two States (California and North Carolina).

Leading in tonnage of talc-group mine production in 1971 were, in descending order, New York, Texas, Vermont, California, and Montana; these States jointly accounted for 84 percent of the total. The same five States made up 87 percent of the total value of 1971 production. In that respect, California was in first place and was followed in order by New York, Texas, Vermont, and Montana.

The total tonnage of U.S. mine production of talc-group minerals in 1971 was the largest on record, and the corresponding total value was second only to that reported in 1970.

Listed alphabetically, the 10 leading domestic producers of talc-group minerals in 1971 were Eastern Magnesia Talc Co., operating in Vermont; Gouverneur Talc Co., in New York; L. Grantham Corp., in California; International Talc Co., in New York; Minerals, Pigments & Metals Div., Chas. Pfizer & Co., in California and Montana; Piedmont Minerals Co., in North Carolina; Southern Clay Products Co., Inc., in Texas; Southern Talc Co., in Georgia; United Sierra Div. of Cyprus Mines Corp., in California, Montana, and Texas; and Windsor Minerals, Inc., in Vermont. Collectively, those firms contributed 79 percent of the 1971 U.S. total tonnage.

Table 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by State

State	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
California	184,660	$2,545	153,227	$2,084
Georgia	45,900	289	53,000	334
North Carolina	92,639	544	85,289	522
Texas	171,420	878	193,830	1,024
Virginia	3,760	9	3,704	8
Other States [1]	529,550	3,507	548,247	3,662
Total	1,027,929	[2] 7,773	1,037,297	7,634

[1] Includes Alabama, Arkansas, Maryland, Montana, New York, Oregon, Vermont, Washington (1970–71); Nevada, Pennsylvania (1970).
[2] Data may not add to total shown because of independent rounding.

Table 3.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by class

(Short tons)

Year	Crude		Ground [1]		Total [2]	
	Quantity [3]	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
1967	42,758	$280	780,998	$20,208	823,756	$20,488
1968	64,877	331	821,601	22,637	886,478	22,968
1969	81,015	362	904,318	25,931	985,333	26,294
1970	95,561	572	851,956	25,407	947,517	25,980
1971	131,961	789	847,309	26,147	979,270	26,936

[1] Includes crushed and sawed material.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes exports to grinders in Belgium and Mexico.

CONSUMPTION AND USES

Apparent U.S. consumption of talc-group minerals (imports plus mine production minus exports) amounted to 918,000 short tons in 1971, down 4 percent from the figure for 1970 and 6 percent from that of 1969. Reported sales of ground material were fractionally lower in tonnage but 3 percent higher in total value than in the previous year. The total tonnage of talc-group products (mostly ground material) sold or used by domestic producers in 1971 was 3 percent greater than in 1970, and the corresponding total value was 4 percent higher.

In the 1971 end-use distribution, 28 percent of the total quantity of talc, soapstone, and pyrophyllite sold or used by U.S. producers was consumed in the manufacture of ceramics (exclusive of floor and wall tile, for which specific data were not released for publication), and 5 percent (talc only in this case) was used in the coating and filling of paper, down from 6 percent in 1970. Other end-use statistics for 1971 (not directly comparable with those for previous years in which some pyrophyllite figures were separately itemized) showed that 16 percent was used in paints, 6 percent as insecticide carrier and diluent, 4 percent for roofing, 3 percent as rubber filler, 3 percent in toilet preparations, and less than 1 percent for textiles. Utilization in the composite category of miscellaneous applications (of which only a minority were specified) accounted for 34 percent of the 1971 total.

Table 4.—Pyrophyllite [1] produced and sold by producers in the United States

Year	Production	Total sales	
	Short tons	Short tons	Value (thousands)
1967	117,457	118,337	$1,579
1968	130,624	120,319	1,748
1969	104,347	110,816	1,632
1970	120,077	95,735	1,317
1971	101,030	90,477	1,155

[1] Includes sericite schist (1967–1970).

Table 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by use

(Short tons)

Use	1970	1971
Ceramics	248,022	270,358
Paint	[1] 154,265	155,140
Insecticides	[1] 33,697	63,381
Paper	52,328	52,886
Roofing	[1] 44,997	35,189
Rubber	[1] 28,348	27,098
Toilet preparations	[1] 13,721	31,249
Textile	[1] 6,187	4,985
Other [2]	365,952	338,984
Total	947,517	979,270

[1] Excludes pyrophyllite.
[2] Includes asphalt filler, brick, crayons, enamel coating, exports, fertilizer, floor and wall tile, foundry facings, insulated wire and cable, joint cement, plastics, refractories, rice polishing, and miscellaneous products.

STOCKS

It was estimated that producers' stocks of talc, soapstone, and pyrophyllite on hand at the end of 1971 amounted to 144,000 short tons, down 30 percent from the figure of 205,000 short tons at yearend 1970. Comparable estimates for previous years were 121,000 short tons for 1967, 161,000 for 1968, and 200,000 for 1969.

PRICES

The average of unit values reported by U.S. crude talc producers in 1971 was slightly below the 1970 figure but near the top of the range (from $6.84 to $7.61 per short ton) recorded in the previous decade. The 1971 average unit value reported for all talc-group minerals sold or used by U.S. producers was the highest on record although only fractionally above the 1970 average.

Engineering and Mining Journal, December 1971, quoted prices for domestic ground talc in carload lots, f.o.b. mine or mill, that ranged from $20 per short ton for Vermont talc, 99 percent through 325 mesh, to $104 per short ton for micronized California talc. Chemical Marketing Reporter, December 27, 1971, listed prices for ground Canadian talc, f.o.b. works, from $20 to $35 per short ton.

Prices for steatite talc, quoted by Industrial Minerals (London), December 1971, in pounds sterling per metric ton, c.i.f., ranged from the equivalent of about $25 per short ton for ground Norwegian material to $110 per short ton for Italian talc of cosmetic quality. Most 1971 talc sales, however, whether in the United States or abroad, were concluded, as customarily, at negotiated prices not on public record.

FOREIGN TRADE

Exports.—The United States exported talc-group minerals in 1971 to 20 countries in the Western Hemisphere, 16 in Europe, 13 in Asia, four in Africa, and to both Australia and New Zealand. Approximately 79 percent of the tonnage exported in 1971 went to destinations in the Western Hemisphere, compared with 55 percent in 1970 and 73 percent in 1969. European nations received 15 percent and Asian nations received 5 percent of the 1971 talc-group exports; Oceania and Africa combined received the remaining 1 percent. As a whole, U.S. exports of natural talc, soapstone, and pyrophyllite in 1971 were 30 percent more in quantity than in 1970 but amounted to 16 percent less in total value. Conspicuously contributing to that divergence, shipments to both Mexico and Canada (the leading recipients) increased markedly in tonnage but much less than proportionally in terms of dollars; shipments to Belgium (in third place) decreased sharply in both respects.

Imports.—The total value of unmanufactured talc-group minerals imported for consumption by the United States in 1971 was below that for any year since 1957, and the corresponding tonnage was the smallest (with the exception of that for 1967) that has been recorded since 1945. Talc imports from Italy (usually one of the foremost sources) dropped in 1971 to the lowest level, in both quantity and total value, since the end of World War II.

Table 6.—U.S. exports of talc, soapstone, and pyrophyllite, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1969	69	$3,713
1970	105	5,739
1971	136	4,844

Tariffs.—Schedules applicable in 1971 provided for import duties on the various classifications of talc as follows: Crude and not ground, 0.02¢ per pound; ground, washed, powdered, or pulverized, 7 percent ad valorem; cut or sawed, or in blanks, crayons, cubes, disks, or other forms, 0.2¢ per pound; and other, not specially provided for, 14 percent ad valorem. The rates applicable to talc, crude and not ground, and to talc, cut or sawed, etc., remained the same after January 1, 1972, but those affecting the other two classes were reduced, as of that date, to 6 percent ad valorem and 14 percent ad valorem, respectively.

Table 7.—U.S. imports for consumption of talc, steatite or soapstone, by class and country

(Short tons and thousand dollars)

Year and country	Crude and unground		Ground, washed, powdered or pulverized		Cut and sawed		Total unmanufactured	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value [1]
1969	9,196	$194	10,897	$392	265	$163	20,358	$749
1970:								
Canada	4,373	43	2,717	69	46	7	7,136	119
France	--	--	4,807	142	--	--	4,807	142
India	54	2	--	--	--	--	54	2
Italy	13,999	652	1,818	129	4	2	15,821	783
Japan	--	--	352	(2)	305	180	657	180
Korea, Republic of	--	--	1,513	68	--	--	1,513	68
Total	18,426	697	11,207	408	355	189	29,988	1,294
1971:								
Canada	4,821	48	3,200	85	4	3	8,025	136
France	--	--	4,225	137	--	--	4,225	137
Germany, West	--	--	2	(2)	--	--	2	(2)
India	--	--	--	--	2	1	2	1
Italy	2,756	142	1,462	123	6	5	4,224	270
Japan	--	--	--	--	282	167	282	167
Korea, Republic of	--	--	622	34	--	--	622	34
Total	7,577	190	9,511	379	294	176	17,382	745

[1] Does not include talc, n.s.p.f.: 1969; $12,479; 1970, $5,651; 1971, $17,997.
[2] Less than ½ unit.

WORLD REVIEW

Argentina.—Talc-group minerals produced in 1970, the last year for which detailed data have been published, were classified as talc (17,800 short tons), steatite (5,900 short tons), and pyrophyllite (7,600 short tons), with a total value equivalent to $275,000. The highest unit value, $12.40 per ton, was that reported for pyrophyllite, followed by $9.50 per ton for talc. The low unit value, $2.10 per ton, assigned to steatite suggests that material that was involved would have been classified in the United States as soapstone.

Australia.—Westside Minerals, N.L., announced plans for an early start of production from a deposit of high-grade talc 90 miles north of Meekatharra in central Western Australia. Published estimates of available reserves ranged from 50,000 tons to 2 million tons of extractable mineral. Negotiations were undertaken to define terms for the possible purchase of the product by a Japanese firm. It was acknowledged that the cost of transportation to and from the seacoast, 250 miles away, would present a major impediment to profitable operation. Similarly, transportation costs were cited by Minefields Exploration, N.L., as being the chief obstacle to successful exploitation of a deposit at Truro, about 50 miles northeast of Adelaide, Southern Australia, said to contain "many hundreds of thousands of tons of recoverable talc."

In New South Wales, tentative plans for mining pyrophyllite at a property controlled by Eden Minerals Pty., Ltd., were shelved when an economic study indicated that profitable sale of the expected grade of mineral to Japan, the only prospective customer, would be doubtful under present conditions. Optimism was expressed concerning the future of the enterprise, however, because of the rising demand for the material by the domestic refractories industry.

Canada.—A magazine article reviewed the 1971 performance of Canadian industrial minerals. One section of the report described the operations of the three companies (Canada Talc Industries, Ltd.; Broughton Soapstone & Quarry Co., Ltd.; and Baker Talc, Ltd.) that produced talc in Canada in 1970 and 1971.[2] Pyrophyllite, sometimes produced for export from one mine in Newfoundland, was not mentioned in this paper.

[2] Killin, A. F. Industrial Minerals. Can. Min. J., v. 93, No. 2, February 1972, pp. 146–148.

France.—A new marketing organization, Luzenac Talc Sales, Ltd., was formed in an arrangement between the United Kingdom's Durham Raw Materials, Ltd., and S. A. des Talcs de Luzenac, operator of the world's largest talc mine in the French Pyrennees. The new company will handle all sales in the United Kingdom of Luzenac's various grades of talc, used especially in cosmetic preparations but also in numerous other applications.

Greece.—Government authorization was granted for establishing a talc processing plant in Crete to be financed by foreign capital. The published notice did not indicate the source of the mineral to be treated.

India.—Indian production of talc-group minerals in 1971 totaled 195,477 short tons, of which 94 percent was classified as steatite and 6 percent as pyrophyllite. Comparable figures for 1970 were a total of 185,641 short tons, 92 percent steatite, and 8 percent pyrophyllite. The unit value reported for both minerals in both years was approximately $3 per short ton (with some uncertainty as to the rupee/dollar rate), indicating that the Indian steatite was of a lower quality than the mineral so designated in the United States.

Mexico.—A journal article published in the United States described the organization, equipment, and operations in Nuevo León of Cerámica Regiomontaña Monterrey, an all-Mexican company that consumes a variety of local raw materials, together with ball clay and talc from north of the border, in the manufacture of ceramic tile. About one-fifth of the facility's current monthly output (17 million units of finished ware in 160 shapes and sizes, 100 color combinations, and over 350 decorative patterns), is marketed in the United States. An expansion program was initiated in 1971 to provide a one-fifth addition to the present capacity of the Monterrey plant.[3]

South Africa, Republic of.—Output of talc-group minerals in 1971 consisted of 9,301 short tons of talc and 3,674 short tons of pyrophyllite (locally termed "wonderstone"). Exports accounted for only 3 percent of the combined tonnage in 1971, compared with 41 percent of the total produced in 1970 (8,375 short tons of talc plus 5,314 short tons of pyrophyllite). Average unit values listed for the exported talc were equivalent to $39 per short ton in 1971 and $22 in 1970; for pyrophyllite, $65 per short ton in 1971 and $101 in 1970.

Sweden.—Exports of talc and soapstone in 1970, totaling 5,909 metric tons (6,513 short tons) and valued at Skr 625,000 ($121,000), amounted to 18 percent of the total quantity of those materials produced in Sweden that year.

United Kingdom.—An account was published in a scientific journal of the procedures used and the results obtained in a detailed study of the characteristics and potentialities for commercial exploitation of a large deposit of metamorphic talc-magnesite rock in the Shetland Archipelago. Discovery of the site, near the village of Cunningsburgh on Mainland Island, was probably prehistoric, but mining there never progressed beyond small-scale cutting of blocks to be carved into cooking pots, fishing sinkers, and spindle whorls. It was concluded that a salable talc product could be prepared from the Cunningsburgh material.[4] The only active production of industrial talc within the United Kingdom in 1971 was from the mine of Alexander Sandison and Sons, Ltd., also in the Shetlands.[5]

[3] Vincent, George. Mexican Tile Production Matches World Efficiency. Ceram. Ind., v. 96, No. 3, March 1971, pp. 32–33.
[4] Bain, J. A., D. A. Briggs, and F. May. Geology and Mineralogical Appraisal of an Extensive Talc-Magnesite Deposit in the Shetlands. Inst. of Min. and Met. (London) Trans., v. 80, No. 774, May 1971, pp. 77–84.
[5] Industrial Minerals (London). Talc: UK Consumption Shows Gradual Rise. No. 40, January 1971, pp. 19–24.

Table 8.—Talc, soapstone, and pyrophyllite: World production by country
(Short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada (shipments)	75,850	72,055	67,000
Mexico	1,469	2,320	1,889
United States	[r] 1,029,238	1,027,929	1,037,297
South America:			
Argentina	23,934	34,066	[e] 34,000
Chile	892	705	1,938
Colombia	1,681	1,899	2,177
Paraguay	99	132	176
Peru (pyrophyllite)	8,618	[e] 8,800	[e] 8,800
Uruguay (ground talc)	2,542	1,801	939
Europe:			
Austria	104,277	110,406	100,995
Finland	[r] 40,095	69,140	110,979
France	[r] 272,271	256,838	[e] 250,000
Germany, West (marketable)	50,081	37,265	39,301
Greece	6,695	6,614	2,045
Italy	[r] 154,273	170,657	152,936
Norway (ground talc)	70,807	[e] 70,500	[e] 70,500
Portugal	1,323	1,992	1,240
Romania	[e] 55,100	62,532	[e] 65,000
Spain	37,179	43,665	[e] 44,000
Sweden	[r] 31,306	35,605	[e] 35,300
U.S.S.R. [e]	419,000	419,000	441,000
United Kingdom	11,311	12,074	[e] 12,000
Africa:			
Arab Republic of Egypt (formerly United Arab Republic)	4,740	7,151	[e] 7,200
Botswana	56	45	143
Morocco (talc)	150	249	[e] 250
South Africa, Republic of [2]	14,902	13,657	12,975
Swaziland	660	280	225
Asia:			
Burma	168	235	237
China, People's Republic of [e]	165,000	165,000	165,000
India	206,674	185,641	195,477
Japan	1,996,045	2,066,230	2,089,474
Korea:			
North [e]	77,000	88,000	99,000
Republic of	[r] 204,496	224,952	234,185
Pakistan (soapstone)	[r] 2,412	3,900	3,888
Philippines	1,038	1,753	1,452
Taiwan (soapstone)	26,867	42,678	43,037
Thailand (pyrophyllite)	2,185	--	55
Oceania: Australia	[r] 61,096	141,253	[e] 60,000
Total	[r] 5,161,530	5,387,019	5,392,110

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Brazil is believed to produce in excess of 50,000 tons annually, but available data are incomplete, and Southern Rhodesia is known to be a producer, but no data are available.
[2] Includes wonderstone (pyrophyllite).

TECHNOLOGY

Experimental beneficiation procedures and testing methods applied in a technological assessment of talc-magnesite ore from a Shetland Islands deposit were outlined in a journal article. Preliminary work indicated that the talc content tended to concentrate in the fines when the rock was crushed, so that enrichment by levigation was suggested. In a number of tests, however, while the air-classified fraction so prepared contained up to 70 percent talc (up from about 40 percent in the ore), losses of that mineral in the rejected coarse portions were excessive. In the final conclusion, a froth flotation scheme, followed by acid leaching for the removal of contained iron, was judged to be the method of treatment most likely to be commercially successful. Differential thermal analysis (DTA) and thermogravimetric analysis (TGA) were found to be especially valuable techniques for determining compositional variations in the entering material and in the fractions obtained in tests. A specimen DTA curve showed an endothermic peak around 680° C corresponding to the evolution of CO_2 from the magnesite, followed by another peak near 960° C, sharp and well-separated, which was attributed to the decomposition of the hydrated talc molecule.[6]

A series of articles published in a British journal reviewed technologies involved in

[6] Work cited in footnote 4.

modern processes for the beneficiation of a variety of nonmetallic minerals. Specific mention was made of talc-group minerals in a discussion of size reduction (crushing, grinding, and related subjects including types, capacity, and performance of appropriate milling equipment) and of applicable separation/concentration methods based on the physical characteristics of those minerals.[7]

The equipment, mining procedures, and processing methods (including dust-control measures) in use by a major New England talc producer were described in a mining industry magazine.[8] The unusual properties that enable high-grade talc to serve advantageously in the manufacture of special-purpose electronic components were mentioned and briefly discussed in an illustrated magazine article.[9] A new and thoroughly modern processing plant was built by Interpace Corp. at Victorville, San Bernardino County, Calif., for the purpose of manufacturing pouring-pit refractories from locally mined pyrophyllite. A specially designed tunnel kiln of an improved type was a salient feature of the new installation.

A patent was issued for the use of ground talc as a getter for ionic contaminants in the impregnated paper that serves as dielectric in certain electrical condensers.[10] Ground talc was a specified ingredient in a mixture that was patented for controlling the undesired agglomeration of grains or pellets of certain organic materials.[11]

Patents were also issued for use of talc, together with a number of other substances, in a puttylike preparation for woodworking[12] and in a formulation for self-hardening modeling clay.[13] A patented preparation for facilitating the removal of porcelain dental prosthetic units from the ceramic dies in which they are formed was based on finely ground talc, suspended in a solution of cellulose acetate in acetone and amyl acetate, as a slip-promoting separation medium.[14]

Fibrous talc, to provide a felted texture, constitutes at least 10 percent of the weight of a patented dry mixture for dispersion in water as a covering application for ceilings.[15] A patent was issued for the production of lightweight insulating refractories from a stated formulation comprising pyrophyllite, kaolin, grog, and sawdust together with a specified proportion of a prefired and granulated blend of gypsum and kaolin.[16]

In the field of minerals beneficiation, three countries issued patents in 1971 for a process by which talc (or other listed nonmetallic minerals) can be decolorized in an aqueous suspension by the addition of dithionite at a rate controlled automatically by the simultaneously measured polarographic diffusion current of the unreacted bleaching agent.[17]

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[7] Jones, G. K. Engineering for Industrial Minerals Treatment Plant; Size Reduction and Size Enlargement; Concentration of Minerals by Size and Gravity; Separating Minerals by Froth Flotation, Electrical Properties, and Other Methods. Ind. Min. (London), No. 45, June 1971, pp. 37–43; No. 47, August 1971, pp. 33–43; No. 49, October 1971, pp. 43–50; No. 51, December 1971, pp. 39–50.

[8] Rock Products. Windham Plant Grinds Talc for Specialized Applications. V. 74, No. 6, June 1971, p. 59.

[9] Ceramic Industry Magazine. Steatite, Workhorse in Electrical Applications. V. 97, No. 1, July 1971, pp. 22–23.

[10] Bullwinkel, E. P., and W. A. Selke (assigned to Kimberly-Clark Corp.). Capacitor Having Talc Scavenger. U.S. Pat. 3,555,377, Jan. 12, 1971.

[11] Baskin, H. A. Process and Composition for Rendering Particulate Urea Substantially Noncaking. U.S. Pat. 3,558,299, Jan. 26, 1971.

[12] Parker, T. G. (assigned to U.S. Plywood-Champion Papers, Inc.). Wood Filler Composition. U.S. Pat. 3,574,155, Apr. 6, 1971.

[13] Shapero, W. H. (assigned to Mattel, Inc.). (No title). Can. Pat. 874,473, June 29, 1971.

[14] Viskery, R. C., and L. A. Badinelli (assigned to Ceramco Equipment Corp.). (No title). Can. Pat. 882,003, Sept. 28, 1971.

[15] Kent, R. C. (assigned to Armstrong Cork Co.). Spray-On Coating Composition. U.S. Pat. 3,617,321, Nov. 2, 1971.

[16] Rankine, A. S. (assigned to Johns-Manville Corp.) Insulating Fire Brick. U.S. Pat. 3,591,393, July 6, 1971.

[17] Rowse, J. B., K. J. Burr, and T. W. Webb (assigned to English Clays Lovering Pochin & Co., Ltd.). Bleaching Process. U.S. Pat. 3,573,943, Apr. 6, 1971; Can. Pat. 861,382, Jan. 19, 1971; Brit. Pat. 1,231,943, May 12, 1971.

Thorium

By Walter C. Woodmansee [1]

A continuing limited demand and excessive stocks for thorium prevailed during 1971. Growing demand for certain rare-earth elements in monazite, the principal domestic source of thorium but mined essentially for its rare-earth content, contributed to the oversupply of thorium. A few companies discontinued thorium processing operations because of the weak market. However, there were indications that demand for thorium hardener, used in magnesium alloys for aerospace applications, may increase moderately in the near future. The long-term potential for thorium nuclear fuels remained good. Progress was made in commercial markets for these thorium-based nuclear fuels.

Legislation and Government Programs.—Effective January 1, 1971, under the "Kennedy round" schedule of tariff reductions, ad valorem duties were reduced to 21 percent on thorium compounds, 7 percent on the metal, and 9 percent on thorium alloys. Further reductions to 17.5 percent, 6 percent, and 7.5 percent, respectively, were scheduled for January 1, 1972. A 10-percent ad valorem surcharge was effective August 16 to December 20, 1971.

The Congress authorized General Services Administration (GSA) disposal of an additional 210 tons ThO_2 equivalent in thorium nitrate that is in excess of the stockpile objective of 40 tons ThO_2 equivalent.[2] The entire excess of 1,792 tons ThO_2 equivalent beyond stockpile needs has now been authorized for disposal, but no sales were made during the year.

DOMESTIC PRODUCTION

Mine Production.—Monazite production of Humphreys Mining Co. near Folkston, Ga., was substantially reduced in 1971, although content of rare-earth oxide (REO) increased from 55 percent to 59 percent. Average ThO_2 grade was 5 percent. Heavy-mineral sands were mined by suction dredge for their titanium minerals and zircon content. The byproduct monazite was sold under contract with W. R. Grace & Co., Chattanooga, Tenn. Monazite was processed essentially for its REO content. Thorium-bearing residues were stockpiled for processing as needed.

Humphreys Mining Co. continued land rehabilitation of a 6-square-mile area disturbed by mining. Mill waste was used as fill, and, after grading, topsoil was respread, fertilized, and planted with grass. These methods were employed for several years before the Georgia Surface Mined Land Use Law went into effect in 1968.

At yearend, development work by Titanium Enterprises, a join venture of American Cyanamid Co. and Union Camp Corp., was near completion on a Pleistocene beach deposit, 35 miles inland and 10 miles from Green Cove Springs, Fla. Mine products will be ilmenite, leucoxene, rutile, monazite, and zircon.[3]

Kerr-McGee Chemical Corp. conducted market feasibility studies on titanium, rare-earth elements, and thorium from a mineral sand deposit in western Tennessee, where a pilot-plant operation had been underway.

In September, mining was terminated at Kendrick Bay, Alaska, after about 56,000 tons of high-grade uranium-thorium ores

[1] Geologist, Division of Nonferrous Metals.
[2] U.S. Congress. An Act to Authorize the Disposal of Thorium from the Supplemental Stockpile. Public Law 92-96, Aug. 11, 1971, 85 Stat. 323.
[3] Engineering and Mining Journal. V. 173, No. 1, January 1972, p. 134.

were shipped to the uranium mill at Ford, Wash. The mining operation was a joint venture of Newmont Mining Co. and Midnite Mines Inc. The principal ore minerals were uranothorite and uranothorianite in granitic rocks.[4] Thorium, which occurred in equal quantities with uranium, was not recovered because of lack of a market.

Refinery Production.—The principal domestic firms processing monazite for rare-earth elements and thorium were W. R. Grace & Co., at Chattanooga, Tenn., and Lindsay Rare Earths, affiliated with Kerr-McGee Chemical Corp., West Chicago, Ill. A number of thorium-processing companies maintain stocks of various compounds and the metal for nonenergy use and for nuclear fuels.

Table 1.—Companies processing and fabricating thorium, 1971

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.
The Dow Chemical Co	Midland, Mich	Stocks of nitrate, oxide, and metal; magnesium-thorium alloy.
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., Davison Chemical Div.	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.
NL 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 Corp., 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

On the basis of estimated production and imports of monazite and thorium compounds, apparent consumption was about 300 tons ThO_2 equivalent in 1971. However, actual industrial demand was probably substantially lower; the available monazite supply was processed essentially for its rare-earth content, and most of the thorium residues entered company holding areas. Nonenergy industrial demand was estimated at 100 to 150 tons ThO_2 equivalent for use (in order of relative importance) in Welsbach incandescent gas lamp mantles; hardener (30 to 40 percent thorium content) for magnesium-thorium alloys (3 percent thorium content) in aerospace applications; dispersion hardening (2 percent ThO_2 content) of metals such as nickel, tungsten, and stainless steel; and miscellaneous electronic, refractory, and chemical (catalytic) applications.

In the nuclear field, research and development studies, sponsored by both the Atomic Energy Commission (AEC) and industry, continued on thorium-uranium fuels, reactor concepts using these fuels, and thorium fuels reprocessing. Examples of the application of the Th_{232}-U_{233} fuel cycle are the high-temperature, gas-cooled reactor (HTGR), the molten-salt breeder reactor, and seed-blanket loadings for the pressurized water reactor at the Atomic Power Station, Shippingport, Pa.[5]

[4] Stephens, F. H. The Kendrick Bay Project. Western Miner. V. 44, No. 10, October 1971, pp. 151–158.

[5] U.S. Atomic Energy Commission, Division of Industrial Participation. The Nuclear Industry—1971. WASH–1174–71, December 1971, p. 52.

AEC's Bettis Atomic Power Laboratory was developing a Th_{232}-U_{233} fuel reactor core to demonstrate breeding in the light water reactor (LWR) system. This is an advancement of seed-blanket technology and is the only known concept for improving fuel efficiency in the common, thermal LWR. According to AEC, successful LWR breeding could lead to development of large domestic thorium resources.

Late in the year, Philadelphia Electric Co. ordered two 1,150-megawatt HTGR's from Gulf General Atomic Co. (GGA), San Diego, Calif. This was the first fully commercial order for the HTGR.[6] Research and development were underway on connecting the high-temperature reactor to gas turbines, which would eliminate the steam cycle. A problem is the reprocessing of the Th_{232}-U_{233} fuel, which may prove costly.

GGA has designed 770-megawatt and 1,000-megawatt HTGR's. The latter will have an initial fuel core using 40 tons of ThO_2 and refueling (after the second year) of 10 tons ThO_2 per year. The Th_{232}-U_{233} fuel consists of multilayered, ceramic-coated particles, which have high integrity at elevated temperatures, high burnup, ease of fabrication, and good quality control.

PRICES

The monazite price continued to decline in the international market. According to trade statistics of the Bureau of the Census, the average declared value for imported monazite was $113.77 per ton, compared with $123.96 in 1970. Domestic monazite was quoted at $180 to $200 per ton (based on REO only), little changed from 1970, but the market price was lower and was further depressed toward the end of the year.

Prevailing prices for thorium nitrate, oxide, and metal showed little, if any, change during the year. Prices listed by the Davison Chemical Division, W. R. Grace & Co., Chattanooga, Tenn., were in the following ranges, per pound, depending on quantity of purchase: Nitrate, wire grade, 47 percent ThO_2, $2.45–$2.50; nitrate, mantle grade, 47 percent ThO_2, $2.50–$2.55; ThO_2, ceramic grade, 99.9 percent ThO_2, $6–$10; and ThO_2, refractory grade, 99.9 percent ThO_2, $7–$11. Lindsay Rare Earths, West Chicago, Ill., quotations were as follows, per pound: Thorium salts, 99.9 percent purity, $6 (chloride)–$65 (iodide); nitrate, $2.55–$6; oxide, $7–$20; and oxalate, $4–$6.

Quotations on thorium metal in pellets by American Metal Market remained steady at $15 per pound. The pure metal was $65 per pound.

FOREIGN TRADE

Imports of monazite, largely for the rare-earth content, were slightly reduced from the 1970 level. Australia and Malaysia remained the principal sources of supply. Imports of thorium oxides and nitrates from France increased substantially. Foreign supply of thoriated gas mantles, mainly from the United Kingdom, increased 44 percent in terms of estimated ThO_2 equivalent content. There were no thorium metal imports in 1971. Exports of thorium in the form of metal, alloys, and compounds are not available; they are included with uranium, which comprises the bulk of these exports.

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[5] The Economist. Nuclear Power's New Joker. V. 240, No. 6681, Sept. 11, 1971, p. 79.

Table 2.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in pounds unless otherwise specified)

	1969		1970		1971		Principal sources and destinations, 1971
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Ore and concentrate (ThO_2 content)	1,544	$11,181	81	$1,296	--	--	
Metals and alloys [1]	788	26,182	5,503	86,021	65,592	$943,930	Canada 59,495; Italy 3,437; Japan 1,993; Belgium-Luxembourg 438.
Compounds [1]	105,620	316,561	4,045,549	24,579,293	6,021,148	38,498,069	Canada 3,355,381; United Kingdom 1,951,471; Netherlands 366,323; West Germany 108,293; Japan 88,217; France 86,045.
IMPORTS							
Ore and concentrate:							
Monazite (short tons)	4,206	493,802	3,448	427,411	3,373	383,733	Australia 1,802; Malaysia Republic 1,571.
ThO_2 content [e]	504,700	--	413,800	--	404,800	--	
Compounds:							
Nitrate	--	--	5	382	1,100	1,891	All from France.
Oxide	442	2,514	10	280	2,481	8,692	Do.
Oxide equivalent, in gas mantles [e 2]	4,100	398,414	4,100	409,110	5,900	618,616	United Kingdom 4,700; West Germany 670; Austria 480.
Other	236	25,848	252	23,253	227	28,195	Switzerland 189; West Germany 27; France 9; United Kingdom 2.

[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, Brazil, India, and Malaysia continued to provide the major share of estimated world production of monazite concentrates in 1971, exclusive of U.S. output, data on which are withheld.

Brazil.—The Comissão Nacional de Energia Nuclear (CNEN) increased monazite production by 15 percent in 1970, the latest year for which complete data are available. The CNEN operated monazite workings at Itabapoana (Rio de Janiero) and Cumuruxatiba (Bahia). Monazita e Ilmenita do Brasil, a private concern, worked a monazite deposit at Guarapari (Espírito Santo) under contract with CNEN.

A change in Brazil's nuclear energy laws, which relaxed regulations relative to exploration, reportedly was drafted, but no official decision was announced.

Canada.—The Department of Energy, Mines, and Resources reported thorium reserves in excess of 100,000 tons ThO_2 in uranium ores minable at $10 per pound U_3O_8. There has been no thorium mine production since 1968, but small quantities have been refined to metallurgical-grade ThO_2 by Rio Algom for Dominion Magnesium, Ltd., Haley, Ontario, which has produced refined thorium metal, pellets, and powder.

Research was underway in modifying techniques to reduce costs and produce high-purity thorium, uranium, and rare-earth elements.[7]

India.—According to Indian Rare Earths Ltd., monazite production at Quilon increased nearly 48 percent during the fiscal year ending March 31, 1971.[8] Production and sales data for fiscal 1970 and 1971 were as follows:

	1970 [1]	1971 [1]
Monazite processed___short tons__	3,299	3,903
Production of thorium hydroxide_______________do____	1,156	1,378
Sales of monazite:		
Quantity_____________do____	3,267	3,745
Value___________thousands__	$138	$147
Sales of thorium hydroxide [2] do____	$91	$68

[1] Fiscal year ending March 31.
[2] To Indian Government.

Because of increasing demand for the rare-earth elements, annual capacity at the Alwaye plant was increased to 1,650 tons.

Thorium reserves in India were listed at 378,000 tons ThO_2.[9] Pilot-plant studies were made on extracting uranium and thorium from crude hydroxide cake, ob-

[7] Williams, R. M., and R. M. Berry. Uranium and Thorium in Canada: Resources, Production and Potential. Department of Energy, Mines, and Resources, Ottawa, Ontario. Prepared for Fourth International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, CONF. 710901-172, May 1971, 21 pp.

[8] Indian Rare Earths Ltd. 21st Annual Report 1970–71. Bombay, 1971, 32 pp.

[9] Dar, K. K., K. M. V. Jayaram, D. V. Bhatnagar, R. K. Garg, (and others). Uranium and Thorium Resources and Development of Techniques for Their Extraction in India. Prepared for Fourth International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, CONF. 710901-233. May 1971, 17 pp.

Table 3.—Monazite concentrates: World production, by country

(Short tons)

Country [1]	1969	1970	1971 [p]
Australia	[r] 4,249	5,027	[e] 4,400
Brazil	2,204	2,544	[e] 2,600
Ceylon	62	18	[e] 18
India [2]	2,708	4,004	[e] 4,400
Malagasy Republic	2	--	--
Malaysia [3]	[r] 1,770	1,827	[e] 1,800
Mauritania	115	[e] 110	[e] 110
Mozambique	--	2	[e] 2
Nigeria	14	14	100
Thailand	72	119	123
United States	W	W	W
Zaire (formerly Congo-Kinshasa)	196	158	--
Total	11,392	13,823	13,553

[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 insufficient to make reliable estimates of output levels.
[2] Year beginning April 1 of that stated.
[3] Exports. In addition to the monazite listed here, Malaysia also records the export of "other ores of thorium" (not more exactly described) as follows in short tons: 1969—180; 1970—433; 1971—NA.

tained by caustic breakdown of monazite and subsequent partial leaching of thorium.

Malawi.—Beach sands along stretches of the Lake Malawi shoreline reportedly contain high heavy-mineral content of ilmenite, rutile, monazite, and zircon, particularly in the Salima area and along the eastern shore. An exclusive prospecting license was granted to an area covering 7,100 square miles, near Salima.

Norway.—The Fen rare-earth mine, near Ulefoss in Telemark, 74 miles southwest of Oslo, contains substantial quantities of thorium in carbonatite and hematitic rocks. Thorium content is 965 parts per million in the carbonatite rate-earth deposit, which totals more than 100 million tons. In the hematite, thorium content of 3,600 parts per million exceeds the total rare-earth content.

Processes for the extraction of the rare-earth and thorium values have been unsuccessful, owing to the extremely fine-grained nature and complex mineralogy of the ore.[10]

Somali Republic.—According to the Ministry of Mining, mining companies were investigating radioactive areas delineated by United Nations Development Programs in the Bur area and in northern region. A deposit in the north, containing mainly thorium and yttrium, was under investigation by Nucleare Somali, which is affiliated with Ente Nazionale Idrocarburi, the Italian national company.

South Africa, Republic of.—Early in the year, the South African Atomic Energy Board reported that Rio Tinto Zinc Corp. —Palabora Mining Co., Ltd., had commissioned a $4.2 million plant for production of thorium sulfate and uranium oxide at Phalaborwa. A heavy-mineral concentrate from the copper operation contains uranothorianite, which is treated by a process developed by the Atomic Energy Board and the National Institute of Metallurgy.[11]

TECHNOLOGY

Research continued on the processing of thorium-rare-earth ores and the separation and recovery of the constituents. In smelting euxenite concentrates, a mixture with aluminum, magnesium, and sodium perchlorate was thermite-reduced to yield a ferrocolumbium product and a slag containing thorium, rare-earth elements, and other values.[12] The slag was solidified, ground, and leached with nitric acid. The leach liquor and residual solids may be processed by conventional methods for recovery of uranium, thorium, rare earth elements, and yttrium.

In separating cerium and thorium from a rare-earth solution, the solute was treated with hydrogen peroxide and potassium iodate, and pH adjustments were made.[13] Iodates of cerium and thorium are precipitated. Thorium can be separated from cerium in monazite processing by forming alkali metal double carbonates during leaching.[14] The insoluble carbonates were separated, and cerium was removed in the insoluble trivalent state from the remaining solution. In a final solution, the thorium was crystallized as a double carbonate.

In other research, thorium was separated from rare-earth elements by a new solvent extraction technique.[15] The leach liquor from uranium ore processing was contacted with a mixture of a dialkyl-substituted orthophosphoric acid and a trialkyl phosphate to extract thorium and the rare-earth elements in the organic phase, which is then separated and treated with hydrochloric or nitric acid to leave thorium in the organic phase and the rare-earth elements in the aqueous phase.

Ultrahigh-purity thorium (impurities less than 50 parts per million, resistance ratio greater than 1,000) was prepared using electrotransport as the refining

[10] Gaudernack, B., and O. Braaten. Occurrence and Extraction of Rare Earths in Norway. Paper presented at Ninth Rare Earths Research Conference, Blacksburg, Va., Oct. 10–14, 1971, 13 pp.

[11] Mining Journal (London). V. 276, No. 7063, Jan. 1, 1971, p. 10.

[12] British Patent No. 1,240,170 (assigned to Nuclear Fuel Services, Inc.). Smelting Euxenite Ore Concentrate for Extraction of Various Metal Values. July 21, 1971.

[13] Chiola, V., and G. J. Kamin (assigned to Sylvania Electric Products, Inc.). Separation of Cerium and Thorium From a Solution of the Rare Earths. U.S. Pat. 3,594,117, July 20, 1971.

[14] Comber, F. R. (assigned to W. J. Reynolds Holdings Ltd.). Extraction of Rare-Earth Values from Monazite, Xenotime, or other Sources, and Separation of Thorium From Cerium. British Pat. No. 1,223,682, Mar. 3, 1971.

[15] Hansen, R. D. (assigned to Dow Chemical Co.). Solvent Extraction of Thorium Values from Yttrium and Other Rare-Earth Values. British Pat. 1,219,305, Jan. 13, 1971.

method.[16] Time, temperature, and prevention of contamination were considered critical. Single high-purity crystals were formed by repeated heating of specimens through the alpha- and beta-phase transformations, followed by prolonged heating slightly below the transformation temperature (approximately 48 hours at 1,320° C. ±10°C).

Several studies were underway on thorium systems.[17] Work on diphenyl sulfoxide complexes indicated that Th (IV) has a tendency to form complexes that have high coordination numbers, depending on the nature of the anion.[18]

Dimensional changes, caused by fuel swelling, in thorium ceramic nuclear fuels during reactor operation were considered analagous to creep deformation.[19] The swelling was dependent on creep strengths of the fuel and the cladding.

In a Canadian study, thorium fuels were considered favorable for use in large-capacity reactors, especially in conjunction with the organic-cooled, heavy-water-moderated concept.[20] A new design in thorium fuel indicated near breeding with high burnup and high neutron economy.

The Oak Ridge National Laboratory, Oak Ridge, Tenn., has published a third volume in its ceramics data series. It deals with the thorium-uranium carbide fuels. The thorium-carbon system is reviewed.[21]

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[16] Peterson, D. T., and F. A. Schmidt. Preparation of High-Purity Thorium and Thorium Single Crystals. J. Less-Common Metals (Amsterdam, Netherlands), v. 24, No. 2, June 1971, pp. 223–228.

[17] Laud, K. R., and F. A. Hummel. The System ThO_2-P_2O_5. J. Am. Ceram. Soc., v. 54, No. 6, June 1971, pp. 296–299.

Schlitz, R. J., E. R. Stevens, and O. N. Carlson. The Thorium-Copper System. J. Less-Common Metals (Amsterdam, Netherlands), v. 25, No. 2, October 1971, pp. 175–185.

[18] Savant, V. V., and C. C. Patel. Diphenyl Sulphoxide Complexes of Th(IV). J. Less-Common Metals (Amsterdam, Netherlands), v. 24, No. 4, August 1971, pp. 459–465.

[19] Seltzer, M. S., J. S. Perrin, A. H. Clauer, and B. A. Wilcox. A Review of Creep Behavior of Ceramic Nuclear Fuels. Reactor Technology, Quarterly Technical Progress Report. (U.S. Atomic Energy Commission), v. 14, No. 2, 1971, pp. 99–135.

[20] Lewis, W. B., M. F. Duret, D. S. Craig, J. I. Veeder, (and others). Large-Scale Nuclear Energy From the Thorium Cycle. Atomic Energy of Canada Ltd., Chalk River, Ontario. Prepared for Fourth International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, CONF. 710901–175, May 1971, 15 pp.

[21] Peterson, S., and C. E. Curtis. Thorium Ceramics Data Manual. Carbides. Oak Ridge National Laboratory, Oak Ridge, Tenn., v. 3, ORNL–4503, April 1971, 34 pp.

Tin

By V. Anthony Cammarota, Jr. [1]

Free world primary tin production and demand were close to balance in 1971. U.S. consumption of primary and secondary tin combined decreased 5.3 percent for the year. Primary and secondary tin consumption declined 1.8 percent and 14 percent respectively. Declines were most severe in the heavier tin-consuming sectors: tinplate 5.8 percent; bronze and brass 19.3 percent; and solder 2.1 percent. Tin, as the mineral cassiterite (SnO_2), is mined and smelted at many places around the world, mainly outside the United States. Most of the nation's tin, in the form of slabs, bars, and ingots, came from Malaysia and Thailand in 1971. Less than 100 long tons of tin was mined domestically from mines in Colorado and Alaska. The United States continued to lead the world in the recovery and use of reclaimed (secondary) tin during 1971, and about one-third of the national supply came from scrap smelted in about 85 smelters located all across the country.

The only major smelter-refinery in the United States, Gulf Chemical and Metallurgical Corp. at Texas City, Tex., continued to smelt Bolivian tin concentrates under a toll agreement with the Bolivian's State-owned Corporación Minera de Bolivia (COMIBOL).

While some tin was released to other Government agencies by the General Services Administration (GSA), the commercial sales of stockpile tin were indefinitely suspended.

The Fourth International Tin Agreement commenced operation on July 1, 1971, with the Federal Republic of Germany and the U.S.S.R. joining as consuming members. Under the Third Agreement, the Buffer Stock made a substantial profit of almost $19,344,000.

Legislation and Government Programs.—No strategic stockpile tin was disposed of by GSA through commercial channels during the year. However, 1,736 long tons of tin were released to other Government agencies, primarily the Agency for International Development (AID) for shipment to India (1,535 long tons) and Turkey (152 long tons). The stockpile objective remained at 232,000 long tons, and at the end of the year, there was an excess of about 19,000 long tons on hand.

The U.S. Department of State stated in April that commercial sales of stockpile tin have been indefinitely suspended, making official a "no sales" policy that had in fact prevailed since the summer of 1968.

Government financial assistance on a participatory basis was available through the Office of Minerals Exploration (OME), U.S. Geological Survey, for tin exploration up to 75 percent of the acceptable costs.

The depletion allowance for tin remained at 22 percent for domestic deposits and 14 percent for foreign deposits.

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[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient tin statistics

(Long tons)

	1967	1968	1969	1970	1971
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	3,048	3,453	345	NA	NA
Secondary	22,667	22,495	22,775	20,001	20,096
Exports (exports and reexports)	2,479	4,495	2,903	4,452	2,262
Imports for consumption:					
Metal	50,223	57,358	54,950	50,554	46,940
Ore (tin content)	3,255	2,439	--	4,667	3,060
Consumption:					
Primary	57,848	58,859	57,730	52,957	51,980
Secondary	22,790	23,102	23,060	20,880	17,970
Price: Straits tin, in New York, average cents per pound	153.405	148.111	164.435	174.135	167.344
World production:					
Mine	214,233	228,332	225,725	229,437	229,533
Smelter	219,175	229,564	225,290	220,939	226,821

NA Not available. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Annual production of tin within the United States in 1971 was somewhat less than 100 long tons. Most of the year's output came from Colorado as a byproduct of the mining of molybdenum. Some tin concentrates were produced from a dredging operation in Alaska. The Lost River Mining Corp., a company set up by Canada's P.C.E. Explorations to conduct operations at a tin-tungsten property in the Lost River area of Alaska's Seward Peninsula, reported encouraging progress. Proved reserves totaled nearly 33 million tons containing 0.286 percent tin. Lost River claimed that the tin reserves at their property constituted the entire known lode tin reserves within the United States. This property, located some 4 to 6 miles from the Bering Sea coast, has a history of small-scale placer tin and later small-scale lode tin mine operations. The company made available $1 million for the planned program of exploratory drilling and studies during 1971.

Smelter Production.—The only tin smelter in the United States is the Texas City, Tex., facility of Gulf Chemical and Metallurgical Corp. In 1971, it operated on Bolivian tin concentrates which formed the base load together with low-cost reclaimed domestic industrial residues to complete the feed. The smelter performed these functions as a contract toll converter for COMIBOL, and the resulting metal was then sold by COMIBOL to U.S. consumers. In addition, a small quantity of tin concentrates from Mexico was smelted. Thus, to all intents and purposes, U.S. tin consumers were wholly dependent upon foreign tin in 1971.

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.

Eighty-five percent of the tin recycled during 1971 did not exist as bar, pig, or other types of actual metal, but as an alloy constituent of metals such as bronzes, brasses, solders, and bearing and type metals. A small amount also remains in chemical compounds. Only about 12 percent of the recycled tin, mostly from new tinplate scrap, found its way to market as metal. This latter volume provided only 3 percent of the total tin supplied to U.S. consumers in 1971, a proportion which does not vary appreciably from year to year.

Secondary tin furnishes 28–30 percent of the total tin supplied to U.S. markets each year. However, secondary tin produced in this country was up slightly in 1971 by 95 long tons.

There are five companies located in 11 States which were engaged in the detinning business in the United States. Normally the raw materials used are tinplate scrap and spent chemicals or tinning solutions. With the rapid rise in the number of recycle centers across the country in response to ecological and conservation campaigns, more used cans found their way to detinning plants.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

		1970	1971
Tinplate scrap treated [1]	long tons	771,415	742,259
Tin recovered in the form of—			
Metal	do	1,988	1,786
Compounds (tin content)	do	620	583
Total [2]	do	2,608	2,369
Weight of tin compounds produced	do	r 1,076	1,105
Average quantity of tin recovered per long ton of tinplate scrap used	pounds	7.57	7.15
Average delivered cost of tinplate scrap	per long ton	$36.28	$28.78

r Revised.
[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.
[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 494 long tons (489 tons in 1970) of tin as metal and in compounds from tin-base scrap and residues in 1971.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery
(Long tons)

Form of recovery	1970	1971
Tin metal:		
At detinning plants	2,397	2,250
At other plants	177	74
Total	2,574	2,324
Bronze and brass:		
From copper-base scrap	9,191	8,850
From lead and tin-base scrap	86	84
Total	9,277	8,934
Solder	4,898	5,482
Type metal	1,517	1,202
Babbitt	683	899
Antimonial lead	351	631
Chemical compounds	700	612
Miscellaneous [1]	1	12
Total	8,150	8,838
Grand total	20,001	20,096
Value (thousands)	$77,956	$75,328

[1] Includes foil, cable lead, and terne metal.

CONSUMPTION

Consumption of primary and secondary tin, taken together, decreased 5.3 percent in 1971. Secondary tin dropped 14 percent while primary tin declined 1.8 percent. A general slowdown in utilization of most of the major tin alloys, such as brass and bronze decreased 19.3 percent; babbitt 2.4 percent; type metal 26.1 percent; collapsible tubes and foil 14.8 percent; and solder 2.1 percent was a contributing factor. The tinplate industry, by far the largest consuming sector, showed a 5.8 percent drop in tin consumed in 1971. Only primary tin is used in the making of tinplate, which accounted for 46 percent of all primary tin consumed during the year. Inroads by tin-free steel and aluminum as alternates to tin in the making of cans, together with sizable imports of tinplate itself, contributed to the lower consumption rate for primary tin in 1971. It should be pointed out that aluminum cans comprised 11.6 percent of the total cans shipped in 1971, an increase of 10.2 percent from the previous year. In 1971, there were seven steel companies engaged in the making of tinplate at 14 mills. During the year, four small tin-consuming companies ceased operations.

Consumption of tin for use in chemicals including tin oxide, tin powder, and in a few minor miscellaneous applications continued to improve during 1971 but tonnages involved were minimal.

Table 4.—Shipments of metal cans [1]

(Thousand base boxes)

Type of can	1970 r	1971 p	1971 change, percent
FOOD AND BEVERAGES			
Fruit and fruit juices	13,337	13,258	−0.6
Vegetables and vegetable juices	24,058	21,939	−8.8
Milk, evaporated and condensed	2,534	2,568	+1.3
Other dairy products	585	452	−22.7
Soft drinks	26,197	28,255	+7.8
Beer	37,593	36,636	−2.5
Meat and poultry	3,723	3,702	−0.6
Fish and other seafoods	3,450	2,664	−22.8
Coffee	3,766	3,759	−0.2
Lard and shortening	1,733	1,639	−5.4
Baby foods	1,053	1,205	+14.4
Pet foods	6,524	5,898	−9.6
All other foods, including soups	14,024	15,520	+10.7
Total	138,577	137,495	−0.8
NONFOOD			
Oils	3,108	3,085	−0.7
Paint and varnish	4,886	4,903	+0.3
Antifreeze	816	765	−6.2
Pressure packing (value type)	5,431	5,285	−2.7
All other nonfood	6,481	6,152	−5.0
Total	20,722	20,190	−2.6
Grand total	159,299	157,685	−1.0
BY METAL			
Steel base boxes [2]	143,064	139,400	−2.6
Short tons (thousand)	5,655	5,510	−2.6
Aluminum base boxes	16,235	18,285	+12.6
Short tons (thousand)	352	393	+11.6

p Preliminary. r Revised.

[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 1971

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31	New	Old	Total
			New	Old	Total				
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	1,337	50,470	--	49,912	49,912	1,895	--	2,146	2,146
Brass, composition or red	2,908	70,216	16,442	53,575	70,017	3,107	537	1,992	2,529
Brass, low (silicon bronze)	815	3,517	2,880	872	3,752	580	--	8	8
Brass, yellow	4,244	57,982	6,626	50,727	57,353	4,873	23	511	534
Bronze	2,565	22,596	3,781	19,102	22,883	2,278	379	1,501	1,880
Low-grade scrap and residues	6,173	89,004	61,622	21,954	83,576	11,601	9	--	9
Nickel silver	563	3,816	657	3,259	3,916	463	6	23	29
Railroad-car boxes	232	1,486	--	1,414	1,414	304	--	67	67
Total	18,837	299,087	92,008	200,815	292,823	25,101	954	6,248	7,202
Brass mills: [1]									
Brass, low (silicon bronze)	4,079	44,310	44,310	--	44,310	3,824	2	--	2
Brass, yellow	22,507	211,578	211,578	--	211,578	14,292	191	--	191
Bronze	725	4,348	4,348	--	4,348	655	200	--	200
Nickel silver	2,618	21,205	21,205	--	21,205	3,254	--	--	--
Total	29,929	281,441	281,441	--	281,441	22,025	393	--	393
Foundries and other plants: [2]									
Auto radiators (unsweated)	528	8,424	--	8,110	8,110	842	--	365	365
Brass, composition or red	607	5,048	1,711	3,018	4,729	926	81	143	224
Brass, low (silicon bronze)	27	416	194	219	413	30	--	2	2
Brass, yellow	674	5,440	2,278	3,129	5,407	707	5	27	32
Bronze	204	756	258	462	720	240	21	35	56
Low-grade scrap and residues	503	393	254	228	482	414	--	--	--
Nickel silver	3	22	18	4	22	3	--	--	--
Railroad-car boxes	341	8,837	--	7,956	7,956	1,222	--	378	378
Total	2,887	29,336	4,713	23,126	27,839	4,384	107	950	1,057
Total tin from copper-base scrap	--	--	--	--	--	--	1,454	7,198	8,652
Lead-base scrap: Smelters, refiners, and others:									
Babbitt	450	10,277	--	10,415	10,415	312	--	505	505
Battery lead plates	r 33,218	440,017	--	434,636	434,636	38,599	--	463	463
Drosses and residues	r 24,021	125,072	128,020	--	128,020	21,073	2,685	--	2,685
Solder and tinny lead	357	10,149	--	10,236	10,236	270	--	1,589	1,589
Type metal	1,417	23,183	--	23,047	23,047	1,553	--	1,095	1,095
Total	r 59,463	608,698	128,020	478,334	606,354	61,807	2,685	3,652	6,337

See footnotes at end of table.

Table 5.—Stocks, receipts and consumption of new and old scrap and tin recovered in the United States in 1971—Continued

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31	New	Old	Total
			New	Old	Total				
Tin-base scrap: Smelters, refiners, and others:									
Babbitt	21	315	8	303	311	25	6	253	259
Block-tin pipe	9	160	--	156	156	13	--	154	154
Drosses and residues	r 521	3,577	3,670	--	3,670	428	1,812	--	1,812
Pewter	1	22	--	22	22	1	--	19	19
Total	r 552	4,074	3,678	481	4,159	467	1,818	426	2,244
Tinplate scrap: Detinning plants	--	--	742,259	--	742,259	--	2,863	--	2,863
Grand total	--	--	--	--	--	--	8,820	11,276	20,096

r Revised.

[1] Brass mill stocks include home scrap; purchased scrap consumption assumed equal to receipts; therefore, lines and total in brass mill section do not balance.

[2] Omits "machine-shop scrap."

Table 6.—Consumption of primary and secondary tin in the United States

(Long tons)

	1967	1968	1969	1970	1971
Stocks Jan. 1 [1]	32,718	30,087	28,152	23,441	21,165
Net receipts during year:					
Primary	56,324	59,018	55,125	r 52,096	51,727
Secondary	2,884	2,101	2,325	r 2,502	2,491
Scrap	21,492	21,919	21,624	19,748	16,179
Total receipts	80,700	83,038	79,074	r 74,346	70,397
Total available	113,418	113,125	107,226	r 97,787	91,562
Tin consumed in manufactured products:					
Primary	57,848	58,859	57,730	r 52,957	51,980
Secondary	22,790	23,102	23,060	r 20,880	17,970
Total	80,638	81,961	80,790	r 73,837	69,950
Intercompany transactions in scrap	2,693	3,012	2,995	2,785	3,055
Total processed	83,331	84,973	83,785	r 76,622	73,005
Stocks Dec. 31 (total available less total processed)	30,087	28,152	23,441	21,165	18,557

r Revised.
1 Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1967—90 tons; 1968—20 tons; 1969—1,185 tons; 1970—80 tons; and 1971—10 tons.

Table 7.—Tin content of tinplate produced in the United States

Year	Tinplate (hot-dipped)			Tinplate (electrolytic)			Tinplate waste—waste, strips, cobbles, etc., gross weight (short tons)	Total tinplate (all forms)		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)		Gross weight (short tons)	Tin content [1] (long tons)	Tin per short ton of plate (pounds)
1967	26,612	263	22.2	5,544,987	29,289	11.9	743,689	6,315,288	29,552	10.5
1968	(2)	(2)	(2)	(2)	(2)	(2)	682,792	6,088,345	28,839	10.6
1969	(2)	(2)	(2)	(2)	(2)	(2)	581,594	5,944,758	26,886	10.1
1970	(2)	(2)	(2)	(2)	(2)	(2)	625,998	5,590,038	25,127	10.1
1971	(2)	(2)	(2)	(2)	(2)	(2)	547,959	5,297,970	23,669	10.0

1 Includes small tonnage of secondary tin and tin acquired in chemicals.
2 Hot-dipped and electrolytic tinplate have been combined to avoid disclosing individual company confidential data.

Table 8.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

	1970			1971		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	407	r 183	r 590	425	169	594
Babbitt	1,944	1,297	3,241	1,977	1,187	3,164
Bar tin	1,019	33	1,052	826	16	842
Bronze and brass	3,387	10,279	13,666	3,013	8,010	11,023
Chemicals including tin oxide	r 1,601	1,524	r 3,125	1,924	1,716	3,640
Collapsible tubes and foil	855	5	860	721	12	733
Pipe and tubing	23	3	26	19	5	24
Solder	13,910	6,274	20,184	13,947	5,812	19,759
Terne metal	222	47	269	249	128	377
Tinning	2,080	63	2,143	2,238	56	2,294
Tinplate [1]	25,127	--	25,127	23,669	--	23,669
Tin powder	1,011	48	1,059	1,513	19	1,532
Type metal	145	964	1,109	90	730	820
White metal [2]	1,156	r 118	r 1,274	1,345	102	1,447
Other	70	r 42	r 112	24	8	32
Total	r 52,957	r 20,880	r 73,837	51,980	17,970	69,950

r Revised.
1 Includes secondary pig tin and tin acquired in chemicals.
2 Includes pewter, britannia metal, and jewelers' metal.

STOCKS

Tinplate mills, which held 69 percent of the plant stocks of pig tin, are the largest users of primary tin. Plans announced during 1970 to reduce warehouse stocks of fabricated sheets of can stock as well as of primary tin metal continued to manifest themselves throughout 1971. Total primary tin stocks were found to be 18 percent below 1970 stocks.

An overall downward trend in industrial stocks of tin in the United States, which began in 1966, persisted in 1971. The grand total of stocks of all tin in the hands of, or en route to, U.S. industrial consumers was off 5.6 percent on December 31, 1971, from stocks at yearend 1970. However, volume afloat at yearend was up 29 percent.

Table 9.—U.S. industry yearend tin stocks

(Long tons)

	1967	1968	1969	1970	1971
Plant raw materials:					
Pig tin:					
Virgin	17,044	15,975	12,281	9,451	7,779
Secondary	283	215	253	222	255
In process [1]	12,760	11,962	10,907	11,492	10,523
Total	30,087	28,152	23,441	21,165	18,557
Additional pig tin:					
In transit in United States	20	1,185	80	10	140
Jobbers-importers	[2] 1,315	1,182	1,210	1,635	1,630
Afloat to United States	4,890	5,390	5,865	3,500	4,510
Total	6,225	7,757	7,155	5,145	6,280
Grand total	36,312	35,909	30,596	26,310	24,837

[1] Tin content, including scrap.
[2] Includes GSA as follows: 428 tons end of December 1967, sold but not delivered.

PRICES

After the dull trading conditions in tin early in the year on the London Metal Exchange (LME), prices began a steady upward climb to almost £1,500 per metric ton. Turnover on March 22 soared to 5,425 metric tons, a figure not seen on the LME for many years. The subsequent announcement by the U.S. State Department that commercial disposals of tin surplus to stockpile requirements were being suspended indefinitely, added buoyancy to the market. However, the underlying air of uncertainty surrounding revaluation of currencies in the latter part of the year led to a fall in tin prices to about £1,407 per metric ton. The Buffer Stock Manager became active to support cash tin at about £1,399 per metric ton. As the dock strikers returned to work in the United States at yearend, prices recovered to £1,433 per metric ton.

The average London price for the year was £1,437.4 per metric ton; the average Penang price was £1,420.97 per metric ton. Prices at New York for prompt delivery of Straits tin averaged 167.344 cents per pound for 1971.

Table 10.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1970			1971		
	High	Low	Average	High	Low	Average
January	184.500	174.000	179.169	162.250	161.000	161.638
February	177.250	170.000	174.910	164.500	161.250	162.855
March	179.250	175.500	177.125	170.000	163.250	167.011
April	188.000	178.750	183.875	170.500	168.000	168.881
May	185.500	172.500	180.538	168.500	164.000	166.025
June	175.000	166.250	170.227	165.750	163.750	164.477
July	166.250	163.750	164.773	167.500	165.500	166.440
August	178.500	165.000	174.512	167.500	165.000	166.074
September	177.250	173.500	174.738	167.500	166.750	167.286
October	174.500	171.750	173.648	168.500	167.250	167.697
November	174.000	169.000	172.250	177.250	168.750	175.388
December	170.250	160.500	163.852	177.500	172.000	174.357
Average	188.000	160.500	174.135	177.500	161.000	167.344

Source: American Metal Market.

FOREIGN TRADE

The United States continued to rely upon foreign sources for tin. The small volume of ore mined in the United States is smelted each year at various plants around the Western World, and in 1971 some Bolivian tin which was toll-smelted in the United States went to U.S. consumers. Malaysia furnished 59 percent of the tin imported into the United States; Thailand 30 percent; and Australia and Indonesia combined 5 percent.

During 1971, 3,050 long tons of tin-in-concentrates were imported from Bolivia for smelting at the Texas City, Tex., smelter of the Gulf Chemical and Metallurgical Corp. In addition, concentrates containing 10 long tons of tin-in-concentrates were imported from Mexico.

Exports from the United States were 2,262 long 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.

Table 11.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate				Tinplate circles, strips and cobbles		Tinplate scrap	
	Exports		Reexports		Exports		Imports		Exports		Imports	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1969	2,362	$8,459	541	$1,927	289,852	$49,160	268,450	$51,339	23,285	$2,577	21,293	$917
1970	4,009	15,222	443	1,701	294,788	59,458	292,611	59,066	21,348	2,628	19,382	591
1971	1,821	6,648	441	1,620	186,151	39,605	372,875	80,562	8,675	1,186	18,071	546

Table 12.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures				Tin compounds	
	Imports			Exports	Imports	
	Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f.	Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.		Tin scrap and other tin bearing material, except tinplate scrap	Long tons	Value (thousands)
	Value (thousands)	Long tons	Value (thousands)	Value (thousands)		
1969	$3,458	948	$1,052	$4,825	22	$71
1970	4,311	776	275	2,466	272	817
1971	4,741	4,125	1,385	1,780	91	257

Table 13.—U.S. imports for consumption of tin [1], by country

Country	1970		1971	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Argentina	--	--	50	$176
Australia	441	$1,505	1,116	3,500
Belgium-Luxembourg	11	42	16	64
Bolivia	--	--	864	3,095
Brazil	388	1,452	167	583
Canada	2	15	240	864
Chile	--	--	269	980
Germany, West	(2)	1	--	--
India	--	--	35	120
Indonesia	1,360	4,985	1,420	5,592
Malaysia	31,819	118,619	27,746	96,950
Netherlands	70	283	25	94
Nigeria	481	1,885	306	313
Norway	5	19	--	--
Peru	--	--	165	593
Singapore	72	280	24	91
Spain	98	402	--	--
Taiwan	--	--	15	55
Thailand	15,395	56,678	13,861	49,126
United Kingdom	412	1,496	621	2,207
Total	50,554	187,662	46,940	164,403

[1] Bars, blocks, pigs, grain, or granulated.
[2] Less than ½ unit.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The Fourth International Tin Agreement commenced operation on July 1, 1971, and will be in effect until June 30, 1976. The votes of the producing countries were agreed upon as follows:

	Votes
Malaysia	440
Bolivia	182
Thailand	133
Indonesia	117
Nigeria	52
Zaire (formerly Congo-Kinshasa)	43
Australia	33
	1,000

The votes of the consuming countries were established as follows:

	Votes
Japan	204
United Kingdom	147
Germany, Federal Republic of	111
France	90
U.S.S.R.	65
Italy	58
Netherlands	45
India	42
Canada	40
Poland	34
Czechoslovakia	34
Belgium	29
Spain	24
Yugoslavia	16
Hungary	15
Denmark	11
Bulgaria	10
Austria	10
Taiwan	8
Korea, Republic of (South)	7
	1,000

The Government of the Netherlands offered as a consumer member to make a voluntary contribution of $1,408,250 to the Buffer Stock. This action is significant because it is the first financial support ever offered to the Buffer Stock from a consumer.

The matter of the European Economic Community (EEC) presented a small problem in July since its member countries would, under the new agreement, hold 333 of the 1,000 consumer member votes. The U.S.S.R., supported by Malaysia, objected to the EEC acting as a bloc. The Council finally decided that each country would vote as a separate entity.

The 20th and final meeting of the Council operating under the Third International Tin Agreement took place the last 2 days of June. It was announced that the amount of tin metal held in the Buffer Stock on June 30, 1971, was 2,692 metric tons.

The first meeting of the new Council convened under the Fourth Agreement on July 1. The producer members of the new Agreement voted not to raise the floor and ceiling prices under which the Buffer Stock Manager would operate. The Buffer Stock, under the Third Agreement, made a substantial profit during its lifetime of almost $19,344,000.

The second meeting of the Council was held in London from October 12 to 14, 1971. It was announced that the prevailing international monetary and trade situation contributed to the decline in the price of tin. The Council also decided that the balance of the aggregate compulsory contributions due to the Buffer Stock should be payable in cash.

In mid-December, the third session was held. The most noteworthy action taken was to extend the authority of the Executive Chairman to call up installments of the balance of the aggregate compulsory contributions due to the Buffer Stock. The Council extended until March 21, 1972, the period for ratification of the Fourth Agreement to offer an opportunity for others to join. On December 31, 1971, the Buffer Stock held 6,637 metric tons of tin metal, an increase of 5,405 metric tons from January 1, 1971.

Australia.—Central Deborah Gold Mining Co., N.L., reported its alluvial tin mining operation at Bald Knob Via Glen Innes, New South Wales, went into production. Sales of 73 percent tin-in-concentrate to Associated Tin Metals Pty., Ltd., were begun in mid-1971. Apparently rich tin oxide values have been encountered by Minerals Recovery (Australasia) N.L. at the company's Emmaville Deep Lead project in New South Wales. It is believed that Australia may possibly become a tin producer as large as Malaysia because of the vast potential of deposits in the Pilbara region of Western Australia. Reserves of tin-bearing gravel at Pilbara show 250 million cubic yards averaging possibly more than 1 pound of tin per cubic yard with some pockets of gravel containing as much as 80 pounds of tin per yard. The Moolyella mine, about 10 miles northeast of Marble Bar, is the principal tin field in the northwest division of Western Australia and second only to Greenbushes among the State's tin producing centers. Cleveland Tin, N.L., one of the two major lode tin mining companies in Australia, has announced an expansion scheme designed to raise its normal annual production of tin-in-concentrates from 1,630 long tons to 2,150 long tons. Additionally, Cleveland is to design and erect a commercial-scale pilot plant for tin flotation designed to recover fine tin from portions of the material now rejected by the gravity concentrator as tailings.

Bolivia.—The three groups of mining enterprises (small, medium, and COMIBOL) produced 27,441 long tons of tin-in-concentrates in 1971. Bolivia maintained its position as the world's second largest tin producer. The cost to COMIBOL to mine and market tin continued to increase in the first half of 1971 to $1.55 per pound compared with $1.46 for the same period in 1970. Its total labor force on June 30, 1970, numbered 21,709, but on the same date in 1971, it had grown to 22,999, an increase of 1,290. Only four mines in the first half made a profit: Huanuni; the Quechisla Group; and two very small mines, the recently acquired Bolivar mine which had been under private lease and the Kami tungsten-tin cooperative. Catavi, which accounts for about 34 percent of COMIBOL's tin production, broke about even in the first half. The Catavi, Huanuni, and the Quechisla Group produced about 61 percent of COMIBOL's output.

Empresa Nacional de Fundiciones

(ENAF) reported that at the end of the first year's operation of the tin smelter at Vinto, all its financial obligations to its suppliers of tin concentrates and to the Central Bank had been paid. The Central Bank acted in many cases as ENAF's source of financing. The smelter employs 400 persons. The Government has invested $15 million in the smelter, which includes provisions for expansion.

The contract for the smelter, which was constructed by Klöckner-Humboldt-Deutz of West Germany, called for a production capacity of 19,684 long tons per year of electrolytic tin of 99.95 percent metal content. This rate of output, however, will not be attained until completion of the second and third stages of the project. The smelter, which currently has a capacity of 7,382 long tons of tin and 787 long tons of tin alloy, produced 7,116 long tons of tin during 1971.

Bolivia hopes to place at least 30 percent of the current capacity of the Vinto smelter in the Andean market. It is thought that Chile, Colombia, Ecuador, and Peru can collectively absorb about 2,000 long tons per year, affording a favorable market for Bolivia's tin on grounds of geographical proximity and the 25-percent reduction in import duties accorded to Andean group countries.

Table 14.—Tin: World mine production by country [1]

(Long tons)

Country	1969	1970	1971 p
North America:			
Canada	r 129	118	131
Mexico	502	532	471
United States	W	W	W
South America:			
Argentina	855	1,153	e 1,000
Bolivia [2]	29,572	28,916	27,441
Brazil	2,608	3,263	e 2,560
Peru (recoverable)	r 70	104	e 100
Europe:			
Czechoslovakia	155	163	--
France	r 246	332	317
Germany, East e	[3] 1,000	[3] 1,000	1,000
Portugal	489	428	515
Spain	261	436	170
U.S.S.R. [4]	27,000	27,000	28,000
United Kingdom	1,622	1,695	1,787
Africa:			
Burundi	84	48	e 50
Cameroon	29	35	22
Congo (Brazzaville) e [5]	48	48	48
Morocco	10	14	7
Niger	34	66	67
Nigeria	8,603	7,833	7,005
Rhodesia, Southern e	600	600	600
Rwanda	1,323	e 1,300	e 1,300
South Africa, Republic of	1,847	1,981	1,997
South-West Africa, Territory of [6]	1,008	1,027	949
Swaziland e [5]	12	12	12
Tanzania	112	104	53
Uganda	163	120	146
Zaire (formerly Congo-Kinshasa)	6,542	6,356	e 6,400
Asia:			
Burma	373	427	680
China, People's Republic of e	20,000	20,000	20,000
Indonesia	17,138	18,761	19,411
Japan	730	780	777
Korea, Republic of (South)	--	--	5
Laos	r 1,050	1,358	1,548
Malaysia	72,167	72,630	74,253
Thailand	20,759	21,435	21,346
Oceania: Australia	8,584	9,362	9,365
Total	r 225,725	229,437	229,533

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] COMIBOL production plus exports by small and medium miners and smelters. (Data for 1971 adjusted to allow for sales by COMIBOL to domestic smelters to avoid double counting.)

[3] Estimate according to the 58th annual issue of Metal Statistics (Metallgesellschaft).

[4] Estimated smelter production.

[5] Estimate by International Tin Council.

[6] Data presented are for years ending June 30 of year stated.

Table 15.—Tin: World smelter production by country [1]

(Long tons)

Country	1969	1970	1971 p
North America:			
Mexico	r 206	525	471
United States [2]	345	W	W
South America:			
Bolivia	85	301	7,116
Brazil	2,245	2,982	2,352
Europe:			
Belgium	4,444	4,190	3,878
Czechoslovakia	69	--	--
Germany, East e	[3] 1,200	[3] 1,200	1,200
Germany, West	1,446	1,176	1,151
Netherlands	5,298	5,843	824
Portugal	501	390	e 500
Spain	r 3,859	2,943	4,751
U.S.S.R. e	27,000	27,000	28,000
United Kingdom	25,982	21,687	22,787
Africa:			
Morocco e	12	12	12
Nigeria	8,839	7,942	7,243
Rhodesia, Southern e	600	600	600
South Africa, Republic of	738	603	703
Zaire (formerly Congo-Kinshasa)	1,851	1,374	e 1,330
Asia:			
China, People's Republic of e	20,000	20,000	20,000
Indonesia	5,900	5,108	e 9,260
Japan	r 1,377	1,356	1,355
Malaysia	87,089	88,886	85,719
Thailand	22,048	21,692	21,336
Oceania: Australia	4,156	5,129	6,233
Total	225,290	220,939	226,821

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] Includes tin content of alloys made directly from ores.
[3] Estimate, according to the 58th annual issue of Metal Statistics (Metallgesellschaft).

Bolivia is planning to build four volatilization plants to recover tin from low-grade mill tailings. In September, the Subsecretary of Metallurgy in the Ministry of Mining and Metallurgy said that the use of German technology in the plants, which had been under consideration, had to be discarded in favor of Soviet technology because the latter would result in a higher recovery rate. Under the plan, four volatilization plants will be built, one each at the Catavi, Huanuni, and Colquiri mines, and the fourth at the town of Oruro. The Catavi unit, to cost $1.5 million, is scheduled to start operating by the end of 1973. Each of the plants will be able to treat 150,000 long tons per year of tailings containing from 0.07 to 3 percent fine tin. It is estimated that the concentrate will have a grade of 50 percent. Final processing will be done at the Vinto smelter.

Engineers from the U.S.S.R. were in Bolivia at yearend planning the construction of the new facilities.

In January, the International Metal Processing Corp. (IMPC), a subsidiary of Harvest Queen Mills of Dallas, Tex., lost its tin operation for treating tailings from the Catavi mine through nationalization. Under terms of an agreement worked out in December to compensate the company for loss of its mill and dredge operation, COMIBOL paid IMPC $1,447,066. The firm will renew operations as a mixed company, with COMIBOL controlling 55 percent. IMPC agreed to share its technology and assist in obtaining financing for expected expansion of the operation. At the end of 10 years, all installations will pass to COMIBOL.

Brazil.—Alluvial tin deposits, richer in tin content than those of Malaysia but more inaccessible than any other in the world, have been discovered in the Pôrto Velho area of Rondônia by the Brazilian subsidiary of Billiton, Companhia de Mineração Ferro-Union. By mid-1971, four major operators were active in tin mining in the Rondônia area of Brazil. The four were W. R. Grace & Cia.-Companhia Estanífera do Brasil (CESBRA) at the Santa Barbara mine; a group at Masangana, mainly Canadian-financed; the combined Companhia Cimento Portland Itaú-NL Industries, Inc., firm, organized in March 1970; and Companhia Industrial Fluminense at Ferusa. A major share of the metallic tin output in recent years has come from a plant in Manaus which has a reported production capacity of 295 long tons per month. In 1971, the Grace-CESBRA firm brought in a 6-cubic-foot connected bucket dredge, the first such equipment to be used in the area. About the same time, Mineração Aripuaña, S.A., began mechanized tin mining at Igarape Preto in the municipality of Novo Aripuaña Amazonas. The company was projecting eventual concentrate production of 300 to 400 long tons per month.

Indonesia.—It was reported early in the year that P.N. Timah, the Indonesian State tin company, planned to expand its Muntok smelter from its current production capacity of approximately 13,000 long tons per year of tin metal to about 27,000 tons per year. Consideration was being given to using two conventional stationary furnaces rather than the rotating type now being used. Cost of the expansion plan was put at $1 million with construction expected to begin before the end of 1971. The bulk of Indonesia's mine output in recent years has been smelted in Malaysia.

The question of reserves continues to be a disturbing factor for the future of tin mining but some progress is being made. Timah is exploring in waters beyond 30 meters in depth in conjunction with Coastal Engineering Survey Consultants, a Netherlands company. This exploration should start having some impact on Timah's reserves in 1974 or 1975.

Following recommendations from a World Bank study in 1970, Timah is overhauling its dredge fleet through assistance from AID. The four remaining steam dredges still operating on the Island of Bangka are scheduled for electrification.

Malaysia.—Malaysia continued to lead the world in production and smelting of tin in 1971. A total of 74,253 long tons of tin-in-concentrate, 40 percent of the free world's supply, was mined. At yearend, there were 63 tin dredges, 965 gravel pump mines, and 50 opencast, underground, and other miscellaneous mines in operation, a slight decrease compared with 1970 figures.

Gravel pump operations, worked for the most part by the same families that own the mines, accounted for about 55 percent of the concentrates produced, while dredging by corporations furnished another 32 percent. Opencast mines brought in 4 percent of the ore produced; underground mines accounted for 3 percent, and the remaining 6 percent came from miscellaneous sources.

In January, Petaling Dredge No. 7, owned by Petaling Tin Berhad, began commercial operations. Selangor Dredging Berhad decided to proceed with the construction of a second dredge. The new dredge will have almost double the throughput of the first dredge, handling 864,000 cubic yards per 600-hour month. It should be ready to start running trials in mid-1973.

Three areas in Perak, covering a total of nearly 13,000 acres, have been made available for mining, the Perak Development Corp. announced. In addition, an agreement in principle was announced for offshore tin prospecting and mining. The Ocean Mining Malaysia Sdn Berhad would work the coasts of Perlis and Kedah; Conzinc Riotinto Sdn Berhad would be involved off the States of Penang, Perak, and Selangor; and the N.V. Billiton Maatschappij group would receive the area off the coasts of the States of Malacca, Johore, and Negri Sembilan. However, Conzinc Riotinto rejected several government conditions, and the National Corporation, Pernas, has now been offered the offshore prospecting rights. According to the Second Malaysia Plan 1971–75, national output will decline somewhat over the next 5 years. The plan estimates that by 1975 tin metal output will be down to 73,000 long tons from the 87,089 long tons in 1970. The large drop takes into account the fact that Indonesia, which currently ships concentrate to Malaysia for smelting, will have its own smelter coming on stream during this period.

Morocco.—A Moroccan firm reported that it was seeking an American partner for a joint venture to develop a tin deposit in Meknes to which it holds the rights. It is estimated that the deposit could produce a minimum annual output of 600 long tons of 45 percent tin metal, although further exploration is necessary to prove total reserves. The deposits are both alluvial and in veins. Reportedly European mining geologists have found the property worth commercial exploitation by open pit despite its small size.

Nigeria.—Production of tin in Nigeria, concentrated in the region around Jos, has declined within the last few years for a number of reasons. Costs are rising faster than prices, and ore bodies of lower quality are being mined. At the present time, all the tin produced is refined in Jos by the Mekeri Smelting Co. During 1971, the smelter operated at about 50 percent capacity. Over the past 4 years, Nigeria's output of tin-in-concentrates has dropped from 9,684 long tons in 1968 to 7,005 long tons in 1971. The Nigerian Government has given monetary incentives to the Nigerian Tin Production and Development Loans Fund Committee as an aid to indigenous miners to purchase mining equipment. The loans, offered at 2 percent below bank loan interest, are repayable according to the number of years the equipment serves the miner.

South Africa, Republic of.—Sharply contrasting fortunes have been disclosed by the Republic of South Africa's two major tin mining companies, Rooiberg Minerals Development and Union Tin Mines. Rooiberg reports tin-in-concentrate output at 1,426 long tons, the highest in the company's history, whereas Union's production reached an 8-year low of 304 long tons. Rooiberg continued to expand during the year, sinking a new shaft and obtaining indications from drilling showing what might be a large area of tin mineralization. Union Tin shows declining trends in both tonnage and value of ore available for stoping. Both companies look to flotation as a means of recovering tin fines which cannot be recovered by existing gravity separation equipment. Rooiberg has decided to install their flotation equipment without delay, and hopes that trials will be run by the end of 1972 with the plant to be fully operational early in 1973.

Thailand.—There are over 400 tin mines on the Island of Phuket, the only island Province of Thailand. These mines are gradually being worked out, although miners still find it profitable to rework old tailings, some of which are being washed for the fourth or fifth time. New deposits for onshore mining are mostly found in mainland Provinces. The main interest now, however, is in offshore tin mining with floating dredges. A number of international companies have obtained offshore concessions, both in the sea around Phuket and off the mainland Provinces of Ranong and Phangnga, and exploration is being actively pursued. The largest U.S. firm with interests in Phuket is Union Carbide Corp. which operates in the area through two subsidiaries, Thailand Exploration and Mining Co., Ltd. (Temco), and Thailand Smelting and Refining Co., Ltd. (Thaisarco). The latter company, in partnership with N.V. Billiton Maatschappij of the Netherlands, operates the only tin smelter in Thailand, which is the fourth largest in the world. Under the terms of the Thaisarco monopoly, all tin mined in Thailand must be refined at the smelter where cash must be paid on delivery of the ore or within 2 weeks of delivery. This arrangement gives the seller some advantage in the fluctuating world market. Temco was established for offshore exploration and exploitation.

Temco II, claimed to be the largest cutter suction tin dredge, arrived in Thailand in preparation for the start of offshore dredging near Phuket. The dredge will operate 24 hours per day with a constant on-board crew of 74 to handle 5 million cubic yards per year. The dredge was expected to be in offshore operation by yearend. Another offshore tin dredge was brought into operation early in 1971 and was producing 2 to 2½ long tons of tin per day before ceasing operations for the monsoon season.

Efforts to achieve better coordination among the various Thai Government agencies concerned with the mining industry were being made. A new organization, the Committee of Mining Industry Development, was established and is designed to foster coordination within the mining industry which has heretofore been lacking, and to promote the progress of the industry to achieve its full export potential.

U.S.S.R.—The U.S.S.R. was expected to begin its first offshore tin mining operation late in 1971 when the lighter Gornyak begins working undersea deposits discovered in the Laptev Sea. Soviet experts believe that underwater tin mining even in the far north will prove cheaper and more productive than on land since no pits, roads, or mining settlements, and far less power will be needed.

United Kingdom.—The Cornish tin mine, Wheal Jane, was reopened in October by Consolidated Gold Fields, Ltd. The Wheal Jane operation will boost Britain's tin production to almost 5,000 long tons per year. Initially, the company plans to produce 1,378 long tons of tin-in-concentrates per year. Future plans for doubling this output would represent about 15 percent of the total U.K. consumption and half of the production. The tin content of the ore is 1.25 percent. After treatment by modern flotation techniques, the high-grade concentrates will be smelted at Liverpool by Williams Harvey and Co., Ltd., and the low-grade concentrate will be processed by Capper Pass and Son Ltd. in Yorkshire. New flotation techniques enable tin concentrate to be recovered economically from an ore body formerly regarded as uneconomic because of the metallurgical problems posed by the fine grain size of much of the tin mineral and the presence of a high proportion of relatively heavy sulfide minerals.

There are currently two other tin mines operating in Cornwall. Cornwall is expected to have a fourth tin mine in operation by yearend. Straus Exploration has announced that it will bring on stream its Pendarves mine with output targeted at about 87,000 long tons per year of tin ore.

TECHNOLOGY

A borehole probe for the in situ assay of ore containing 0.1 percent or more of tin is being brought into commercial production in the United Kingdom. The new instrument is intended to meet the needs of the industry for a quick and inexpensive way of assessing the commercial value of underground ore bodies.[2]

A dental alloy that shows greater resistance to corrosion than does the usual dental alloy of silver and tin has been developed at the University of Virginia, Charlottesville, Va.[3] Several U.S. dental schools are running clinical tests on the gold-silver-tin alloy.

A lead-tin alloy fluoborate plating process, making possible for the first time control of deposit characteristics such as brightness and alloy composition over a wide current density range, has been reported.[4]

A new high-intensity discharge lamp utilizing tin chloride, which is claimed to produce light closely matching color quality of sunlight at high noon, has been developed.[5] Other advantages include the long life of the lamp and a nearly perfect maintenance of light output throughout its life.

Tin chemicals, particularly dibutyltin dilaurate and stannous octoate, have made important contributions to plastics technology. These two compounds are highly efficient catalysts for foam systems.[6] Versatile organotins have been used as stabilizers for polyvinyl chloride,[7] and they hold some promise of being effective agents in controlling Bilharzia, a tropical parasitic disease.[8]

A modified alkaline tin-plating bath which is claimed to allow faster plating speeds and longer bath life than conventional processes has been developed.[9]

As an aid in disseminating information on tin technology, the Tin Research Institute has produced a 17-minute color film which describes the work being done at the Institute and at its overseas Tin Centers.[10]

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[2] Mining Magazine. In Situ Tin Assays. V. 124, No. 1, January 1971, pp. 65–67.

[3] Chemical and Engineering News. V. 49, No. 28, July 12, 1971, p. 42.

[4] American Metal Market. V. 78, No. 234, Dec. 8, 1971, p. 7.

[5] Quarterly Revue Tin Research Institute. Tin and Its Uses. High Intensity Lamp Based on Tin Chloride. No. 90, 1971, pp. 12–13.

[6] Quarterly Revue Tin Research Institute. Tin and Its Uses. Tin Chemicals in the Chair. No. 90, 1971, pp. 6–8.

[7] Quarterly Revue Tin Research Institute. Tin and Its Uses. Organotins Clear the Way for PVC. No. 87, 1971, pp. 13–17.

[8] Quarterly Revue Tin Research Institute. Tin and Its Uses. Organotins Against Bilharzia. No. 88, 1971, pp. 7–10.

[9] Quarterly Revue Tin Research Institute. Tin and Its Uses. Faster Tin Plating From Alkaline Baths: The Tin Sol Process. No. 88, 1971, pp. 11–12.

[10] Quarterly Revue Tin Research Institute. Tin and Its Uses. A New Film: Tin Research. No. 89, 1971, pp. 10–11.

Titanium

By Frank E. Noe [1]

After a fair first quarter supported by shipments to the Boeing supersonic transport (SST) program, the titanium metal industry suffered a disastrous setback as a result of the cancellation of the supersonic project and the failure of military and commercial programs to move at the pace originally expected. By yearend, the three domestic sponge production plants had been shut down and the plants of the two major producers of ingot and mill products were idled by strikes. Production and consumption of sponge and ingot were down sharply. Imports for consumption of unwrought titanium and waste and scrap were 54 percent below the 1970 level.

Ilmenite production in the United States dropped to the lowest level since 1959, and world output of both ilmenite and rutile decreased moderately.

Titanium pigment production remained at about the same level as in 1970, but consumption showed a slight increase. Two chloride-process plants and a sulfate-process plant were shut down during the year, while the country's only calcium titanium pigment (C-pigment) plant was being phased out at year's end.

Legislation and Government Programs.—The stockpile objectives for rutile and titanium sponge metal remained at 100,000 tons and 33,500 tons, respectively. Government inventory of rutile at yearend was 56,525 tons. Total stockpile inventories of sponge metal at yearend were 35,015 tons, of which 8,514 tons were of substandard grade and available for disposal.

Government exploration assistance for rutile, available through the Office of Minerals Exploration, U.S. Geological Survey, remained at 75 percent of the approved cost of exploration. No applications for financial assistance were submitted in 1971. The depletion allowance for ilmenite and rutile remained at 22 percent for domestic deposits and 14 percent for foreign deposits.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient titanium statistics

	1967	1968	1969	1970	1971
United States:					
Ilmenite concentrate:					
Mine shipments___short tons__	882,414	960,118	893,034	920,964	713,549
Value____________thousands__	$18,519	$19,484	$18,636	$18,626	$15,403
Imports__________short tons__	170,585	178,154	110,853	231,119	185,618
Consumption__________do____	919,206	959,558	1,003,501	969,786	896,638
Titanium slag: Consumption_do____	122,926	142,168	138,553	129,247	147,191
Rutile concentrate: [1]					
Imports_______________do____	167,100	174,366	204,645	243,089	215,109
Consumption__________do____	153,457	160,273	185,432	188,006	227,907
Sponge metal:					
Imports for consumption do____	7,144	3,443	6,332	6,543	3,023
Consumption__________do____	20,062	14,237	20,124	16,414	12,145
Price: Dec. 31, per pound_____	$1.32	$1.32	$1.32	$1.32	$1.32
World: Production:					
Ilmenite concentrate___short tons__	3,036,517	3,222,247	3,545,567	3,955,713	3,720,907
Rutile concentrate__________do____	310,752	332,792	436,819	459,907	416,487

[1] Mine shipments withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Concentrates.—Production of ilmenite concentrates dropped 21 percent, the lowest level in 11 years. Producers were E. I. du Pont de Nemours & Co., Inc., Starke and Highland, Fla.; Humphreys Mining Co., Folkston, Ga.; SCM Corporation, Glidden-Durkee Division, Lakehurst, N.J.; NL Industries, Inc., Tahawus, N.Y.; and American Cyanamid Co., Piney River, Va. No domestic production of rutile concentrate was reported.

The American Cyanamid Co. closed its ilmenite mine at Piney River, Va., in June. Titanium Enterprises, a joint venture of American Cyanamid and the Union Camp Corp., had almost completed installation of plant facilities by yearend at its Green Cove Springs property in Fla. The first phase of mining was scheduled to begin in January 1972 with all phases to be in full swing by July of that year. The deposit, located on an ancient pleistocene beach lying 35 miles inland from the Atlantic Ocean, will be mined at a rate to produce some 140,000 tons of concentrates per year.

In January American Smelting and Refining Co. (Asarco) announced plans to develop beach sand deposits discovered by Asarco geologists in New Jersey in 1957. The company concluded a 10-year agreement with E. I. du Pont de Nemours & Co., Inc., under which Asarco will supply du Pont with up to 165,000 long tons of ilmenite concentrate per year. Estimated cost of the project, including the suction dredge to be used for mining, is over $15 million. Site preparation was begun on the plant near Lakehurst, N.J., and production at a rate of 20,000 tons of ore per day is expected to start in April 1973.

Kerr-McGee Corp., a major producer of titanium pigments, continued engineering and pilot plant work to develop methods for processing heavy mineral deposits located in western Tenn.

Metal.—Production of titanium sponge was about 34 percent lower than in 1970. The producing companies were Titanium Metals Corporation of America (TMCA), Henderson, Nev., owned by NL Industries, Inc., and Allegheny Ludlum Steel Corp.; RMI Company, Ashtabula, Ohio, owned by National Distillers & Chemical Corp. and United States Steel Corp.; and Oregon Metallurgical Corp. (Oremet), Albany, Oreg., partly owned by Armco Steel Corp. and Ladish Co. At the end of the first quarter, the SST program was cancelled, and this, coupled with the stretchout of commercial and military aircraft development and production, resulted in very poor demand for titanium metal during the rest of the year. Sponge inventories built up to the extent that TMCA and Oremet shut down their sponge production facilities at the end of August, and RMI shut down its plant in December. At yearend, the primary titanium producers were seeking governmental action to preserve this basic part of the industry.

Production of titanium ingot, including alloys, was 18,387 tons, a decrease of about 26 percent from 1970 production. Nine companies that produced titanium ingot from sponge metal and scrap are as follows:

Company	*Plant location*
Crucible Steel Company of America.	Midland, Pa.
Harvey Aluminum, Inc	Torrance, Calif.
Howmet Corp	Whitehall, Mich.
Oregon Metallurgical Corp	Albany, Oreg.
RMI Company	Niles, Ohio
Teledyne Titanium, Inc	Monroe, N.C.
Titanium Metals Corporation of America.	Henderson, Nev.
Titanium Technology Corp	Pomona, Calif.
Titanium West, Inc	Reno, Nev.

The mill products plant of TMCA, the nation's largest titanium producer, was closed on September 30 by a strike. Early in November, a strike also closed the melting plant and mill products plant of RMI, the nation's second largest titanium producer. The plants of both companies remained closed at yearend.

Pigment.—On a gross-weight basis, titanium dioxide (TiO_2) pigment production in 1971 was 2 percent lower than that of 1970. However, the average TiO_2 content of pigments produced increased, and on a TiO_2-content basis, output increased by almost 2 percent. Rutile-type pigment was produced by all nine pigment companies and comprised approximately 62 percent of the total production. Most of the remainder was anatase-type pigment, produced by five companies, and composite-type, produced by one company. Companies producing titanium pigments and plant locations are as follows: American

Table 2.—Production and mine shipments of titanium concentrates [1] from domestic ores in the United States

Year	Production (short tons, gross weight)	Shipments: Short tons (gross weight)	Shipments: TiO_2 content (short tons)	Shipments: Value (thousands)
1967	935,091	882,414	463,286	$18,519
1968	978,509	960,118	506,260	19,484
1969	931,247	893,034	480,918	18,636
1970	867,955	920,964	487,298	18,626
1971	683,014	713,549	388,785	15,403

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite. Production of rutile concentrate in the United States was discontinued in 1968.

Cyanamid Co., Piney River, Va., and Savannah, Ga.; American Potash & Chemical Corp., a subsidiary of Kerr-McGee Corp., Hamilton, Miss.; Cabot Titania, Inc., wholly owned subsidiary of Cabot Corp., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., Edge Moor, Del., Antioch, Calif., and New Johnsonville, Tenn.; NL Industries, Inc., St. Louis, Mo., and Sayreville, N.J.; New Jersey Zinc Co., controlled by Gulf & Western Industries, Gloucester, N.J.; PPG Industries, Inc., Natrium, W. Va.; SCM Corporation, Glidden-Durkee Division, Baltimore, Md.; and Sherwin Williams Chemical, a subsidiary of Sherwin-Williams Co., Ashtabula, Ohio.

During the year, the capacity of the titanium pigment industry decreased by about 36,000 tons as American Cyanamid shut down and dismantled its old sulfate-process plant at Piney River, Va., and PPG Industries closed its 3-year-old chloride-process plant at Natrium, W. Va. Toward the end of the year, NL Industries announced the shutdown of parts of its titanium pigment capacity in the United States and Canada because of high costs. The plants to be closed were the chloride-process facilities at Sayreville, N.J., and Varennes, Quebec, and the calcium pigment section of its St. Louis plant. During the final quarter, du Pont announced that anatase pigment would be made by the chloride process whereas previously anatase-grade pigment was produced only by the sulfate process. This development could be of considerable importance in meeting antipollution restrictions and hasten the phaseout of du Pont's sulfate-process production.

Welding Rod Coating.—A total of 225,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output, 32 percent contained rutile; 50 percent, ilmenite and leucoxene; 7 percent, a mixture of rutile and manufactured titanium dioxide; 10 percent, manufactured titanium dioxide; and 1 percent, miscellaneous mixtures and titanium slag.

Table 3.—Titanium-metal data

(Short tons)

	1967	1968	1969	1970	1971
Sponge metal:					
Imports for consumption	7,144	3,443	6,332	6,543	3,023
Industry stocks	2,900	2,600	1,909	r 2,516	2,724
Government stocks (DPA inventories)	20,711	20,711	20,385	19,994	19,994
Consumption	20,062	14,237	20,124	16,414	12,145
Scrap-metal consumption	5,822	4,701	7,566	7,242	6,149
Ingot: [1]					
Production	25,960	19,234	28,490	24,331	18,387
Consumption	25,386	18,323	27,082	23,687	17,058
Net shipments of mill products [2]	13,634	11,900	15,940	r 14,480	11,241

r Revised.
[1] Includes alloy constituents.
[2] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDCF-263. Net shipments are derived by subtracting the sum of producers' receipts of each mill shape from the industry's gross shipments of that shape.

Table 4.—Titanium-pigment data

(TiO_2 content)

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1967	589,449	582,325	$297,283
1968	623,691	632,106	323,216
1969 r	664,253	654,490	334,521
1970	r 655,293	643,746	320,014
1971	p 652,977	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, which is used chiefly for making titanium dioxide pigment, declined more than 7 percent, while the amount of Sorel slag consumed by the pigment industry increased 14 percent. Consumption of rutile, which is used principally for producing titanium dioxide pigment, titanium metal, and also in welding rod coatings, increased 21 percent.

Metal.—Inasmuch as the demand for titanium metal is closely tied to the fortunes of the aerospace industry, the collapse of the SST project and the exceedingly slow development of military and commercial aviation programs created serious problems for titanium suppliers. Consumption of titanium sponge and ingot declined 26 and 28 percent, respectively. Consumption of titanium metal as gaged by shipments of mill products fell 22 percent below that of 1970. Titanium consumption in commercial aircraft during the year again surpassed that in military aircraft and comprised slightly under 50 percent of total end use. Military aircraft took about 30 percent, and industrial applications improved its position in the industry.

A large domestic producer of titanium metal estimated the end-use distribution of titanium mill products as follows:

	Consumption, percent		
	1969	1970	1971
Jet engines	54	53	51
Airframes	28	25	26
Space and missiles	8	9	7
Industrial	10	13	16
Total	100	100	100

Industrial applications are varied. The corrosion resistance in aggressive chemical environments has been acknowledged for several years. The use of titanium tubing has increased annually and titanium tubing is being utilized in all major industries requiring heat exchange. In May 1971 the Consolidated Edison Co. of New York purchased a full powerplant surface condenser containing some 165 miles of welded titanium tubing for the Staten Island power station. The Westinghouse Electric Co. is building a plant for the State of Pennsylvania which will handle acid mine drainage and convert it to fresh water and chemical byproducts. The plant will contain over 2 million feet of welded tubing. Titanium sheet and plate was extensively used for corrosion resistant equipment either in solid or clad steel construction. A leading chemical producer has placed in service the first titanium tank truck ever built for general chemical trucking. The titanium tank replaced a rubber-lined tank and has an estimated useful life of 15 years in comparison with a 3-year life for the rubber-lined tank. A newly developed titanium metal anode system was installed at the Augusta, Ga., chlorine-caustic soda plant of the Olin Corp. Other nonaerospace uses include plating racks, marine hardware, ordnance equipment, pump castings, batteries, and prosthetic applications such as the auricle birdcage heart valve.

Pigments.—In 1971 titanium pigment consumption on a gross-weight basis, using shipments as a gage, was 2 percent greater than that of 1970.

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 (estimated)	Gross weight	TiO_2 content (estimated)	Gross weight	TiO_2 content (estimated)
1967	919,206	488,236	122,926	86,945	153,457	147,158
1968	959,558	510,353	142,168	100,591	160,273	153,600
1969	1,003,501	541,840	138,553	98,075	185,432	178,090
1970:						
Pigments	966,350	515,860	129,247	91,639	140,790	135,350
Titanium metal	--	--	--	--	(2)	(2)
Welding-rod coatings and fluxes	510	356	(3)	(3)	15,634	14,917
Alloys and carbide	r 2,905	r 1,320	(3)	(3)	79	75
Ceramics	(2)	(2)	--	--	r 391	r 377
Glass fibers	--	--	--	--	(2)	(2)
Miscellaneous	21	13	--	--	r 31,112	r 29,644
Total	r 969,786	r 517,549	129,247	91,639	r 188,006	r 180,363
1971:						
Pigments	890,226	481,141	147,191	104,375	191,786	183,970
Titanium metal	--	--	--	--	(2)	(2)
Welding-rod coatings and fluxes	641	474	(3)	(3)	15,113	14,383
Alloys and carbide	2,599	1,104	(3)	(3)	(2)	(2)
Ceramics	(2)	(2)	--	--	403	390
Glass fibers	--	--	--	--	(2)	(2)
Miscellaneous	3,172	1,714	--	--	20,605	19,608
Total	896,638	484,433	147,191	104,375	227,907	218,351

r Revised.
[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.

Table 6.—Distribution of titanium-pigment shipments, by industry

(Percent)

Industry	1967	1968	1969	1970	1971
Distribution by gross weight:					
Paints, varnishes, and lacquers	61.9	60.7	58.5	59.6	57.2
Paper	14.6	14.9	17.0	17.0	18.0
Floor coverings	2.7	2.4	2.3	1.8	2.2
Rubber	2.8	2.9	2.6	2.6	2.8
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.4	1.4	1.3	1.3	1.0
Printing ink	2.0	2.1	2.3	2.2	2.1
Roofing granules	1.1	.8	.9	.9	1.0
Ceramics	1.9	2.1	2.0	1.8	2.0
Plastics (except floor covering and vinyl-coated fabrics and textiles)	5.1	6.0	6.2	6.6	6.6
Other (including export)	6.5	6.7	6.9	6.2	7.1
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, and lacquers	57.5	56.5	54.3	55.8	53.8
Paper	17.2	17.4	19.5	19.3	19.9
Floor coverings	3.1	2.7	2.6	2.1	2.4
Rubber	3.2	3.3	3.0	3.0	3.1
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.6	1.6	1.4	1.4	1.1
Printing ink	2.3	2.4	2.6	2.5	2.4
Roofing granules	1.4	1.0	1.1	1.0	1.1
Ceramics	2.2	2.4	2.4	2.1	2.2
Plastics (except floor covering and vinyl-coated fabrics and textiles)	6.0	6.9	7.1	7.6	7.2
Other (including export)	5.5	5.8	6.0	5.2	6.8
Total	100.0	100.0	100.0	100.0	100.0

STOCKS

Industry stocks of rutile decreased 9 percent to 214,849 tons, equivalent to slightly less than a year's supply at the 1971 consumption rate. Ilmenite inventories decreased 19 percent but stocks of titanium slag increased slightly over 4 percent. Yearend stocks of titanium sponge metal held by producers, melters, and semifabricators totaled 2,724 tons, compared with 2,516 tons on hand at the end of 1970. Titanium metal scrap held by melters and semifabricators at yearend was 4,808 tons, 431 tons more than at the end of 1970. Stocks of composite and pure TiO_2 held by producers were 16 percent less than the previous year—89,344 tons compared with 106,858 tons.

Table 7.—Stocks of titanium concentrates in the United States, Dec. 31

(Short tons)

Year and stock	Ilmenite		Titanium slag		Rutile	
	Gross weight	TiO_2 content (estimated)	Gross weight	TiO_2 content (estimated)	Gross weight	TiO_2 content (estimated)
1970:						
Mine	(1)	(1)	--	--	--	--
Distributor	194,523	118,428	--	--	(2)	(2)
Consumer	r 609,518	r 335,684	r 115,256	81,761	r 236,638	r 226,873
Total	r 804,041	r 454,112	r 115,256	81,761	r 236,638	r 226,873
1971:						
Mine	(1)	(1)	--	--	--	--
Distributor	165,095	103,937	--	--	(2)	(2)
Consumer	486,080	284,859	120,402	85,475	214,849	205,762
Total	651,175	388,796	120,402	85,475	214,849	205,762

r Revised.
1 Included with "Distributor" to avoid disclosing individual company confidential data.
2 Included with "Consumer" to avoid disclosing individual company confidential data.

PRICES

Concentrates.—Prices for ilmenite, as quoted in Metals Week, remained the same as those of 1970. Domestic ilmenite of 60 percent titanium dioxide (TiO_2) content was quoted at $30 to $35 per short ton. Imported ilmenite containing 54 percent TiO_2, f.o.b. Atlantic ports, was quoted at $20 to $21 per long ton. The quoted price for imported rutile (96 percent TiO_2) remained steady at $185 throughout the year. This price, however, referred only to small lot spot purchases and did not represent the price paid by large consumers holding long-term contracts. The latter price was probably no more than two-thirds of the quoted price. Titanium slag (70 percent TiO_2) was increased to $48 per long ton in March and remained at that figure for the remainder of the year.

Manufactured Titanium Dioxide.—Although some producers posted increased prices for rutile pigment to 27.5 cents per pound in January, the increases were never fully realized. During the spring and summer months, overcapacity and competition caused prices to spiral downward although changes in selling price were not always reflected in list prices. By September, the price for rutile pigment had dropped to 23 cents per pound, and there was some indication that the actual price was somewhat lower. In November, regular rutile grades were quoted at 26 cents per pound, and nonchalking grades at 27 cents per pound. With improvement in demand from the slack summer months, the price held at this level at yearend. Prices on other pigment grades were also unsteady and generally followed the erratic price pattern of rutile pigment. Yearend quotations from the Oil, Paint and Drug Reporter of December 27 were as follows:

	Price per Pound
Anatase:	
20-ton lots, bags, freight allowed	$0.26
Less than 5-ton lots, same basis	.27
Paper-grade costs 4 cents per pound less.	
Slurry, 50 tons (dry TiO_2 basis) in railcars, f.o.b. works	.215
Rutile, all grades:	
20-ton carlots, bags, freight allowed	.26–$0.27
Less than 5-ton lots, same basis	.27– .28
Titanium dioxide-calcium pigment:	
30 percent TiO_2, regular bags:	
30-ton carlots, f.o.b	.09125
Less than carlots, works	.09875
50 percent TiO_2:	
Bags, 30-ton carlots, works	.14125
Drums, less than carlots, works	.14875

Metal.—Prices for various grades of titanium sponge of domestic, British, and Japanese origin (99.3 percent titanium; Brinell hardness 115 maximum) quoted in Metals Week of December 20 follow:

	Price per Pound
Domestic titanium sponge	$1.32
Japanese and British titanium sponge	1.20–$1.25

Ferrotitanium.—Nominal prices, which have remained unchanged since 1962, were quoted in Metals Week at yearend as follows:

	Price
Low-carbon, 25–40 percent titanium, per pound	$1.35
Medium-carbon, 17–21 percent titanium, per short net ton	375.00
High-carbon, 15–19 percent titanium, per short net ton	310.00

FOREIGN TRADE

Titanium dioxide exports to 46 countries, mainly to Canada (37 percent) and Japan (19 percent), increased 2 percent to 26,759 tons valued at $9,378,423. The quantity of ores and concentrates exported to nine countries increased 66 percent. Canada was the principal recipient with 79 percent, followed by South Vietnam with 11 percent. Exports of unwrought metal and alloy and waste and scrap to 16 countries (45 percent to United Kingdom and 29 percent to Italy) decreased 41 percent with a 56-percent decline in value. There was a 75-percent drop in exports of combined intermediate titanium mill shapes and wrought metal and alloys, but the unit value increased 85 percent. Of the 13 countries to which intermediate mill shapes were exported, Canada received 52 percent and West Germany dropped to second place with only 28 percent. Italy received 27 percent and the United Kingdom received 16 percent of the wrought titanium and alloys shipped to 27 countries.

Imports of ilmenite from Australia decreased about 77 percent below the 1970 level while imports of Sorel slag from Canada increased 11 percent. Imports of ilmenite from India was reported for the first time in several years. However, the high unit value of the import indicates that the material is more apt to have been a rutile substitute than natural ilmenite.

Although rutile imports from Australia dropped 12 percent, the unit value increased 34 percent. Imports from Sierra Leone were only slightly lower than in 1970 despite the fact that Sherbro Minerals closed its mining operation in April. Imports for consumption of unwrought titanium and waste and scrap from seven countries decreased 54 percent from the previous year. Japan supplied slightly over 82 percent of these materials, practically all as titanium sponge. The value per pound of imports was $0.827, compared with $0.80 in 1970 and $0.82 in 1969. Imports for consumption of wrought titanium declined 50 percent to 274 tons, principally from Japan and Canada. Imports of titanium dioxide from 12 countries, principally from Japan, Canada, France, and Finland, totaled 42,832 tons, valued at $15,708,749. The tariff on unwrought titanium and waste and scrap was lowered to 18 percent ad valorem on January 1, 1971, but the suspension of duty on waste and scrap was extended until June 30, 1973. A 10 percent ad valorem surcharge was imposed on August 16 for dutiable imports up to the statutory limit. The surcharge was rescinded on December 20, 1971.

Table 8.—U.S. exports of titanium products, by classes

Year	Ores and concentrates		Metal and alloy sponge and scrap		Intermediate mill shapes and mill products, n.e.c.		Pigments and oxides	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	1,424	$183	2,802	$1,936	1,773	$9,206	24,507	$7,510
1970	r 1,058	r 201	r 2,902	r 2,588	1,740	10,435	r 26,194	r 7,950
1971	1,760	299	1,711	1,139	430	4,788	26,759	9,378

r Revised.

Table 9.—U.S. imports for consumption of titanium concentrates, by country

Country	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ilmenite:						
Australia	28,524	$371	96,123	$976	21,953	$218
Canada [1]	82,329	5,546	134,996	5,455	150,188	6,465
Finland	--	--	--	--	302	18
India	--	--	--	--	13,175	1,118
Total	110,853	5,917	231,119	6,431	185,618	7,819
Rutile:						
Australia	176,550	14,273	223,407	18,395	196,555	21,664
Japan	--	--	--	--	500	19
Sierra Leone	26,422	1,793	19,682	1,401	18,054	1,472
Other countries	1,673	119	--	--	--	--
Total	r 204,645	16,185	r 243,089	19,796	215,109	23,155

r Revised.
[1] Mainly titanium slag averaging about 70 percent TiO_2. Data does not include ilmenite ore for use as heavy aggregate imported in quantities of 288,312; 30,744; 192,431 short tons in 1969, 1970 and 1971, respectively.

Table 10.—U.S. imports for consumption of unwrought titanium and waste and scrap

Country	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Austria	--	--	--	--	4	$3
Belgium-Luxembourg	--	--	13	$30	--	--
Canada	214	$138	111	96	118	128
France	--	--	3	4	--	--
Germany, West	13	9	142	153	66	70
Italy	--	--	--	--	--	1
Japan	4,591	7,611	4,507	7,436	2,498	4,333
Netherlands	23	6	9	6	3	3
Sweden	--	--	25	26	--	--
Switzerland	--	--	3	7	--	--
U.S.S.R.	836	1,317	1,035	1,662	214	331
United Kingdom	655	1,267	695	1,083	120	131
Total	6,332	10,348	6,543	10,503	3,023	5,000

WORLD REVIEW

Conditions and events in the United States during 1971, which affected overseas producers of titanium pigment, sponge, and mineral raw materials, were the continued economic recession, the imposition of a 10 percent surtax on dutiable imports, and the various dock strikes. Weak demand and overcapacity in the pigment industry resulted in substantial price cutting to the point that domestic prices fell below those for imported material. Imposition of the surtax in August effectively barred the possibility for improved sales during the rest of the year. Japan looks to the United States as the major market for its exports of sponge metal. The collapse of titanium demand in the United States during the last half of the year coupled with the surtax on imports left Japan without its principal market. The loss to the overseas pigment and sponge producers of the U.S. market caused cutbacks in production which in turn reduced consumption of mineral raw materials. Rutile producers who have enjoyed increasing demand annually did not reduce their scale of operations to compensate for the reduction in demand. As a result, what had been a seller's market at the beginning of the year was rapidly becoming a buyer's market at yearend as warehouse space for overabundant stocks disappeared. Rutile substitutes, although still far from being competitive with the natural mineral, were produced in increasing amounts. While a number of processes for upgrading ilmenite were still in the developmental stage, sales of commercial tonnages of Benilite, Rupaque, and the unnamed product of Western Titanium N.L., were made in the United States. Benilite Corporation of America cancelled previously announced plans to construct a commercial plant to treat imported ilmenite at Corpus Christi, Tex. The shipment of unbeneficiated ilmenite long distances to a treatment plant is not considered economic. In India, Dhrangadhra Chemical Works, Ltd., operating under a license from Benilite, produced commercial quantities of rutile substitute. The Benilite Corp. also announced the licensing of Ballarpur Paper and Straw Mills, Ltd., India, to use the Corporation's cyclic process at a plant in Cochin, India. Ishihara Sangyo Kaisha of Japan began operation of its full-scale plant at a rate of 28,000 tons per year but expects to increase the rate to the designed capacity of 40,000 tons in 1972. In Australia, Western Titanium N.L. continued to operate its semicommercial 10,000- to 15,000-ton-per-year plant at Capel but postponed a decision to go ahead with a 100,000-ton-per-year commercial plant. Shipment of a 10,000-ton order to an American consumer was delayed because of imposition of the 10 percent surtax on imports into the United States. Two other Australian companies active in ilmenite upgrading but whose processes have not reached semicommercial scale development were Murphyores Holdings, Ltd., and Chlorine Technology, Ltd. Murphyores announced an agreement with Mitsubishi Chemical Industries of Japan under which the two companies would undertake a development program concerning the Murphyores-Commonwealth Scientific and Industrial Research Organization (CSIRO) or MURSO process for beneficiating ilmenite. Chlorine Technology, Ltd., announced satisfactory results from a pilot plant at Mt. Morgan and was continuing feasibility studies for the erection of a full-scale plant, probably at Melbourne.

Australia.—Planet Metals, Ltd., announced encouraging results in its search for rutile off the coast of New South Wales. Based on the drilling of more than 1,000 holes, some extending 40 feet below the sea floor in waters up to 120 feet in depth, Planet announced reserves of over 375 million tons of sands bearing 0.20 to 0.22 percent rutile and a further 500 million tons of indicated reserves. The company is considering dredging from a barge with a throughput of 10,000 tons of sand per hour. Dry separation of the heavy mineral concentrate would be onshore in the usual manner. The problem of how to work underwater deposits in areas of heavy seas and typhoons has blocked exploitation of known offshore deposits for sometime, and Planet's approach to the problem and its costs will be watched with great interest.

Early in the year, Norseman Titanium N.L. and Mid-East Minerals N.L. announced plans to start production of il-

Table 11.—Titanium: World production of concentrates (ilmenite and rutile) by country

(Short tons)

Country [1]	1969	1970	1971 [p]
Ilmenite:			
Arab Republic of Egypt	225	--	--
Australia	[r] [2] 794,239	[2] 980,993	898,206
Brazil [3]	22,358	22,756	[e] 22,000
Canada (titanium slag) [4]	[r] 749,234	844,700	854,600
Ceylon	[r] 91,332	93,209	93,700
Finland	152,339	166,449	153,772
India	56,708	87,000	[e] 100,000
Japan:			
Ilmenite concentrate	4,482	3,467	[e] 3,300
Titanium slag	5,617	8,683	6,097
Malaysia	146,197	212,145	171,941
Norway	540,945	638,193	707,244
Portugal	[r] 227	262	[e] 1,000
South Africa, Republic of	18,194	--	--
Spain	[r] 32,223	29,901	26,033
United States [5]	931,247	867,955	683,014
Total	3,545,567	3,955,713	3,720,907
Rutile:			
Australia	399,100	405,156	404,233
Brazil	10	258	[e] 250
Ceylon	3,036	[e] 3,100	[e] 3,100
India	2,751	2,800	3,200
Sierra Leone	31,379	48,593	5,704
South Africa, Republic of	543	--	--
Total	436,819	459,907	416,487

[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] Includes leucoxene.

[3] Production of Comissão Nacional de Energia Nuclear only.

[4] Containing approximately 70–72 percent TiO_2.

[5] Includes a mixed product containing ilmenite, leucoxene and rutile.

menite sand in the Busselton area of Western Australia in the first half of 1972. Two wet concentrators were to be established, one at Capel, and the other at Wonnerup. Norseman also announced the start of construction of a dry separation plant about 3 miles north of Capel. Production at the rate of 125,000 tons per year of ilmenite was planned by early 1972. At yearend, an indication of the state of the ilmenite industry was dramatized by the announcement by Norseman and Mid-East that they had indefinitely postponed their plans to mine at Capel and Busselton.

Early in the year, excitement was generated by the announced discovery of a new beach sand area around Eneabba, 160 to 170 miles north of Perth and 17 miles from the sea. The Western Australia area is a major source of ilmenite but rutile has been rare. The original rutile discovery seems to have been made by Western Titanium, a major ilmenite producer. Local farmers immediately staked claims for offering to interested mining companies. Allied Minerals, which held options to buy 22 claims at Eneabba, entered a joint venture with A. V. Jennings Industries (Australia) Ltd. Jennings will hold the controlling 55 percent interest, and Allied Minerals the remainder. Construction work was scheduled to begin in June 1972 with the first cargo of export rutile to leave through the port of Geraldton in mid-1973. Reserves are placed at more than 14 million tons of heavy minerals (about 9 percent of the beach sands) containing an average of 8 percent rutile, 37 percent ilmenite, 32 percent zircon, 20 percent altered ilmenite, 1 percent monazite, and 2 percent other minerals. The initial production target is for some 50,000 tons of rutile per year. Dry mining will be initiated using bucket-wheel excavators to remove mineral sands at a rate of 4.5 million tons per year, and this will be increased later to between 9 million and 12 million tons per year.

Table 12.—Australia: Exports of ilmenite and rutile concentrates, by country
(Short tons)

Destination	1969	1970	1971 p
ILMENITE [1]			
France	123,895	110,461	132,117
Japan	127,369	250,657	208,859
United Kingdom	258,665	229,075	324,057
United States	41,091	99,870	58,539
Other countries	83,482	34,644	21,950
Total	634,502	724,707	745,522
RUTILE			
Canada	2,993	13,133	8,768
France	6,061	6,758	3,164
Germany, West	10,995	6,674	7,942
Japan	32,331	37,025	33,015
Netherlands	24,363	40,376	34,539
United Kingdom	34,773	41,929	24,210
United States	168,386	215,877	215,405
Other countries	55,105	50,712	43,282
Total	335,007	412,484	370,325

p Preliminary.
[1] Includes leucoxene.

Brazil.—Titanio do Brasil, S.A. (TIBRAS), commissioned its new 22,000-ton-per-year titanium dioxide plant at Arembepe, near Salvador in Bahia. Designed by Laporte, the new sulfate-process plant will use imported ilmenite feed stock until a domestic supply can be developed.

Canada.—Killarney Oil and Gas Development, Ltd., has discovered the presence of leucoxene on its iron and titanium property located in the southern part of New Brunswick Province. The leucoxene was present in all four diamond drill holes drilled on the property and is contained in a zone of sand above an iron-titanium gabbro zone. Sté Quebecoise d'Exploration Minière (Soquem), the mining exploration agency of the Province of Quebec, has the mining rights to an area in northern Quebec containing upwards of 100 million tons of ilmenite-hematite. The ore contains 10.5 percent TiO_2, 43 percent iron, 1.6 percent chromium, and 0.17 percent vanadium oxide. The property is in an area 500 miles north of Quebec in the Magpie District. Soquem announced that a separation process developed by researchers at Montreal's École Polytechnique would make possible the separation of the various constituents in the ore, but does not indicate whether the process is economical.

Germany, West—Rapid progress is reported in the exploration of new ore deposits in the North Sea off the coast of West Germany. The first small prospecting ship started exploration off the lower Saxony coast in July. The aim of this first voyage will be a rough delineation of the deposits as they are within the 3-mile limit. Prospecting will be carried out by the Bluno, a chartered research ship owned by the Kiel firm, Hagenuk. In 80 percent of the assays to date, titanium oxide accounts for 1.0 percent of the heavy mineral content.

India.—The Ballarpur Paper and Straw Mills, Ltd., was licensed to use the BCA cyclic process for the production of beneficiated ilmenite at a plant at Cochin, India. The Indian upgrading plant is intended to form the first part of a large titanium complex to be constructed near Quilon in southwest India. The whole project, which will draw its ilmenite feed stock from local deposits, will eventually consist of a pigment plant with a planned output of some 25,000 tons per year, titanium sponge metal production 3,000 tons, titanium tetrachloride 80,000 tons, magnesium metal 5,000 tons, and 15,000 tons of pig iron.

Japan.—Japan's production of titanium sponge by two producers, Osaka Titanium Co., Ltd., and Toho Titanium Co., Ltd., was 7,470 short tons, down 27 percent from the 10,174 short tons produced in 1970. A third titanium sponge producer, New Metals Industries Co., completed a plant capable of producing 180 metric tons of sponge per month at the end of 1970 and started test production in January 1971. However, by the time the tests were completed, world titanium demand was stagnant, and the plant was never placed into commercial operation. Titanium slag produced by Hokuetsu Metal Co. was 6,097 tons, down 30 percent from the previous year. Exports of sponge totaled 3,089 tons of which 2,549 were destined for the United States, 266 tons for France, and 148 tons for the Netherlands.

Table 13.—Malaysia: Exports of ilmenite by country

(Short tons)

Destination	1969	1970	1971
Japan	146,187	240,148	[1] 174,755
Korea, South	--	3,326	[1] 6,246
Singapore	10	230	NA
United Kingdom	--	1,139	NA
Other	--	543	NA
Total	146,197	245,386	[e] 183,000

[e] Estimate. NA Not available.
[1] Imported from Malaysia.

Netherlands.—NV Titaandioxydefabriek Tiofine announced a December increase of 6 to 7 percent in their price for titanium dioxide because of the high cost for environmental provisions. The company's pollution levies were to be increased by 250 percent from January 1, 1972. Other factors contributing to the increase were higher energy and wage costs and an increase in raw material prices. Tiofine is a joint venture of American Cyanamid, Shell/Billiton, and Akzo, and is the only producer of titanium dioxide in the country. The sulfate-process plant, located in the Botlek area, produces about 35,000 tons per year of which more than 60 percent is sold to the Dutch paint industry.

Norway.—Titania A/S, an affiliate of NL Industries, Inc., was on schedule with the expansion of its ilmenite mining operations at Tellnes and should be producing at a 1-million-ton-per-year rate in 1972. Installation of new mining equipment continued, and orders had been placed for 20 large Wemco-Fagergren froth flotation cells.

Sierra Leone.—Sherbro Minerals, Ltd., 80 percent owned by PPG Industries and 20 percent by British Titan, shut down its rutile mining operation in April. The Sherbro operation, once heralded as the answer to the world's need for more rutile, was in constant trouble and never came near the originally planned mining rate of 100,000 tons per year. The Sierra Leone Government immediately began searching for another company to carry on the mining operation, and at yearend had tentatively reached an agreement with Sierra Rutile, Ltd., a joint enterprise of Armco Steel Corp. and Nord Resources Corp., of the U.S. (Armco-Nord) for an exploratory program.

Spain.—According to Spanish sources, ilmenite production should reach 40,000 tons per year in 1980. Reserves are estimated to be approximately 800,000 tons, mostly in northwestern Spain, with an average 10 percent TiO_2 content. Ilmenite consumption in 1969 amounted to 16,000 tons and 31,700 in 1970. Minas de Dubra S.A., 50 percent owned by Montecatini-Edison of Italy which has mines in Carobelo, said that it will step up production substantially in order to reduce the amount of ilmenite that has now to be imported.

U.S.S.R.—The Soviet Union began construction of its largest titanium dioxide plant to date. The new unit will probably produce about 20,000 tons of sulfate-process pigment per year. The plant is located on a coastal site at Krym in the Crimea. The mineral raw materials will probably come from Egypt or other countries in the area.

Soviet metallurgists have developed several new titanium alloys which are predicted to find a wide range of industrial applications. The most promising are with aluminum and ruthenium oxide. They can be used for chemical purposes, especially for electrolysis for chlorine.

United Kingdom.—As in the United States, growth in titanium consumption has not matched early expectations. Although present capacity of Imperial Metal Industries' plant at Witton exceeds 5,000 tons per year, a very substantial portion is excess capacity. The major aerospace markets in Britain are for the Rolls-Royce redesigned RB–211 engines for the TriStar jet. The RB–211 design currently calls for 4 to 5 tons of titanium ingot for such components as discs, rings and blades, and perhaps half a ton of titanium sheet. The Concorde also requires 4 to 5 tons of titanium per engine, as well as another 13 tons in the fuselage. However, authority to order long-lead items has only been given for 16 aircraft. The third largest titanium market is the Hawker Harrier's Pegasus engine which uses nearly 2 tons of ingots each. Smaller, but just building to its peak, is the Anglo-French Jaguar military aircraft, the British version of which calls for about 1 ton of titanium. In Europe, aerospace continues to dominate the market for titanium, the breakdown being some 60:40. Laporte Industries (Holdings) Ltd. reports that the titanium dioxide plant using the chloride process inaugurated in 1970 is only achieving a 20,000-ton annual output against a hoped for full capacity rate of 40,000 tons. The plant produces good quality product and creates no effluent problems, but production is retarded by continuing corrosion problems.

TECHNOLOGY

The probability that natural rutile will be in short supply sometime within the next 2 decades has long been recognized. To combat this problem, research has been under way around the world to develop from ilmenite, a rutile substitute which would have comparable physical and chemical attributes available at a lower price than that of natural rutile. Many processes have been announced but as yet there are few commercial plants. The more successful processes were reviewed late in the year in a technical magazine.[2] The author groups the processes in three general categories and includes his opinions of future developments.

Bureau of Mines investigations of methods for producing a synthetic rutile or a high-titanium product from such minerals as ilmenite, perovskite, and titaniferous magnetite, was continued, and a progress report was published.[3] Investigations were also underway on the two-stage sodium-magnesium reduction of titanium tetrachloride, lower cost processing of titanium sponge and scrap, and on direct chlorination of ilmenite.

Expansion of a program originally limited to Alabama led to cooperative program between the Bureau of Mines and industry to determine the recoverability of heavy minerals from sand and gravel operations in the Southeastern United States and a report was published.[4] The Bureau also concluded a survey of the secondary titanium market, and a report was published.[5]

The utilization of the affinities of metal oxides for chlorine in order to separate the metal with the highest affinity from the ore and from other metals with lower affinities was described at the annual meeting of the American Institute of Chemical Engineers in August at Atlantic City, N.J.[6] By chlorinating the same ore several successive times, the several minerals present may be separated in a pure form in the order of their chlorine affinities. By using the Halomet process, pure iron may be separated from a very poor ore while at the same time, pure titanium chloride can be separated to make titanium dioxide pigment. It is claimed that the company developing the process is now operating a pilot plant in West Germany to produce directly pure titanium as a solid metal in a second step of the process.

A Japanese company has developed a low-cost process for melting titanium sponge and scrap in vacuum furnaces by hot hollow cathode discharge beams (plasma).[7] High-frequency, 80-volt, direct current is used to generate plasma by ionizing argon gas onto a hollow cathode under a vacuum of 10^{-2} millimeters of mercury. Installation of the first vacuum furnace incorporating the new system was to be completed by mid-1971 at the Naoetsu plant of Nippon Stainless Steel Co.

A review of the applications of electron beam melting to investment casting, titanium scrap recovery, and consolidation

[2] Roberts, J. M. C. Ilmenite Upgrading. Mining Magazine, v. 125, No. 6, December 1971, p. 543.

[3] Elger, G. W., and W. A. Stickney. Production of High-Purity Synthetic Rutile From a Domestic Ilmenite Concentrate. BuMines TPR 37, August 1971, 10 pp.

[4] Davis, E. G., and G. V. Sullivan. Recovery of Heavy Minerals From Sand and Gravel Operations in the Southeastern United States. BuMines RI 7517, 1971, 25 pp.

[5] Gray, J. J., and P. McIlroy. A Survey of the Secondary Titanium Market. BuMines IC 8532, 1971, 17 pp.

[6] Othmer, Donald F., and Rudolf Nowak. Halide Metallurgy. Pres. at Symp. on Recent Advances In Separation Techniques, 70th Ann. Meeting, AIChE, Atlantic City, N.J., August 1971, Preprint Je-1, 27 pp.

[7] U.S. Bureau of Mines. Titanium: Japan. Mineral Trade Notes, v. 68, No. 5, May 1971, p. 16.

were discussed.[8] Based on work being conducted for the Air Force Materials Laboratory by RMI Company, the use of the electron beam for the recovery of turnings containing carbides or other high-density inclusions was discussed.[9] The tendency of titanium to seize or gall and the difficulty in brazing and soldering the metal can be eased by a new method for plating strongly adherent electrodeposits of nickel, chromium, platinum, and ruthenium onto titanium.[10] For what is believed to be the first time, precision spherical pivot bearings were produced from titanium for use in the movable swept wings of the Grumman F14 Navy jetfighter.[11] The bearings with Teflon wear surfaces are 45 percent lighter than comparable bearings of steel.

Porous titanium filter elements for processing liquids and gases are available in plates, cylinders, and disks.[12] The filter elements have excellent corrosion resistance and can withstand high differential pressures while featuring extremely uniform pore sizes and high usable porosity for maximum flow rate and minimum pressure drop at required particle retention levels.

The Eastman Kodak Co. of Rochester, N.Y., was reportedly testing titanium dioxide as a possible substitute for silver on photographic film; applied by a vacuum method, a thin coating of titanium dioxide is light sensitive and results in a film able to produce photo images.[13]

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[8] Stephan, Herbert, and Walter A. Dietrich. New Applications of Electron Beam Melting and Casting. Research/Development, v. 22, No. 4, April 1971, p. 44.

[9] Metal Bulletin Monthly. No. 9, September 1971, p. 47.

[10] Iron Age. V. 207, No. 7, Feb. 18, 1971, p. 28.

[11] American Metal Market. V. 78, No. 42, Mar. 3, 1971, p. 15.

[12] American Metal Market. V. 78, No. 61, Mar. 30, 1971, p. 12.

[13] Industrial Minerals. No. 44, May 1971, p. 48.

Tungsten

By Richard F. Stevens, Jr.[1]

During 1971, domestic production of tungsten in concentrate fell 28 percent, to 6.9 million pounds; and consumption decreased 30 percent, to 11.6 million pounds. Imports for consumption of tungsten concentrate dropped to a 33-year low of 0.4 million pounds of tungsten, the second lowest reported annual import level on record. Concentrate exports decreased by a factor of almost 10 to 2.0 million pounds and Government stockpile releases fell to 1.4 million pounds of tungsten.

Although the average reported price, f.o.b. domestic mines, of shipped tungsten concentrate rose slightly, the European price dropped sharply during the year.

The Government's two-phase tungsten disposal program administered by the General Services Administration (GSA) was initiated in late 1970 and continued throughout 1971. Under this program, the only releases were made early in the year before the European price fell below the shelf-price.

In mid-1971 the import-export restrictions on trade of tungsten concentrate with the People's Republic of China (formerly Mainland China) were removed. Although Chinese tungsten was reportedly offered at both the Spring and Fall Canton Fairs at prevailing *Metal Bulletin (London)* price quotations, no U.S. imports of tungsten concentrate of Chinese origin were reported.

The significant drop in prices and trade of tungsten concentrate which occurred during the year reflected the general slump in U.S. industrial activity. This slump was also observed in the economy of other industrialized Free World countries such as Japan, the United Kingdom, and West Germany. While tungsten activity in

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Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten and thousand dollars)

	1967	1968	1969	1970	1971
United States:					
Concentrate:					
Production	r 8,465	r 8,663	7,805	9,625	6,900
Shipments	7,842	9,042	7,910	9,312	6,827
Value	$14,574	$20,293	$18,770	$23,790	$20,184
Consumption	13,860	11,038	13,053	16,700	11,622
Releases from Government stocks	6,393	3,225	38,314	r 15,066	1,381
Exports [1]	974	623	7,151	19,470	2,006
Imports, general	2,004	1,824	1,534	1,299	577
Imports for consumption	1,699	1,743	1,503	1,284	418
Stocks, Dec. 31:					
Producers	1,007	626	519	787	863
Consumers	1,134	574	1,066	1,467	2,657
Primary products:					
Production	12,604	10,538	13,334	17,605	11,730
Consumption	13,663	13,108	16,056	15,352	11,159
Stocks, Dec. 31:					
Producers	5,168	4,747	3,392	4,569	3,722
Consumers	2,518	2,364	1,778	2,698	2,541
World:					
Ore and concentrate:					
Production	62,725	68,380	71,754	75,554	80,728
Consumption	62,628	64,410	76,650	83,574	65,859

r Revised.
[1] Estimated tungsten content.

Eastern European countries was also down, the economy of the Communist bloc countries was not affected as much as that of most non-Communist countries.

Legislation and Government Programs.—The two-phase stockpile disposal policy that was finalized in December 1970, was continued during 1971 and about 1.4 million pounds of tungsten in concentrate were released during the year. No releases of material were made when the price of tungsten concentrate fell below the GSA shelf price. Under the first phase of this program, GSA offered excess tungsten concentrate, for domestic consumption only, on a first-come, first-serve basis at a shelf price of $55 per short ton unit (stu) adjusted for premiums and penalties. Only about 631,527 pounds of tungsten in concentrate was sold through mid-May, at an average adjusted price of $55.31 per stu. No further disposal sales were made during the year. Under the second phase of this program, excess tungsten concentrate for export was offered for sale each month on a sealed-bid basis, however, the price of material sold for export could not be below the adjusted shelf price ($55 per stu). Only one sale was made under this sealed-bid phase when 749,368 pounds of tungsten in concentrate was sold in January at an adjusted price of $62.06 per stu.

As indicated in table 2, almost 2.4 million pounds of contained tungsten in concentrate were sold but unshipped and remained in GSA storage sites at yearend 1971. Since 10,060,387 pounds of contained tungsten (National Stockpile: 266,349 pounds and DPA Inventory: 9,794,038 pounds), were sold but unshipped as of Dec. 31, 1970, 7,668,794 pounds of tungsten entered the market during 1971.

On June 11, 1971, the 21-year old legal restriction on tungsten trade with the People's Republic of China was rescinded.[2] However, imports of Chinese tungsten would be subjected to the economic restriction of higher tariff applicable to materials of Communist bloc origin ($7.93 per stu versus $4.76 per stu for non-Communist World producers).

[2] U.S. Department of State. Trade with the People's Republic of China. Telegram 103604, June 11, 1971, 6 pp.

Table 2.—U.S. Government tungsten stockpile materials inventories and objectives
(Thousand pounds, tungsten content)

Material	Objective	Inventory by program Dec. 31, 1971			Total
		National (strategic) stockpile	DPA inventory	Supplemental stockpile	
Tungsten ore and concentrate:[1]					
Stockpile grade	55,656	72,608	6,236	3,304	82,148
Nonstockpile grade	--	40,277	809	1,153	42,239
Total inventory	--	112,885	7,045	4,457	124,387
Ferrotungsten	--	2,141	--	--	2,141
Tungsten metal powder, hydrogen reduced:					
Stockpile grade	1,200	1,196	--	--	1,196
Nonstockpile grade	--	102	--	--	102
Total inventory	--	1,298	--	--	1,298
Tungsten metal powder, carbon reduced:					
Stockpile grade	547	546	--	--	546
Nonstockpile grade	--	171	--	--	171
Total inventory	--	717	--	--	717
Tungsten carbide powder:					
Stockpile grade	1,900	841	--	1,080	1,921
Nonstockpile grade	--	112	--	--	112
Total inventory	--	953	--	1,080	2,033

[1] Includes 2,391,593 pounds of tungsten concentrate sold but unshipped.

DOMESTIC PRODUCTION

As a result of lower demand, declining European prices, the recession in the domestic economy, and the oversupply condition caused by large, nonrestricted Government stockpile releases, mine production of tungsten concentrate dropped 28 percent compared with revised 1970 data and totaled 6.9 million pounds of tungsten in 1971. Production, as measured by mine shipments which reflected concentrate entering the commercial market during the year, fell 27 percent to 6.8 million pounds. While 66 mines in eight Western States and North Carolina reported production and 65 mines reported shipments of tungsten concentrate in 1971, only one, the Climax mine and mill of the Climax Molybdenum Co., a division of American Metal Climax, Inc. (AMAX), near Leadville, Colo., operated continuously. The major mineral value recovered at Climax was molybdenum. Concentrates of tungsten, tin, and pyrite were recovered as byproducts and were entirely dependent upon the rate of molybdenum production. Climax's tungsten concentrate production decreased substantially during the year and sales fell 16 percent from the record level set in 1970.[3]

Mine and mill employees, members of the International Union of Operating Engineers, at the largest domestic tungsten producer, Union Carbide Corp., were on strike for 2 months during the summer of 1971.[4] Because of the strike and the general decrease in economic activity, tungsten production at Union Carbides' Pine Creek mine and mill near Bishop, Calif., fell about 25 to 30 percent. At Pine Creek, tungsten was the major mineral value recovered along with minor amounts of byproduct molybdenum, copper, silver, and gold. At the mill Union Carbide processed scheelite ore having an average content of less than 1.0 percent WO_3 on a "straight through" basis and produced ammonium paratungstate (APT), a high purity intermediate processed form of tungsten suitable for ready conversion to tungsten metal powder. A new underground ore transfer system at Pine Creek was completed in 1970 and the aerial tram previously used was placed on standby in September.[5] A new ore handling system and trestle at the mine portal permits unit-car dumping to the crusher from which crushed ore was transferred to the mill by belt conveyor. A new flotation circuit was installed and became operational in March 1970 to increase Union Carbides' rated mill capacity.

During the first half of 1971, tungsten was recovered at the Tungsten Queen mine and mill of Ranchers Exploration and Development Corporation near Townsville, N.C., from hubnerite ores having an average content of less than 0.5 percent WO_3. By June, the mill recovery had been increased from 60 to 80 percent and approached the maximum recovery projected for the mill.[6] Mining costs declined significantly during June primarily as a result of the use of more experienced mining personnel. Tungsten concentrate produced was sold for between $50 and $65 per stu on the Western European market. When the quoted European price fell below this

[3] American Metal Climax Inc. Annual Report 1971. 40 pp.
———. Annual Report 1970. 40 pp.
[4] Union Carbide Corporation. Annual Report 1971. 21 pp.
[5] Davis, Fenelon F. 1970 California Mining Activity. California Geology, v. 24, No. 9, September 1971, pp. 172–173.
[6] Ranchers Exploration and Development Corp. Annual Report 1971. 24 pp.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value f.o.b. mines [1]		
	Short tons 60 percent WO_3 basis	Short ton units WO_3 [2]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1967 r	8,240	494,385	7,842	$14,574	$29.48	$1.86
1968 r	9,501	570,040	9,042	20,293	35.60	2.24
1969 r	8,312	498,706	7,910	18,770	37.64	2.37
1970 r	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

r Revised.
[1] Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2] A short ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten.

level, the Tungsten Queen was unable to operate profitably and was shutdown August 15, 1971. Although Ranchers is maintaining the mine and mill on a standby basis almost all of the experienced operating personnel have left the area. If Ranchers should decide to reopen the facilities, it is estimated that some 6 to 9 months might be required to obtain a new trained labor force.

During the year, tungsten concentrate production and/or shipments were reported from Mohave and Santa Cruz Counties, Ariz.; Fresno, Inyo, Kern, and San Bernardino Counties, Calif.; Lake County, Colo.; Custer County, Idaho; Churchill, Clark, Elko, Humboldt, Nye, and Pershing Counties, Nev.; Vance County, N.C.; Baker County, Oreg.; and Tooele County, Utah. In addition, the exact county source of minor quantities of tungsten production in California, Montana, and Nevada was unknown and credited to "Undistributed." Most of the intermittent tungsten production was sold as low grade concentrate (about 15 percent WO_3) to two of the major domestic processors, Union Carbide at Bishop, Calif., and the Nevada Divison of Kennametal Inc. at Fallon, Nev., where the tungsten was processed.

The Nevada Scheelite mine near Rawhide, Mineral County, Nevada, closed since 1958, was leased to Rawhide Mining Co. by Kennametal Inc. and reconditioned during the year, prior to beginning production operations. A 100-ton-per-day mill was being constructed on the site to process ore into concentrate. The mill was expected to become operational in 1972. All of the production from the mine will be sold to Kennametal.

Central Valley Mining Co., Fresno, Calif., announced plans to start tungsten production in the Redlick Mining District of Esmeralda County, Nev. Mined ore will be hauled about one-fourth of a mile to a stockpile from which it will be fed into a crusher and initial concentration mill. The resulting low-grade concentrate will be shipped to the Nevada Division of Kennametal Inc. for final processing to commercial grade concentrate.

The corporate tungsten processing operations of Teledyne Wah Chang–Glen Cove, on Long Island, N.Y., were transferred to the Teledyne Wah Chang–Huntsville, operation in Huntsville, Ala., late in the year. The Glen Cove separation and reduction facilities were taken over by a new tungsten processor, Li Tungsten Corp. Although Wah Chang moved, most of the Glen Cove personnel remained with Li Tungsten Corp. which advertised itself as being "The oldest 'new' tungsten producer in the nation."

CONSUMPTION AND USES

Cutting and wear resistant materials which contain tungsten carbide continued to represent the major end use of tungsten and accounted for 46 percent of the total tungsten product consumption which fell 27 percent to 11.2 million pounds, tungsten content, in 1971. The consumption pattern of intermediate tungsten products used to make the end use items remained unchanged and was as follows: tungsten carbide (38 percent); tungsten metal powder (34 percent); chemicals, scheelite, and scrap (21 percent); and ferrotungsten (7 percent).

Several special reviews were published that discussed and evaluated tungsten consumption patterns, tungsten economics, and supply-demand relationships.[7]

An updated directory of non-Communist world ferroalloy companies was published. It listed their products, plants, programs, and capacities.[8]

In 1971, GTE Sylvania, formally Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corp., expanded its tungsten operations by purchasing the Walmet Corp., a producer of ce-

[7] American Metal Market. International Tungsten Report. Sec. 2, Feb. 5, 1971, 16 pp.
———. Nuclear Metals Report. Sec. 2, Nov. 10, 1971, 6 pp.
Barbier, Claude. The Economics of Tungsten. Metal Bulletin Books Ltd., London, 1971, 191 pp.
Larson, L. P., R. L. Lowrie, and G. R. Leland. Availability of Tungsten at Various Prices From Resources in the United States. BuMines Inf. Circ. 8500, 1971, 65 pp.
Romagnoly, E. Tungsten. Eng. and Min. J., v. 173, No. 3, March 1972, pp. 106–108.
Sherman, Joseph E. Recovery of Tungsten. Barron's National Business & Financial Weekly (Chicopee, Mass.), Apr. 3, 1972, pp. 11 and 18.

[8] Metal Bulletin. Ferro-Alloys, A Metal Bulletin Special Issue. London, 1971, 192 pp.

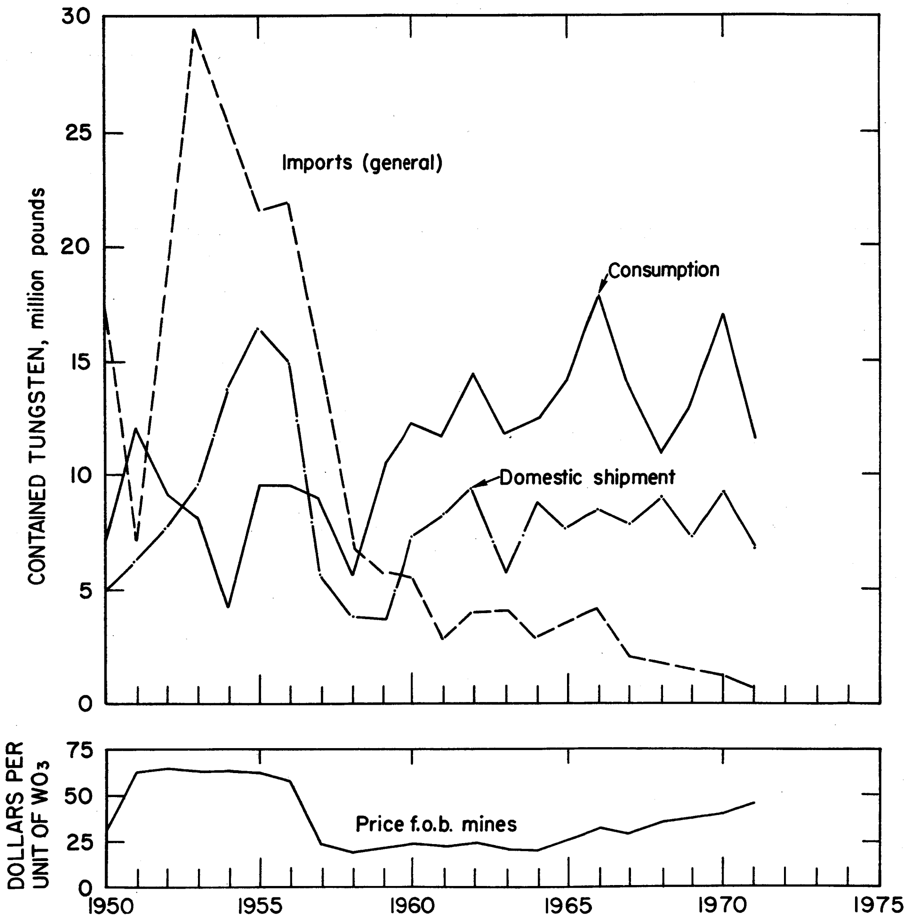

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate.

mented carbide products at Royal Oak, Mich.[9]

As a result of complaints made by several State Highway Departments and the subsequent restriction of tire stud usage in some States where studs previously had been permitted, new designs of tungsten carbide tire studs were being evaluated. Because the original stud design reportedly caused excessive wear and damage to highways, new studs were being designed so that tires and studs would wear at the same rate.

Kennametal Inc. reported the development of standardized carbide tooling systems which reduce the necessity of maintaining large inventories of tungsten carbide cutting tools.[10] New labor-saving equipment was installed and manufacturing facilities were enlarged at Kennametal's principal mining tool plant at Bedford, Pa. In addition, the company's wholly-owned consolidated subsidiary, Kennametal G.m.b.H., completed construction of a carbide sintering and manufacturing plant in West Berlin to serve the growing West German tool industry.

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[9] General Telephone & Electronics Corp. Annual Report 1971. 32 pp.
[10] Kennametal Inc. Annual Report 1971. 19 pp.

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 crystalline	Chemicals	Other [1]	Total
1970 [r]						
Gross production during year	10,989	6,170	3,454	17,207	2,658	40,478
Used to make other products listed here	7,184	--	--	14,401	1,288	22,873
Net production	3,805	6,170	3,454	2,806	1,370	17,605
Shipments [2]	9,278	6,065	3,416	10,312	3,141	32,212
Producer stocks, Dec. 31	1,772	381	701	1,188	527	4,569
1971						
Gross production during year	7,505	3,638	1,511	10,350	833	23,837
Used to make other products listed here	4,387	--	--	7,698	22	12,107
Net production	3,118	3,638	1,511	2,652	811	11,730
Shipments [2]	6,548	3,902	1,757	8,098	985	21,290
Producer stocks, Dec. 31	1,780	196	632	936	178	3,722

[r] Revised.
[1] Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, and pellets.
[2] Includes quantities consumed by producing firms for manufacture of products not listed here.

Table 5.—Consumption, by end use, and stocks of tungsten products in the United States in 1971

(Thousand pounds, contained tungsten)

	Ferrotungsten [1]	Tungsten metal powder [2]	Tungsten carbide powder	Other tungsten materials [3]	Total [4]
Steel:					
Stainless and heat resisting	80	W	--	107	187
Alloy	83	--	--	66	149
Tool	411	W	--	1,009	1,420
Cast irons	W	--	--	16	16
Superalloys	50	W	W	159	209
Alloys (exclude steels and superalloys):					
Cutting and wear resistant materials	W	975	3,915	192	5,082
Other alloys [5]	36	395	248	124	803
Mill products made from metal powder	--	2,027	2	15	2,044
Chemical and ceramic uses	--	--	1	380	381
Miscellaneous and unspecified	108	410	71	280	869
Total [4]	769	3,807	4,237	2,346	11,159
Consumer stocks Dec 31, 1971	237	857	759	688	2,541

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-tungsten metal powder.
[3] Includes tungsten chemicals, natural and synthetic scheelite, tungsten scrap, and other.
[4] Data may not add to totals shown because of independent rounding.
[5] Includes welding and hard-facing rods and materials and nonferrous alloys.

Kennametal's new tungsten carbide refinery at Fallon, Nev., completed its first full year of operation with higher yields than had been possible at the old refinery.

To meet a variety of metal removal needs, the VR/Wesson Division of Fansteel Inc. developed a wide selection of specialized tungsten carbide-base cutting tools.[11] A new patented tungsten carbide-chromium carbide-cobalt cutting tool will cut without chipping at low speeds and has wear resistance and hardness at high temperatures.

[11] Fansteel Inc. Annual Report 1971. 16 pp.

PRICE AND SPECIFICATIONS

The domestic price of tungsten ore and concentrate throughout 1971 was quoted at $55 (nominal) per stu reflecting the GSA shelf price established for the tungsten disposal program. As quoted in Metal Bulletin (London) and in Metals Week, the world tungsten price remained above the nominal GSA price ($55 per stu) through the first week in May but fell below this level during the rest of the year. The world price reached its highest quotation in late January and early February when it was reported at £30.05 per metric ton unit (mtu) ($65.42 per stu). The lowest quotation, reached in December, was reported at £16.00 per mtu ($34.84 per stu).

The price of APT delivered to contract customers ranged from about $56 to $58 per stu throughout 1971. A conversion fee of $11 per stu was charged for converting tungsten concentrate to APT at a recovery of 96 percent.

The quoted prices of both carbon- and hydrogen-reduced tungsten metal powder remained unchanged during the year. Carbon-reduced tungsten metal powder (99.9-percent purity in 1,000-pound lots) was quoted by Metals Week at $4.50 per pound of contained tungsten. The quoted price of hydrogen-reduced tungsten metal powder (99.99-percent purity) ranged from $5.43 to $6.36 per pound of contained tungsten.

The quoted price of ferrotungsten in lots of 5,000 pounds or more, ¼-inch lump, packed, f.o.b. destination, continental United States, 70 to 80 percent tungsten, rose during 1971 from $3.75 in January to $4.60 per pound of contained tungsten at yearend. The quoted price of UCAR, Union Carbide's special high-purity ferrotungsten, was unchanged at $4.00 per pound of contained tungsten. The U.S. dealer price of ferrotungsten in 1971 was quoted at $4.50 (nominal) per pound of contained tungsten. The price of exported ferrotungsten indicated in table 9 averaged $4.27 per pound of estimated tungsten content.

The price of scheelite concentrate for direct addition to steel melts, although not quoted, was believed to range from about $47 to $54 per stu, equivalent to about $2.96 to $3.40 per pound of contained tungsten.

Table 6.—Monthly price quotations of tungsten concentrate in 1971

Month	Wolfram and scheelite: London market, pounds sterling (£) per metric ton unit of WO_3, 65 percent basis:		Equivalent quotations, dollars per short ton unit of WO_3, 65 percent basis:		
	Low	High	Low	High	Average [1]
January	28.90	30.05	$62.92	$65.42	$63.87
February	27.90	30.05	60.74	65.42	62.55
March	25.25	29.05	54.97	63.25	58.77
April	25.00	26.25	54.43	57.15	55.79
May	22.80	26.00	49.64	56.61	53.10
June	22.00	24.00	47.90	52.25	49.46
July	18.25	22.00	39.73	47.90	44.21
August	16.40	19.00	35.71	41.37	38.18
September	16.40	19.00	35.71	41.37	38.73
October	18.25	21.75	39.73	47.35	43.88
November	19.50	22.00	42.46	47.90	44.85
December	16.00	19.50	37.83	42.46	38.95

[1] Arithmetic average of weekly quotations. Equivalent 1971 average price (through August 15) $53.45; duty $4.76, equivalent average price, duty paid, $58.21 per short ton unit. Equivalent average price (August 16 through December 20) $40.76; duty $7.93, equivalent average price, duty paid, $48.69 per short ton unit.

FOREIGN TRADE

Exports.—Exports of tungsten concentrate fell by a factor of almost 10 to slightly more than 2 million pounds, estimated tungsten content, in 1971. Almost all of this material represented excess tungsten purchased from the GSA stockpile. Effective Jan. 1, 1971, export data on ferrotungsten and ammonium paratungstate, which previously had been in "basket" categories, was reported separately

Table 7.—U.S. exports of tungsten ore and concentrates, by country
(Thousand pounds and thousand dollars)

Country	1970			1971		
	Gross weight	Tungsten content [1]	Value	Gross weight	Tungsten content [1]	Value
Belgium-Luxembourg	2,634	1,359	$3,873	--	--	--
Canada	469	242	958	94	48	$211
Czechoslovakia	1,837	948	3,382	--	--	--
France	452	233	809	100	52	220
Germany:						
East	1,556	803	2,481	--	--	--
West	11,771	6,074	18,915	1,864	962	3,752
India	--	--	--	170	88	245
Japan	3,723	1,921	6,358	293	151	559
Mexico	2	1	7	--	--	--
Netherlands	1,609	830	2,655	357	184	657
Poland	3,004	1,550	4,538	--	--	--
South Africa, Republic of	300	155	565	--	--	--
Sweden	1,708	881	2,595	267	138	402
U.S.S.R.	896	462	1,411	--	--	--
United Kingdom	7,773	4,011	12,584	742	383	1,277
Total	37,734	19,470	61,131	3,887	2,006	7,323

[1] Tungsten content estimated by multiplying the gross weight by a factor of 0.516 equal to 0.65 (to convert from 65 to 100 percent WO_3 basis) times 0.7931 (to convert from WO_3 to W basis).

Table 8.—U.S. exports of ammonium paratungstate in 1971, by country

Country	Pounds (gross weight)	Value
Australia	519	$1,038
Chile	384	787
Germany, West	53,850	157,543
Haiti	689	1,378
Honduras	499	948
Lebanon	1,286	2,000
Sweden	200	624
Total	57,427	164,318

Table 9.—U.S. exports of ferrotungsten in 1971, by country

Country	Pounds (gross weight)	Pounds (estimated tungsten content)	Value
Brazil	1,886	1,509	$7,544
Canada	14,646	11,717	58,584
France	1,620	1,296	6,481
Germany, West	1,952	1,561	7,808
Italy	22,046	17,637	70,000
Japan	45,172	36,138	157,028
Mexico	11,020	8,816	34,024
Sweden	22,000	17,600	69,900
Total	120,342	96,274	411,369

and indicated the flow and trade of these processed intermediate tungsten products. During 1971 tungsten concentrate containing an estimated 590 pounds of tungsten, valued at $800 were reexported to Mexico, about 140 pounds, gross weight, of tungsten wire, valued at $3,185 were reexported to the Netherlands, and 1,116 pounds, gross weight, of wrought tungsten valued at $23,463 were reexported to West Germany.

During the year, exports of unwrought tungsten metal and alloys in crude form, waste, and scrap fell 10 percent to 1,324,000 pounds, gross weight, valued at $2,367,441 and were shipped primarily to West Germany (66 percent), Austria (10 percent), Belgium (7 percent), and Canada (6 percent). Exports of tungsten and tungsten alloy powder decreased 19 percent to 326,683 pounds, gross weight, valued at $1,684,250. Most of these exports were shipped to Austria (38 percent), the United Kingdom (23 percent), Finland (13 percent), West Germany (9 percent), and Canada (7 percent).

Tungsten and tungsten alloy wire exports in 1971 rose 8 percent to 119,345 pounds, gross weight, valued at $2,479,737, distributed primarily as follows: Canada (16 percent); West Germany (14 percent); Brazil, Singapore, and the United Kingdom (12 percent each); and Belgium (9 percent). Exports of wrought tungsten and tungsten alloys fell 34 percent to 70,223 pounds, gross weight, valued at $1,059,523. Shipments were primarily to West Germany (47 percent); Canada (13 percent); the United Kingdom (8 percent); and Mexico (7 percent).

Imports.—During the year, tungsten concentrate imports for consumption decreased

67 percent to a 33-year low and the second lowest reported annual level on record.

Tungsten carbide imports in 1971, primarily from West Germany (72 percent), and Canada (22 percent) increased 80 percent and totaled 132,205 pounds of contained tungsten valued at $803,398. Imports of tungsten waste and scrap containing over 50 percent tungsten fell 48 percent to 14,464 pounds of tungsten, valued at $113,042; shipments were received from West Germany (59 percent); the Netherlands (16 percent); Canada (14 percent); and the Republic of South Africa (11 percent). During the year, imports of unwrought tungsten in lumps, grains, and powder rose 33 percent to 99,454 pounds of tungsten, valued at $609,942. These imports came from West Germany (89 percent) and Sweden (11 percent). Imports of wrought tungsten decreased by 22 percent to 5,414 pounds, gross weight, valued at $365,846 in 1971. Most of this material was imported from Japan (41 percent); Austria (29 percent); the Netherlands (13 percent); and Sweden (12 percent).

Imports of material classified as "Other Metal-Bearing Materials in Chief Value Tungsten" in 1971 totaled 38,118 pounds of contained tungsten, valued at $79,506

Table 10.—U.S. imports [1] of tungsten ore and concentrates, by country

(Thousand pounds and thousand dollars)

Country	1970			1971		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	--	--	--	101	58	$140
Brazil	--	--	--	55	31	71
Canada	r 2,035	1,234	$2,986	334	203	426
Guatemala	--	--	--	3	(2)	1
Mexico	45	27	70	174	93	290
Peru	66	38	157	322	192	556
Total	r 2,146	1,299	3,213	989	577	1,484

r Revised.
1 Data are "general imports," that is, they include tungsten imported for immediate consumption plus material entering warehouses.
2 Less than ½ unit.

Table 11.—U.S. imports for consumption of tungsten ore and concentrates, by country

(Thousand pounds and thousand dollars)

Country	1970			1971		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	--	--	--	101	58	$140
Canada	r 2,035	1,234	$2,986	334	203	426
Guatemala	--	--	--	3	(1)	1
Mexico	25	12	33	156	81	219
Peru	66	38	157	119	76	247
Total	r 2,126	1,284	3,176	713	418	1,033

r Revised.
1 Less than ½ unit.

Table 12.—U.S. imports for consumption of tungsten and tungsten carbide forms

(Thousand pounds and thousand dollars)

Year	Ingots, shot, bars, and scrap		Wire, sheets, and other forms, n.s.p.f.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	33	$65	30	$552	63	$617
1970	35	173	190	1,560	225	1,733
1971	17	117	129	1,804	146	1,921

Table 13.—U.S. import duties on all forms of tungsten

(Per pound of contained tungsten)

Tariff classification	Article	Rate of duty [1]	
		Effective Jan. 1, 1971	Effective Jan. 1, 1972
601.54	Tungsten ore	$0.30	$0.25.
603.45	Other metal bearing materials in chief value tungsten	$0.25 plus 12 percent ad valorem.	$0.21 plus 10 percent ad valorem.
607.65	Ferrotungsten	$0.25 plus 7.5 percent ad valorem.	$0.21 plus 6 percent ad valorem.
629.25	Waste and scrap containing by weight not over 50% tungsten	$0.25 plus 7.5 percent ad valorem.	$0.21 plus 6 percent ad valorem.
629.26	Waste and scrap containing by weight over 50% tungsten	12.5 percent ad valorem	10.5 percent ad valorem.
629.28	Unwrought tungsten, except alloys in lump, grain and powder	$0.25 plus 15 percent ad valorem.	$0.21 plus 12.5 percent ad valorem.
629.29	Unwrought tungsten ingots and shot	12.5 percent ad valorem	10.5 percent ad valorem.
629.30	Unwrought tungsten, n.e.c	15 percent ad valorem	12.5 percent ad valorem.
629.32	Tungsten alloys, unwrought, containing by weight not over 50% tungsten	$0.25 plus 7.5 percent ad valorem.	$0.21 plus 6 percent ad valorem.
629.33	Tungsten alloys, unwrought, containing by weight over 50% tungsten	15 percent ad valorem	12.5 percent ad valorem.
629.35	Wrought tungsten	do	Do.
416.40	Tungstic acid	$0.25 plus 12 percent ad valorem.	$0.21 plus 10 percent ad valorem.
417.40	Ammonium tungstate	do	Do.
418.30	Calcium tungstate	do	Do.
420.32	Potassium tungstate	do	Do.
421.56	Sodium tungstate	do	Do.
422.40	Tungsten carbide	$0.25 plus 15 percent ad valorem.	$0.21 plus 12.5 percent ad valorem.
422.42	Other tungsten compounds, n.e.c	$0.25 plus 12 percent ad valorem.	$0.21 plus 10 percent ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value tungsten	do	Do.

[1] Not applicable to Communist countries.

from Thailand (59 percent) and Norway (41 percent). In previous years, this category was believed to primarily cover synthetic scheelite. During the year, imports of ferrotungsten totaled 29,673 pounds of contained tungsten, valued at $98,155 from Sweden (69 percent) and Brazil (31 percent).

Calcium tungstate imports, all from West Germany, decreased 14 percent in 1971 and totaled 16,329 pounds of tungsten, valued at $178,292. Imports classified as "Mixtures of Two or More Inorganic Compounds in Chief Value Tungsten" fell 41 percent to 37,420 pounds of tungsten, valued at $245,485 from Canada (70 percent) and West Germany (30 percent). In 1970 most of the 63,084 pounds imported under this classification came from Sweden (86 percent) and West Germany (13 percent). There were no reported imports of tungstic acid, potassium tungstate, sodium tungstate, or ammonium tungstate during the year.

As the final part of the 5-year program of tariff reductions agreed upon at the "Kennedy round" of tariff negotiations, the U.S. import duties on all forms of tungsten from non-Communist countries were further reduced, effective January 1, 1972. However, the statutory rates, applicable to Communist bloc countries, remained unchanged and were 50 cents per pound of contained tungsten ($7.95/stu) for tungsten ore and concentrate.

Because of the difference in duty rates, tungsten concentrate is not expected to be imported directly into the United States from the People's Republic of China, the world's major tungsten producing country.

From August 16 through December 20, 1971, a 10 percent ad valorem surcharge, not to exceed the statutory rate, (Presidential Proclamation 4074), was imposed on all imports. During this period, the duty on all tungsten ore and concentrate imports was 50 cents per pound of contained tungsten ($7.93/stu).

WORLD REVIEW

Neither the Committee on Tungsten of the United Nations Conference on Trade and Development (UNCTAD) nor its subsidiary, the Working Group, met during the year, but the Committee staff continued to canvass, tabulate, and report world tungsten statistics in the quarterly bulletin Tungsten Statistics. These UNCTAD statistical reports are available to governments and the public for an annual subscription fee of U.S. $3.00. Single copies are available for U.S. $0.85 each. The request and fee for the publication should be sent to: Distribution Section, United Nations, Palais des Nations, 1211 Geneva, Switzerland.

Australia.—Major expansion of the open pit tungsten mine and concentrator of King Island Scheelite (1947) Ltd., a wholly-owned subsidiary of Peko-Wallsend Ltd., was postponed pending research on artificial (synthetic) scheelite and recovery of the weakened world tungsten market.[12] Exploration adjacent to the King Island property, possibly the world's largest scheelite deposit, located on King Island between Tasmania and the Mainland, indicated that the tungsten ore reserves extend under the sea. Special mining methods for extracting this material were evaluated. Ore reserves were estimated at 8 million tons of ore with an average content of 0.75 percent tungsten oxide (WO_3).

During the year, 4,682,550 tons of ore were mined and 304,691 tons of ore having an average grade of 0.44 percent WO_3 were treated to produce 100,240 stu of WO_3.

In fiscal year 1971 (July 1970 through

[12] Peko-Wallsend Ltd. (Sydney, Australia). Annual Report 1970–71. 32 pp.
——. Annual Report 1969–70. 32 pp.

Table 14.—Tungsten: World production by country
(Thousand pounds of contained tungsten [1])

Country [2]	1969	1970	1971 [p]
North and Central America:			
Canada	3,223	3,058	3,973
Guatemala [e]	90	90	90
Mexico	[r] 637	635	899
United States	[r] 7,805	[r] 9,625	6,900
South America:			
Argentina	[r] 320	317	302
Bolivia	4,059	4,068	4,079
Brazil	[r] 1,914	2,549	3,082
Peru	1,519	1,773	1,698
Europe:			
Austria [3]	300	187	99
France	49	128	661
Portugal	2,934	3,142	3,056
Spain	443	899	1,164
U.S.S.R. [e]	14,300	14,800	15,400
Africa:			
Niger	--	2	[e] 2
Rwanda	375	[e] 400	[e] 440
South Africa, Republic of	64	7	13
South-West Africa, Territory of [4]	212	139	209
Tanzania	13	7	9
Uganda	117	161	146
Zaire (formerly Congo-Kinshasa)	143	--	--
Asia:			
Burma	[r] 368	483	798
China, People's Republic of [e]	17,600	17,600	17,600
India	46	40	35
Japan	1,343	1,493	1,609
Korea, North [e]	4,720	4,720	4,720
Korea, Republic of	4,345	4,564	4,539
Malaysia	304	300	250
Thailand	1,442	1,567	5,529
Oceania:			
Australia	[r] 3,051	2,789	3,411
New Zealand	18	11	15
Total	[r] 71,754	[r] 75,554	80,728

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Conversion factors: WO_3 to W, multiply by 0.7931; 60 percent WO_3 to W, multiply by 0.4758.
[2] In addition to the countries listed, the following also produced tungsten, but reliable data are not available: Hong Kong, Nigeria, and Southern Rhodesia.
[3] Content of WO_3 concentrate.
[4] Data are for the South-West Africa Co., Ltd. only, and are for the year ended June 30 of the year stated.

Table 15.—World consumption of tungsten ores and concentrates, by country [1]

(Thousand pounds, tungsten content)

	1969	1970	1971 [p]
Actual consumption:			
Australia	110	88	88
Austria	3,395	4,387	3,417
Canada	[r e] 551	[e] 441	[e] 435
Czechoslovakia	3,023	[e] 3,084	[e] 2,900
India	243	340	[e] 330
Japan	7,302	8,962	4,579
Portugal	688	763	498
Sweden	3,371	3,289	3,228
United Kingdom	7,079	8,691	4,819
United States	13,053	16,700	11,622
Apparent consumption, including stock variations:			
France	3,329	3,192	2,467
Apparent consumption, excluding stock variations:			
Argentina	66	86	86
Belgium-Luxembourg	(2)	64	42
Brazil	317	355	463
Bulgaria [3]	80	80	80
China, People's Republic of [3]	1,400	1,450	1,500
Germany:			
East [3]	800	850	700
West	9,299	7,112	5,324
Hungary [3]	50	50	50
Italy	53	152	[e] 120
Korea, North [3]	3,500	3,500	3,500
Netherlands	489	496	613
Poland	3,422	3,924	3,876
South Africa, Republic of [3]	630	700	650
Spain	(2)	168	472
U.S.S.R.	14,400	14,650	14,000
Total	[r] 76,650	[r] 83,574	65,859

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition, the following countries are known or believed to consume tungsten concentrate but specific data are not available: Denmark, Finland, Israel, Norway, Romania, Switzerland, and Yugoslavia.

[2] Revised to none.

[3] Estimate by author of chapter.

Primary Source: UNCTAD Committee on Tungsten and Annual Company Reports.

June 1971), 51 percent of the 4,377,855 tons of overburden removed from the King Island tungsten operations were used in the construction of a main breakwater for the new port development at Grassy. A further 470,157 tons of overburden were used to form an inner breakwater and to reclaim area for the roll-on roll-off wharf facility. This new port for the island is being constructed on behalf of the Tasmanian Government.

Canada.—Continuous open pit production of high-quality scheelite concentrates, which was maintained throughout 1971 by the country's major tungsten producer, Canada Tungsten Mining Corp. Ltd. (CTMC), fell about 12 percent at the company's mine and mill located at Tungsten (formerly Flat River), Northwest Territories, near the Yukon border. Total mine production totaled 164,420 stu of WO_3 (2.6 million pounds of contained tungsten), and the concentrator operated at 93.7 percent of possible time treating an average of 498 dry tons per day.[13] Overall recoveries of WO_3 averaged 76.39 percent during the year. The average grade of ore milled continued to decrease and fell from 1.39 percent WO_3 in 1970 to 1.19 percent WO_3 in 1971.

Since metallurgical research studies indicated that improvements in recoveries could be achieved through the addition of equipment, construction was started in June and the altered and enlarged mill circuit was put on stream in December. In conjunction with the mill expansion, a new tailings impoundment area was constructed in the valley south of the plant and townsite.

In addition to the scheelite, 241,797 pounds of byproduct copper concentrate was produced during the year, a decrease of 34 percent compared with 1970. After being containerized, all the copper concentrate was stockpiled to await the development of higher copper prices.

CTMC estimated its reserves of ore in place on Dec. 31, 1971, at 443,778 tons, averaging 1.36 percent WO_3. In addition,

[13] Canada Tungsten Mining Corp. Ltd. (Toronto, Canada). Annual Report 1971. 9 pp.

107,882 tons of scheelite ore averaging 1.22 was stockpiled. The stockpiled material and estimated reserves, which contain approximately 11.7 million pounds of tungsten, are adequate to sustain the current rate of production for about 4 or 5 years. Additional diamond drill exploration of the area, conducted during the summer, indicated the presence of a large low-grade chert formation underlying the present pit. This material, which totals approximately 3.5 million tons containing an estimated 0.65 percent WO_3, could only be recovered by more expensive underground operations and is currently not considered ore. It is anticipated that about 700,000 tons of the chert material of a somewhat higher grade can be recovered by open pit operations along with the scarn ore in the present pit.

CTMC carried out mining operations on a 6-day-per-week schedule between June 1 and early October 1971. During this period, 202,000 tons of ore containing an average of 1.06 percent WO_3 were mined, crushed, and stockpiled. Waste removal totaled 250,000 tons with an additional 150,000 tons broken and ready for removal in 1972.

The Vancouver leach plant in Vancouver, British Columbia, operated continuously throughout the year on a 5-day-per-week schedule to upgrade concentrate from Flat River. The metallurgical changes made at the mine concentrator improved the Vancouver leaching operation. Improved recoveries during the latter half of the year resulted in an overall average recovery of 98 percent.

Arrangements were made to convert some tungsten concentrate into ferrotungsten in Canada. This procedure will help CTMC to supply the form of tungsten needed for addition to steel melts by high-speed tool steel companies in Canada and abroad.

During 1971 the Canex Tungsten Division of Placer Development Ltd. produced 86,010 stu (1.36 million pounds of contained tungsten) from its Invincible scheelite property at Salmo, near Trail, British Columbia.[14] The Canex mill treated 172,512 tons of ore with an average content of 0.61 percent WO_3. The recovery averaged 81.6 percent with approximately one quarter of the production recovered as a high-grade table concentrate. During the year, the average price received for tungsten concentrate was $42.25 per stu of WO_3, f.o.b. Vancouver, B.C. The mill inventory at yearend was 22,920 units (0.36 million pounds of contained tungsten).

Some difficulties were encountered in producing a uniform grade of concentrate. By yearend, however, a consistently acceptable grade was being produced and off-grade tungsten concentrates were re-treated and blended to improve marketability. Reserves of broken and unbroken ore at Salmo were 308,000 tons at a grade of 0.67 percent WO_3.

Korea, North.—Tungsten ore is found in workable concentrations in quartz-tungsten vein deposits and in scheelite deposits in the Mannen and Kensu mining centers of industrialized North Korea.[15] Some 80 percent of the North Korean tungsten concentrate production is believed to be consumed in the country's expanded steel industry. The balance of North Korea's tungsten production is exported primarily to Eastern European Communist bloc countries. Data currently available indicates that a minor amount was also exported to two Western European countries, France and the United Kingdom.

Korea, Republic of.—The Sandong deposit is one of the most significant single occurrences in the world, containing 1 to 3 percent WO_3 and 1 to 1.5 percent molybdenum plus bismuth. Production from the Sandong mine is responsible for almost 90 percent of the South Korean tungsten output as shown in the following tabulation:[16]

Company	Short tons
Bando Mining Co., Ltd	80
Chong Yang Industries Co., Ltd	42
Korea Tungsten Mining Co., Ltd.:	
Dalsong mine	86
Sandong mine	3,640
Okbang Mining Co., Ltd	100
Wolak Mining Co., Ltd	42
Other companies (11 mines)	99
Total	4,089

Because tungsten exports reportedly represent over a third of South Korea's earnings from mineral exports, a modernization and expansion program was completed in 1971

[14] Placer Development Ltd. (Vancouver, Canada). Annual Report 1971. 28 pp.

[15] World Minerals and Metals. The Minerals Industry of Korea. The British Sulphur Corp. Ltd. (London), No. 6, March-April 1972, pp. 20–22.

[16] Bureau of Mines. Tungsten: Republic of Korea. Mineral Trade Notes, v. 69, No. 6, June 1972, p. 26.

at the mill adjacent to the Sandong mine, raising capacity from 1,550 to 1,800 tons per day.

Portugal.—Beralt Tin and Wolfram Ltd., the country's major tungsten producer, recovered tungsten from its orebody located at Panasqueira, Biera Baixa, Portugal, and subsequently treated the ore to produce high-purity commercial-grade tungsten concentrate.[17] Owing to the sharp decline in the stoping grade of ore, the production of tungsten concentrates fell 11 percent to 1,569 tons of tungsten. Production of byproduct tin concentrate fell 24 percent to 29 tons, and production of byproduct copper concentrate fell 34 percent to 506 tons in 1971. The areas available for mining during the year were lower in grade as a result of the depletion of many of the richer areas during previous years. Development is being concentrated in new areas to the South, where richer values are thought to exist; nevertheless, it can be expected that mining operations will continue in the future at a lower average grade.

Because of the recent drop in tungsten prices, the reserves at Panasqueira that could be profitably mined were drastically reduced. To economically mine a larger portion of these ores, which are marginal at present price levels, the mining costs must be lowered. Reduced unit costs can be achieved by increased production, however, this will require a larger proven ore reserve. Increased reserves will also provide greater flexibility in grade control, particularly during severe tungsten price fluctuations. To improve the firm's reserve position development work was increased by 50 percent during the year and will be increased further during the next few years. Exploratory work will continue to probe ahead to determine the trends in grade beyond the area currently being mined.

The proposed increase in production and development will depend largely on the availability of an adequate supply of skilled labor. The labor shortage coupled with high absenteeism continued to be a serious problem. While Beralt's labor force was up to strength at yearend, turnover remained high and there was a shortage of skilled and technically experienced machine operators. The problem was partially alleviated by the employment of untrained or semiskilled labor from Cape Verde.

The new heavy media separation preconcentration plant became operational in July. Considerable difficulties were experienced owing primarily to the inability of the main bucket elevator to achieve its rated capacity. The plant continued operations at a reduced rate during the year and operated in conjunction with the handpicking plant until modifications could be made. The Rio mill operated efficiently throughout the year and the high grade of concentrate was maintained at an average assay of 75.5 percent WO_3.

A comprehensive feasibility study conducted on the erection of a tungsten processing plant in Portugal indicated that a plant of economic size would be costly and, at best, only moderately profitable. However, bearing in mind the Portuguese Government's desire to have tungsten concentrates processed within the country and the advantage to Beralt in securing a long term domestic outlet, discussions were conducted to plan for the establishment of such a plant when economic conditions improve.

While some 11 Portuguese mines report tungsten production, Beralt is the country's major tungsten producer.[18] Of the 10 small tungsten mines, one, Minas de Borralha, is under French ownership.[19]

Rhodesia, Southern.—Although tungsten was produced by some 60 small and intermittent operations located primarily in the Bulawayo and Salisbury districts, the major production was obtained from the Beardmore mine of Messina (Transvaal) Development Co. at Bikita. The R.A.N. mine at Bindura, which had previously been Rhodesia's major tungsten producer, is no longer active. At Messina's Beardmore mine in 1971, 36,190 tons of ore averaging 0.88 percent WO_3, was recovered from mine stopes and 2,860 tons containing an average of 0.40 percent were obtained from the mine's development ends.[20] An addi-

[17] Beralt Tin and Wolfram Ltd. (London). Annual Report 1971. 18 pp.
[18] UNCTAD Committee on Tungsten (Geneva, Swizerland). Tungsten Statistics. V. 6, No. 2, April 1972, 68 pp.
[19] World Minerals. Minerals World. The British Sulphur Corp. Ltd. (London), No. 1, May-June 1971, pp. 18–26.
[20] The Messina (Transvaal) Development Co. Ltd. (Johannesburg, Rep. of South Africa). Annual Report 1971. 31 pp.

tional 3,520 tons were reclaimed from stockpiles and delivered to the mill.

Hand sorting improved the grade of ore fed to the Beardmore mill from 42,570 tons at 0.84 percent WO_3 in 1970 to 36,960 tons at 0.95 percent WO_3 in 1971. Recovery in the gravity concentrator was 73.3 percent and overall recovery, including sorting, improved from 66.0 percent to 71.9 percent. Concentrator throughput was 1,760 tons more than was forecast, but the decline in the mill head content from 1.27 percent WO_3 to 0.95 percent WO_3 resulted in a production of only 391 tons of concentrate assaying 65.95 percent WO_3. The slimes fraction of the tailings amounted to 26 percent of the concentrator throughput and averaged 0.70 percent WO_3. This material was stored separately for future treatment. A special processing plant which was designed for this material will become operational by mid-1972. Messina announced plans to mill 39,600 tons of ore during 1972 for a production of 220 tons of WO_3 in concentrate. At yearend 1971, Beardmore's ore reserves totaled 74,800 tons containing 0.71 percent WO_3.

Zaire, Republic of.—Production of tungsten concentrate in the Republic of Zaire (formerly Congo-Kinshasa) was reported to have increased about 37 percent to 471 tons during 1971.[21] Almost all of the 1971 tungsten production was recovered from three major deposits in Kivu Province where transportation from mine to port presented a major problem.

TECHNOLOGY

Studies conducted by Bureau of Mines scientists evaluated methods of electrowinning tungsten from scheelite $2(CaWO_4)$ concentrates.[22] Crude WO_3 prepared by the acid digestion process was processed by electrometallurgical methods to produce tungsten metal of 99.9 percent purity. The tungsten recovery varied from 79 to 83 percent and most of the tungsten loss was in the dragout electrolyte which could be recovered by subsequent hydrometallurgical processing.

The applicability of the freeze-drying technique for the preparation of dispersion-strengthened tungsten powders was investigated by Bureau of Mines engineers.[23] They reported that although the high surface area of tungsten powder prepared by freeze drying is advantageous in some applications, the powder may be more readily contaminated by oxygen. Tungsten powder made by the freeze-drying technique can be fabricated by powder-metallurgical (PM) techniques into tungsten sheet with a lower recrystallization temperature, a lower ductile-to-brittle transition temperature, and a higher purity than commercial PM tungsten sheet.

A method of strengthening the high-temperature properties of tungsten alloys was developed by Bureau metallurgists.[24] This process, designated oxyreaction, involved additions of a reactive metal compound powder, zirconium nitride (ZrN), zirconium tungsten (ZrW_2), or hafnium tungsten (HfW_2), to the tungsten base metal which contains some oxygen. The oxyreaction process circumvents many of the agglomerating and coarsening problems encountered in conventional methods for dispersing a stable oxide in the metal. Oxyreaction strengthening results from a combination of solid-solution strengthening and dispersion strengthening.

The second report in a series, which describes current practices and trends in the application of solvent extraction processes that lead to the recovery of byproduct tungsten, was issued by the Bureau of Mines during the year.[25] The first report of this series described the fundamentals of solvent extraction.[26]

Studies were conducted during the year by Bureau metallurgists in an attempt to develop economic techniques to recover

[21] U.S. Consulate, Lubumbashi, Rep. of Zaire. Minerals Industry Report for Zaire. State Department Airgram A–021, June 6, 1972, 17 pp.

[22] Gomes, John M., Kenji Uchida, and M. M. Wong. Comparison of Techniques for Electrowinning Tungsten From Scheelite. BuMines Rept. of Inv. 7580, 1971, 10 pp.

[23] Ferrente, M. J., R. R. Lowery, and G. B. Robidart. Tungsten and Dispersion-Strengthened Tungsten Made By Freeze Drying. BuMines Rept. of Inv. 7485, March 1971, 32 pp.

[24] Blickensderfer, Robert, Mark I. Copeland, and William L. O'Brien. A new Internal Oxidation Process for Strengthening Tungsten. BuMines Rept. of Inv. 7521, June 1971, 40 pp.

[25] Rosenbaum, Joe B., D. R. George, and Joan T. May. Metallurgical Application of Solvent Extraction, Part 2: Practice and Trends. BuMines Inf. Circ. 8502, January 1971, 19 pp.

[26] Bridges, D. W., and J. B. Rosenbaum. Metallurgical Applications of Solvent Extraction, Part I: Fundamentals of the Process. BuMines Inf. Circ. 8139, 1962, 45 pp.

tungsten from the large low-grade brine deposits of Searles Lake, Calif.

The chlorination kinetics of tungsten, molybdenum, and their binary alloys were studied as part of the Bureau's evaluation of chlorine extractive metallurgy processes.[27] Of the metals and alloys studied, tungsten was the least reactive and its single crystals showed marked anisotropy upon chlorination.

Another Bureau of Mines study evaluated methods of reclaiming tungsten carbides from secondary materials (scrap).[28]

A study of domestic ferroalloy usage, which reviewed tungsten resources, U.S. Government stockpile activities, ferroalloy specifications, and pollution control activities, was released during the year.[29] An improved definition of the superalloy class of materials was developed, the demand for tungsten in the steel industry was evaluated, and tungsten demand in ferroalloys was projected to 1980.

The elevated temperature properties of chemical vapor deposited (CVD) tungsten tubing and the determination of friction coefficients of tungsten was evaluated directly from hoop stress tests.[30] Several studies reported by the National Aeronautics and Space Administration (NASA) evaluated the development of CVD tungsten by the reduction of gaseous tungsten hexafluoride (WF_6) with hydrogen (H_2) gas.[31] CVD tungsten metal of essentially 100 percent purity and density is built up as a dense deposit on a heated graphite mandrel. Following deposition, the mandrel is separated by simple machining, leaving a tungsten shell structure of the required shape and thickness.

Pressure hydrometallurgy has been successfully used in the U.S.S.R. to extract tungsten and molybdenum by single-stage leaching of low-grade materials inside a rotating autoclave.[32] The concentrate originally contains about 8 to 12 percent tungsten, which is placed into solution by leaching in an autoclave. The resulting solution is separated and filtrated. The first filtrate is recycled for pressure-leaching of high-grade scheelite concentrates.

A comprehensive quarterly report, Tungsten News, reports the latest available technical information on tungsten. Interested persons can be placed on the mailing list to receive this report by sending a request to: Dr. Janet Z. Briggs, Vice President and Director of Technical Information, Editor —Tungsten News, Climax Molybdenum Co., 1270 Avenue of the Americas, New York, N.Y. 10020.

Methods of producing high-purity ammonium metatungstate and of separating molybdenum from tungsten values during the liquid-liquid solvent extraction of ammonium metatungstate from aqueous ammonium tungstate were developed.[33]

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[27] Landsberg, C. L. Hoatson, and F. E. Block. The Chlorination Kinetics of Tungsten, Molybdenum, and Their Alloys. J. Electrochem. Soc., v. 118, No. 8, August 1971, pp. 1331–1336.

[28] Starliper, A. G. and H. Kenworthy (assigned to the U.S. Department of the Interior). Reclamation of Refractory Carbides From Carbide Materials. U.S. Pat. 3,595,484, July 27, 1971.

[29] National Research Council. Trends in the Use of Ferroalloys by the Steel Industry of the United States. National Materials Advisory Board, NMAB-276, (Nat. Acad. Sci.-Nat. Acad. Eng.), Washington, D. C., July 1971, 130 pp.

[30] Chun, J. S., P. S. Nicholson, A. Sosin, and J. B. Byrne. Chemical Vapor Deposited Tungsten —Mechanical Evaluation at High Temperature. J. Electrochem. Soc., v. 118, No. 9, September 1971, pp. 1492–1498.

[31] National Aeronautics and Space Administration. Fabrication of Large Tungsten Structures by Chemical Vapor Deposition. NASA Tech. Brief 71–10212, July 1971, 2 pp.

Stubbs, V. R. Investigation of Advanced Regenerative Thrust Chamber Designs. NASA–CR–72742, Nov. 15, 1970, 88 pp. (Available from the National Technical Information Service, Springfield, Va. as N71–14135.)

National Aeronautics and Space Administration. Welding, Bonding, and Sealing of Refractory Metals by Vapor Deposition. NASA Tech. Brief 67–10232, July 1971, 2 pp.

[32] Habashi, Fathi. Pressure Hydrometallury: Key to Better and Nonpolluting Processes. Eng. and Min. J., v. 172, No. 2, February 1971, pp. 96–100.

———. Pressure Hydrometallurgy: Key to Better and Nonpolluting Processes. Eng. and Min. J., v. 172, No. 5, May 1971, pp. 88–94.

[33] Chiola, Vincent, Phyllis R. Dobbs, Fred W. Liedtke, and Clarence D. Vanderpool (assigned to Sylvania Electric Products, Inc., New York). Process for Producing Ammonium Metatungstate. U.S. Pat. 3,591,331, July 6, 1971.

Chiola, Vincent, Phyllis R. Dobbs, and Tai K. Kim (assigned to Sylvania Electric Products Inc., New York). Separation of Molybdenum Values From Tungsten Values by Solvent Extraction. U.S. Pat. 3,607,007, Sept. 21, 1971.

Chiola, Vincent, Phyllis R. Dobbs, Tai K. Kim, and John A. Powers (assigned to Sylvania Electric Products Inc., New York). Separation of Molybdenum Values From Tungsten Values by Solvent Extraction. U.S. Pat. 3,607,008, Sept. 21, 1971.

Uranium

By Walter C. Woodmansee [1]

The domestic and world uranium surplus continued during 1971. Domestic U_3O_8 mine and mill production was at a rate similar to that of 1970. Ore reserves continued to increase although exploration for uranium was declining. Fewer mines were in operation. One new mill went on stream, and three other mills were scheduled for completion in 1972. A problem facing the industry was to provide incentives for increased exploration for new reserves that will be needed in the future.

The year 1971 was the first full year that the U_3O_8 market was entirely private. The Atomic Energy Commission (AEC) terminated its U_3O_8 purchasing program at yearend 1970 after acquiring U_3O_8 valued at nearly $3 billion since the program's inception in 1948, including a large stockpile. The AEC proposed a schedule for disposal of this stockpile over a period of several years, but industry response was negative.

The domestic U_3O_8 price remained soft under conditions of excess supply. The estimated average domestic price per pound was in the $6 to $6.50 range. Prices in the world market apparently were lower. New mines were under development in Australia, Canada, and the Territory of South-West Africa.

Progress was made in new uranium enrichment technology and world enrichment capacity. Expansion was underway at the AEC's three gaseous diffusion plants, which, however, continued to operate at only partial capacity. The major industrialized nations continued research on enrichment methods and were negotiating agreements for future production and marketing of enriched uranium. The AEC offered to share its gaseous diffusion technology with U.S. industry [2] and with foreign governments under appropriate safeguards. In addition to uranium enrichment, private facilities were under development for nuclear fuels manufacturing, reprocessing, and waste management.

New nuclear reactors for electric power were completed in the United States, the leader in commercial nuclear power development, and worldwide. Several of the less developed countries announced plans for nuclear power, and most of the industrialized nations were committed to ambitious nuclear programs for future energy supplies.

The domestic nuclear power program faced new problems resulting from the landmark decision of a Federal Court of Appeals in the case involving the nuclear plant at Calvert Cliffs, Md. This decision, not appealed, committed the AEC to an evaluation of the total environmental impact of a nuclear facility in implementing the National Environmental Policy Act of 1969. A total of 103 plants in operation, under construction, or on order at that time were affected by the decision. The AEC commenced a major reorganization of its regulatory function in order to consider total environmental quality, with public participation, and to increase efficiency in the licensing and regulatory responsibility. New AEC regulatory legislation, guidelines, and interim criteria, which affected the status of nuclear plants at all stages of development, were announced.[3]

New emphasis was placed on fast breeder development following the President's announcement committing the Nation to a commercial fast breeder reactor during the 1980's. Plans were made for two demonstration liquid-metal fast-breeder reactors

[1] Geologist, Division of Nonferrous Metals.

[2] U.S. Atomic Energy Commission. News Releases. AEC to Permit Access to Enrichment Technology, v. 2, No. 25, week ending June 23, 1971, p. 3; AEC Names 22 Companies in First Step of Industry Access to Enrichment Technology, v. 2, No. 48, week ending Dec. 1, 1971, p. 8.

[3] U.S. Atomic Energy Commission. Annual Report to Congress for 1971. January 1972, 249 pp.

(LMFBR) with private industry participation. After shares were pledged by both industry and Government, siting of the first demonstration LMFBR was planned in the Tennessee Valley Authority system.[4]

According to the Bureau of Labor Statistics, employment in all sectors of the nuclear industry slightly exceeded 154,000 in 1970 (most recent available data), about 2,000 employees more than in the preceding

[4] American Metal Market. V. 78, No. 183, Sept. 22, 1971, p. 9.

Table 1.—Salient uranium concentrate (U_3O_8) statistics

(Short tons U_3O_8 unless otherwise specified)

	1967	1968	1969	1970	1971
Production:					
Domestic:					
Mine: [1]					
Ore thousand tons	5,272	6,448	5,904	6,324	6,279
Content of ore	10,657	12,570	12,281	12,768	12,907
Average grade of ore percent U_3O_8	0.202	0.195	0.208	0.202	0.205
Recoverable [e] [2]	10,330	12,070	11,870	12,340	12,260
Value [e] [3] thousands	$165,239	$182,698	$142,161	$149,464	$152,029
Mill, concentrate [4]	[r] 11,253	[r] 12,368	[r] 11,609	[r] 12,905	12,273
World [e] [5]	19,098	23,005	23,083	23,858	24,582
Purchases of concentrate:					
Atomic Energy Commission:					
Quantity	8,425	7,337	6,184	[r] 2,520	--
Value thousands	$134,785	$117,026	$72,336	$28,078	--
Price per pound	$8.00	$8.00	$5.85	$5.59	--
Private industry [e]	700	5,000	6,200	9,300	12,800
Imports, concentrate	1,309	470	1,504	665	942
Reserves [6] thousand tons	148	161	204	246	273
Employment [7] number of persons	6,751	8,355	9,059	8,165	7,373

[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] Based on estimated recoverable content, average AEC price, and estimated average price for private sales for 1967–70; private sales only in 1971.
[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 U.S. Bureau of Mines.

Table 2.—Nuclear industry employment [1]

Operation	Number of reporting units	Number of employees
Government facilities:		
Laboratory and research	25	49,375
Defense production	9	30,975
Other	26	18,211
Subtotal	60	98,561
Private facilities:		
Uranium milling	15	1,712
Production of feed materials	7	639
Production of special nuclear materials	19	1,673
Fuel fabrication and recovery	13	5,183
Reactors and components	39	21,321
Reactor operation and maintenance	30	2,153
Radioisotopes	31	1,052
Instruments	56	5,153
Waste management	8	81
Laboratory and research	62	2,793
Defense production	4	57
Accelerators	7	740
Industrial radiography	50	1,733
Design and engineering	47	9,341
Miscellaneous	46	1,884
Subtotal	434	55,515
Total	494	154,076

[1] Data as of mid-1970.

Source: U.S. Atomic Energy Commission from data provided by Bureau of Labor Statistics.

year. Employment in the uranium exploration, mining, and milling sectors was nearly 10 percent lower than in 1970.

Exploration and Reserves.—Surface exploratory and development drilling in the United States declined by 34 percent in 1971, according to an AEC survey. There were 990 drilling projects for uranium in 15 States. The footage was distributed by States, as follows: Wyoming, 39.6 percent; Texas, 25 percent; New Mexico, 19.8 percent; Colorado, 7.1 percent; Utah, 3.9 percent; South Dakota, 2.0 percent; and others, 2.6 percent.

The industry planned 14.4 million feet of surface drilling (11.7 million feet exploration, 2.7 million feet development) in 1972 at an estimated cost of $34.9 million, and 13.5 million feet in 1973 at an estimated cost of $32.7 million. At yearend, 19 million acres of uranium lands were held for exploration and mining, compared with nearly 20 million acres at the beginning of the year.[5]

Table 3.—Surface drilling for uranium

	1970	1971
Type of drilling:		
Exploration ---- million feet --	17,981	11,400
Development ---------- do ----	5,547	4,052
Total	23,528	15,452
Number of holes:		
Exploration	43,980	28,416
Development	14,874	10,440
Total	58,854	38,856
Average depth per hole:		
Exploration	409	401
Development	373	388

Source: U.S. Atomic Energy Commission.

Domestic ore reserves ($8 per pound U_3O_8) increased to 126.5 million tons at an average grade of 0.216 percent U_3O_8, containing 273,200 tons U_3O_8, an increase of 27,000 tons U_3O_8 during the year. There were 732 ore-reserve properties. These reserves were distributed by States, as follows: New Mexico, 50.2 percent; Wyoming, 34.7 percent; Texas, 5.3 percent; Colorado, 3.3 percent; Utah, 3.1 percent; and others, 3.4 percent.

According to the AEC, potential resources were reduced in both the $8- and $10-per-pound categories, compared with 1970, as shown in the following tabulation:

Year (at yearend)	Value (per pound U_3O_8)	Resources (thousand tons U_3O_8)	Potential (thousand tons U_3O_8)
1970	$8	246	490
	10	300	680
1971	8	273	460
	10	333	650

Reduction in exploratory drilling during the year was considered a significant factor in the lower estimates of potential resources.

DOMESTIC PRODUCTION

Mine.—Mine output in terms of ore grade and U_3O_8 content increased slightly in 1971, although there was a slight reduction in tonnage of ore received at the uranium mills. Recoverable U_3O_8 mine production, by State, was distributed as follows: New Mexico, 43 percent; Wyoming, 28 percent; Colorado, 10 percent; Utah, 6 percent; other States (Alaska, South Dakota, Washington, and Texas), 13 percent. In addition, 17,000 pounds U_3O_8 were recoverable from miscellaneous other operations, including mine leach, mine waters, and raffinate.

There were 240 producing properties recorded by the AEC. A total of 193 underground mines accounted for 45.3 percent of the total mine output; 29 open pit mines produced 53.3 percent; and the miscellaneous activities provided the remaining 1.4 percent.

Mill.—Production at 17 operating uranium mills decreased nearly 5 percent in 1971, mainly owing to lagging demand for U_3O_8. Output was at only 80 percent of capacity, which was 15,000 to 16,000 tons U_3O_8 per year. The Utah International, Inc., mill in the Shirley Basin, Wyo., went on stream during the year. Three mills under construction and scheduled for completion in 1972 will increase annual capacity to 19,000 tons U_3O_8. Sixteen milling companies or partnership arrangements, indicated in table 6, controlled more than 80 percent of the domestic uranium reserves.

Early in the year, Continental Oil Co. (CONOCO)-Pioneer Nuclear, Inc., started

[5] U.S. Atomic Energy Commission, Grand Junction Office, Grand Junction, Colo. Statistical Data of the Uranium Industry. Jan. 1, 1972, pp. 37–52.

Table 4.—Uranium mine and mill production, by State

State	Ore receipts at mills						U_3O_8 content (recoverable) [1]			
	1970			1971			1970		1971	
	Quantity (short tons)	Value (thousands)	Average grade (percent)	Quantity (short tons)	Value (thousands)	Average grade (percent)	Quantity (thousand pounds)	Value [e] (thousands)	Quantity (thousand pounds)	Value [e] (thousands)
Colorado	599,277	$11,886	0.25	555,947	$10,858	0.25	2,727	$15,832	2,536	$15,725
New Mexico	2,904,968	44,004	.21	2,462,777	42,739	.23	11,574	69,970	10,567	65,517
Utah	398,094	6,742	.22	412,246	5,588	.19	1,635	10,023	1,445	8,959
Wyoming	1,783,697	23,650	.20	2,050,627	26,858	.18	6,346	38,768	6,986	43,311
Other [2]	684,690	7,258	.16	816,782	12,027	.22	2,400	14,871	2,986	18,517
Total	6,370,726	93,540	.21	6,298,379	98,070	.21	24,682	149,464	24,520	152,029

[e] Estimate.
[1] Does not include uranium recovered by miscellaneous operations (mine leach, mine waters, and raffinate).
[2] Alaska, South Dakota, Texas, and Washington; combined to avoid disclosing individual company confidential data.

Table 5.—U.S. uranium milling companies and plants in 1971

Company	Plant location	Capacity (tons of ore per day)
The Anaconda Co	Bluewater, N. Mex	3,000
Atlas Corp	Moab, Utah	1,500
Continental Oil Co.—Pioneer Nuclear, Inc	Karnes County, Tex	[1] 1,750
Cotter Corp	Canon City, Colo	450
Dawn Mining Co	Ford, Wash	500
Federal Resources Corp.—American Nuclear Corp	Gas Hills, Wyo	950
Humble Oil and Refining Co	Powder River Basin, Wyo	[1] 2,000
Kerr-McGee Corp	Grants, N. Mex	7,000
Mines Development, Inc	Edgemont, S. Dak	650
Petrotomics Co	Shirley Basin, Wyo	1,500
Rio Algom Mines, Ltd	La Sal, Utah	[1] 500
Susquehanna-Western Inc	Falls City, Tex	1,000
Do	Ray Point, Tex	1,000
Union Carbide Corp	Uravan, Colo. }	2,000
Do	Rifle, Colo. }	
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		31,900

[1] Under construction; planned completion in 1972.

Source: U.S. Atomic Energy Commission.

Table 6.—U.S. uranium mill statistics in 1971

(Short tons U_3O_8 unless otherwise specified)

Operating mills ... number	17
Average daily milling rate ... tons of ore	17,100
Mill receipts, content of ore	12,907
Mill feed:	
Content of ore	12,856
Other [1]	212
Total	13,068
Recovery rate ... percent	94
Production	12,273
Shipments	13,574
Stocks:	
Content of ore, Jan. 1, 1971	145
Content of ore, Dec. 31, 1971	196
Concentrate, Jan. 1, 1971	3,401
Concentrate, Dec. 31, 1971	2,100
In process:	
Concentrate, Jan. 1, 1971	419
Concentrate, Dec. 31, 1971	467

[1] Concentrate from leaching operations, mine waters, and refinery residues.

Source: U.S. Atomic Energy Commission.

mill construction 8 miles west of Falls City in Karnes County, Tex. The mill, operated by CONOCO, will produce 1.5 million pounds U_3O_8 per year, starting in 1972.[6]

Humble Oil and Refining Co. contracted with Fluor Utah Engineers and Constructors, Inc., for a mill in the Powder River Basin, near Douglas, Wyo. This mill was scheduled for completion late in 1972 and full production in 1973.

Nuclear Fuel Materials.—*Uranium Hexafluoride.*—Existing capacity for conversion of U_3O_8 to UF_6 was the equivalent of 19,000 tons U (Allied Chemical Corp., Metropolis, Ill., 14,000 tons U, and Kerr-McGee Corp., Sequoyah, Okla., 5,000 tons U). Kerr-McGee Corp. planned to double the capacity at its Sequoyah, Okla., plant.

For the recovery of UF_6 from slightly enriched (to 5 percent U_{235}) uranium scrap generated during the processing and fabrication of nuclear fuels and from spent fuel assemblies, three plants were under construction—at Barnwell, S.C., West Valley, N.Y., and Morris, Ill. (see table 7). Atlantic-Richfield Oil Co. (ARCO) decided to discontinue operations in the nuclear fuels

[6] Engineering and Mining Journal. Conoco and Pioneer Construct Uranium Mill. V. 172, No. 3, March 1971, p. 32.

Table 7.—Principal companies with capacity for processing and fabricating nuclear fuel materials in 1971

Company	Location	UF_6	UO_2	UO_2 pellets	Fuel fabrication					Depleted uranium		Scrap		Spent fuel reprocessing	Enriched U to UF_6
					UO_2	Carbide	Special	U-233	Pu	Metal	Compounds	U	Pu		
Allied Gulf Nuclear Services, Inc	Barnwell, S.C	--	--	--	--	--	--	--	--	--	--	--	--	[1]X	[1]X
Allied Chemical Corp	Metropolis, Ill	X	--	--	--	--	--	--	--	--	--	--	--	--	--
Atomics International Div., North American Rockwell Corp.	Canoga Park, Calif	--	--	--	X	X	X	--	X	X	--	--	[1]X	--	--
The Babcock and Wilcox Co	Lynchburg, Va	--	[1]X	[1]X	X	--	--	--	X	--	--	[1]X	[1]X	--	--
Combustion Engineering, Inc	Windsor, Conn	--	[1]X	X	X	--	--	--	[1]X	--	--	--	--	--	--
General Electric Corp	Morris, Ill	--	--	--	--	--	--	--	--	--	--	--	--	[1]X	[1]X
Do	San Jose and Vallecitos, Calif.	--	--	--	--	--	--	--	X	--	--	X	[1]X	--	--
Do	Wilmington, N.C	--	X	X	X	--	--	--	--	--	--	X	--	--	--
Gulf General Atomic Co	San Diego, Calif	--	--	--	--	X	X	[1]X	--	--	--	X	--	--	--
Gulf United Nuclear Fuel Corp	Elmsford and Pawling, N.Y.	--	--	--	--	X	--	--	X	--	--	--	[1]X	--	--
Do	Hematite, Mo	--	X	X	--	X	--	--	--	--	X	--	--	--	--
Do	New Haven, Conn	--	--	--	X	--	X	--	--	X	--	--	--	--	--
Jersey Nuclear Co	Richland, Wash	--	X	X	X	--	--	--	X	--	--	[1]X	[1]X	--	--
Kerr-McGee Corp	Cimarron, Okla	--	X	X	X	X	X	--	X	X	X	X	X	--	--
Do	Sequoyah, Okla	X	--	--	--	--	--	--	--	--	--	--	--	--	--
NL Industries	Albany, N.Y	--	--	--	--	--	X	--	--	X	--	--	--	--	--
Nuclear Chemicals and Metals Corp	Huntsville, Tenn	--	[1]X	--	--	X	--	--	--	--	X	[1]X	--	--	--
Nuclear Fuel Services, Inc	Erwin, Tenn	--	X	X	X	X	--	X	X	X	X	X	X	--	--
Do	West Valley, N.Y	--	--	--	[1]X	--	--	--	[1]X	--	--	--	--	X	[1]X
Nuclear Materials and Equipment Corp. (NUMEC).[2]	Apollo, Pa	--	X	X	X	X	X	--	--	--	X	X	--	--	X
Do	Leechburg, Pa	--	X	X	X	X	X	X	X	X	--	--	X	--	--
Nuclear Metals Div., Whittaker Corp.	West Concord, Mass	--	--	--	--	--	X	--	--	--	--	--	--	--	--
Tennessee Nuclear Specialties, Inc	Jonesboro, Tenn	--	X	--	--	--	--	--	--	X	--	X	--	--	--
Texas Instruments, Inc	Attleboro, Mass	--	--	--	--	--	X	--	--	--	--	--	--	--	--
United Nuclear Corp	Wood River Junction, R.I.	--	--	--	--	--	--	--	--	--	--	X	--	--	--
Westinghouse Electric Corp	Cheswick, Pa	--	--	X	X	X	--	--	X	--	--	--	X	--	--
Do	Columbia, S.C	--	X	X	X	--	--	--	--	--	--	[1]X	--	--	--

X Indicates capacity shown.
[1] Under construction or planned.
[2] Formerly an Atlantic Richfield Oil Co. subsidiary; facilities acquired by Babcock and Wilcox Co. in November.

Source: U.S. Atomic Energy Commission.

industry, and its Nuclear Materials and Equipment Corp. (NUMEC) was taken over by Babcock and Wilcox Co. (B&W) late in the year. Plans for a plant at Leeds, S.C., for conversion of slightly enriched uranium to UF_6 were cancelled. The only domestic facility for conversion of highly enriched uranium (over 5 percent U_{235}) was the NUMEC plant at Apollo, Pa.

According to the AEC, 76 percent of the UF_6 fed for enrichment in fiscal 1971 was from domestic sources and 24 percent was from foreign sources.

Enriched Uranium.—Production of enriched uranium reached 7.8 million Separative Work Units (SWU),[7] more than 25 percent over the 1970 rate. Revenues from enrichment services contracts totaled $217 million. At yearend, 37 domestic and 34 foreign service contracts involving 150 SWU were in effect, and 16 contracts were completed. At $32 per SWU, contracts in force were valued at $4.8 billion.[8]

Increased power availability permitted the expansion of enrichment services. A Cascade Uprating Program (CUP) will increase power in several stages to 6,100 megawatts in 1978. The AEC's three gaseous diffusion plants—at Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio— were operated at only partial capacity, owing to available service contracts and power needs elsewhere. Total annual capacity was 17.2 million SWU. CUP and a Cascade Improvement Program (CIP), which involves modifications and improvements to equipment, will expand annual capacity to 26.5 million SWU at an estimated cost of $995 million. An addition to plant facilities was underway at Oak Ridge. With planned CIP and CUP, the AEC estimated that new enrichment capacity would be necessary in fiscal year 1982, considering the new power levels and accumulated inventories of enriched uranium.

Production also will be augmented by a plan, announced in May, to increase the tails assay from 0.2 percent U_{235} to 0.3 percent U_{235}, effective July 1, 1971. This would increase production by about 25 percent at a given level of plant operation.

Plutonium.—Fissile plutonium (Pu) was becoming available in increasing quantities. The recovery rate was about 900 pounds in 1971 and was expected to expand fairly rapidly thereafter. Strong interest continued in Pu recycling. The first Pu recycle contract for replacement fuels was awarded to Westinghouse Electric Corp. by the Tennessee Valley Authority in 1970; since then, most fuels contracts contained provisions for Pu recycle. Production will be determined by the economics of recycling compared with oxide fuel fabricating costs.

Table 8.—Projected domestic plutonium supply from nuclear fuels [1]
(Pounds)

Year	Fissile plutonium recoverable per year
1971	900
1972	1,100
1973	2,000
1974	4,600
1975	8,800
1980	34,400
1985	81,800

[1] Without plutonium recycle.

Source: U.S. Atomic Energy Commission.

AEC research in Pu recycle was phased out, but a number of projects were sponsored by private industry.

In January, Nuclear Fuel Services, Inc. (NFS), contracted to provide four mixed oxide fuel assemblies for demonstration reactors in this country and two for a test reactor in Norway.

Fabrication.—The fabrication of uranium in nuclear fuel assemblies involved more than 2 million pounds U in 1971 and was expected to surpass 30 million pounds by 1990. Substantial progress was made toward development of private facilities for nuclear fuels manufacturing. Jersey Nuclear Co., a subsidiary of Standard Oil Co. (New Jersey), completed facilities for the design and fabrication of boiling water reactor (BWR) and pressurized water reactor (PWR) cores. Gulf General Atomic Co. (GGA) joined with United Nuclear Corp. (UNC) to form Gulf United Nuclear Fuels Corp. (GGA 57 percent, UNC 43 percent), headquartered at Elmsford, N.Y. UNC provided personnel and its facilities in New York, Connecticut, and Missouri. In June, NFS started construction of an Engineering Test Facility, adjacent to its Engineering Center, Rockville, Md. NFS planned to start construction of fuel fabrication facilities at West Valley, N.Y., in

[7] Measure of work expended in separating a quantity of uranium (in kilograms or metric tons) at a given assay into two fractions—one enriched in U_{235} to a specified grade and the other deficient in U_{235} to a specified tailings grade.

[8] P. 124 of work cited in footnote 3.

1972. This plant will provide UO_2 and mixed oxide (UO_2-PuO_2) fuels. Texas Instruments, Inc., fabricated highly specialized fuels for the high-flux isotope reactor, and the Nuclear Metals Division, Whittaker Corp., provided similar fuels for the CP–5 Argonne research reactor.

NUMEC came under B&W ownership when ARCO decided to discontinue its interests in the nuclear industry. B&W may discontinue the fabrication of complete UO_2 fuel assemblies at its NUMEC operations because this service is performed at its Lynchburg, Va., plant. B&W proceeded with plans to construct a UO_2 fuels plant based on a process licensed from Nuclear-Chemie und Metallurgie G.m.b.H. (NUKEM), West Germany, which uses ammonium uranyl carbonate to produce high-quality UO_2.

Both Atomics International and NL Industries discontinued fabrication of uranium-aluminum metallic fuels but maintained facilities for special uranium alloy fuels, prepared by melt-and-cast techniques. Gulf United remained as the only commercial fabricator of uranium-aluminum type fuels.

Reprocessing.—AEC continued reprocessing spent fuels for recovery of U, Pu, and neptunium (Np) at Savannah River, S. C., Richland, Wash. and the National Reactor Testing Station (NRTS), Idaho. The AEC planned to phase out its Purex facility at Richland, Wash., and invited industry interest in conducting feasibility studies on commercial application of this process as part of its policy of encouraging private reprocessing capability.

The nuclear fuels reprocessing industry was expected to expand rapidly during the remainder of the decade. Private capacity was 1 ton U (contained in spent fuel) per day at the NFS plant in West Valley, N.Y., the only operating commercial reprocessing plant. This plant was under expansion to 3 tons U per day from multiple fuels. Other companies had reprocessing plants under construction—General Electric Co. at Morris, Ill. (1 ton per day of low-enrichment UO_2), completed late in the year; Allied Gulf at Barnwell, S.C. (5 tons per day of low-enrichment UO_2 and mixed UO_2-PuO_2 fuels), scheduled for completion in 1974.

Table 9.—Projected annual domestic requirements for spent fuels reprocessing [1]

(Short tons uranium)

Year	Requirements		
	Committed	Uncommitted	Total
1971	44	11	55
1972	132	33	165
1973	230	130	360
1974	680	390	1,070
1975	1,060	500	1,560
1980	1,280	1,820	3,100

[1] Estimate based on 110 commercial-size light water reactors.

Source: U.S. Atomic Energy Commission.

The scheduled ARCO plant at Leeds, S.C., was cancelled.

Scrap uranium from the fabrication plants also was recovered under AEC's Scrap Recovery Program and by private industry. In fiscal year 1971, seven contracts involving 3,395 pounds U, were awarded to industry (NUMEC, 1; NRS, 3; Gulf United, 3). An effort was underway to reprocess a backlog AEC scrap inventory.

Waste Management.—A number of companies have been licensed for the collection, packaging, transportation, and storage of radioactive materials, including wastes. Three companies stored low-level radioactive commercial wastes at the following six-locations: Nuclear Engineering Co. at Richland, Wash., Beatty, Nev., Sheffield, Ill., and Morehead, Ky.; NFS at West Valley, N.Y.; and Chemical-Nuclear Services, Inc., at Barnwell, S.C. Waste materials were accumulated at a rate in excess of 1 million cubic feet per year from commercial operations and 1.5 million to 2.0 million cubic feet per year from AEC operations. The commercial rate was expected to double by 1975 and quadruple by 1980.[9] High-level wastes were stored at reprocessing plant locations. The industry was expected to annually generate as much as 10,000 cubic feet of the high-level wastes by 1980 and more than 30,000 cubic feet by 1990. AEC projections for radioactive waste accumulations were revised downward because of delays in reactor development and improved technology in waste management.

[9] U.S. Atomic Energy Commission, Division of Industrial Participation. The Nuclear Industry—1971. WASH 1174–71, pp. 153–162.

CONSUMPTION AND USES

Demand for uranium in the nuclear power industry was at a slightly accelerated pace compared with that of 1970. According to an AEC nuclear fuel supply survey of utility companies, reactor manufacturers, and U_3O_8 producers, 12,800 tons U_3O_8 was committed or on order (9,300 tons U_3O_8 in 1970); actual requirements for first core fueling and reloads were 6,900 tons U_3O_8.[10] All U_3O_8 deliveries were to commercial buyers for the first time; the AEC terminated U_3O_8 purchases, effective yearend 1970, although remaining small quantities from 1970 contracts were delivered in early 1971. During its uranium concentrate purchasing program, which started in 1947 the AEC acquired 173,660 tons U_3O_8, valued at nearly $3 billion, at an average price of $8.52 per pound U_3O_8.[11]

Table 10.—Projected domestic commercial uranium delivery commitments

(Short tons U_3O_8)

Year	Commitments [1] Annual	Cumulative
1971	12,800	[2] 12,800
1972	11,700	24,500
1973	12,400	36,900
1974	13,100	50,000
1975	13,500	63,500
1976	5,700	69,200
1977	4,800	74,000
1978	4,900	78,900
1979	4,100	83,000
1980	2,900	85,900

[1] In the post-1980 period, through 1992, an additional 8,800 tons have been committed. In addition, 6,300 tons have been committed to foreign buyers, of which 1,600 tons were scheduled for delivery post-1971.
[2] Pre-1971 deliveries were 19,400 tons.

Source: U.S. Atomic Energy Commission.

Table 12.—Atomic Energy Commission domestic uranium purchases [1]

Year	Tons U_3O_8	Value (thousands)
1947	67	$966
1948	102	1,531
1949	177	3,106
1950	459	9,882
1951	766	15,788
1952	874	20,719
1953	1,163	28,559
1954	1,700	42,271
1955	2,784	66,485
1956	5,958	132,294
1957	8,482	166,506
1958	12,437	233,605
1959	16,239	287,763
1960	17,637	304,717
1961	17,348	289,777
1962	17,008	268,005
1963	14,217	225,221
1964	11,846	189,563
1965	10,442	167,069
1966	9,488	151,773
1967	8,425	134,785
1968	7,337	117,317
1969	6,184	72,458
1970	2,520	28,035
Total	173,660	2,958,195

[1] The AEC's uranium purchasing program terminated at yearend 1970.

Source: U.S. Atomic Energy Commission.

As of yearend 1971, past deliveries and forward commitments totaled 114,000 tons U_3O_8, and forward commitments (after deliveries and reductions in agreements) were 81,900 tons U_3O_8, 7,500 tons less than yearend 1970. About 62 percent of cumulative deliveries plus commitments was to utility companies; the remaining 38 percent

[10] U.S. Atomic Energy Commission, Division of Production and Materials Management, Supply Evaluation Branch. Nuclear Industry Fuel Supply Survey. WASH-1196. April 1972, 12 pp.
[11] Page 8 of work cited in footnote 5.

Table 11.—Projected domestic U_3O_8 and enriched uranium requirements, at various tails assays

(Short tons)

Year	Requirements: 0.20 percent U_3O_8	0.20 percent Equivalent SWU [1]	0.25 percent U_3O_8	0.25 percent Equivalent SWU [1]	0.30 percent U_3O_8	0.30 percent Equivalent SWU [1]
1972	9,000	4,740	XX	XX	XX	XX
1973	9,400	5,730	XX	XX	XX	XX
1974	11,800	5,950	12,900	5,290	14,300	4,740
1975	16,900	9,480	18,500	8,380	20,500	7,600
1980	34,500	22,200	37,800	19,600	41,800	17,600
1985	63,200	42,100	69,200	37,400	76,800	33,500

XX Not applicable.
[1] Separative Work Units; quoted in kilograms or metric tons but converted to equivalent short tons for comparative purposes.

Source: U.S. Atomic Energy Commission.

was to reactor manufacturers. Reduced demand in the near term, compared with 1970 projections, reflected the continuing delays in nuclear power development.

Contracts were in effect for U_3O_8 delivery as late as 1992. Peak commitments are for 1975, followed by a sharp drop in 1976. Table 13, which gives projected fuel supply arrangements in first-core fuels and reloads, indicates the relatively short-term uranium-procurement policy prevalent in the nuclear industry.

Orders for UF_6 by utility and reactor companies was the equivalent of 10,000 tons U in 1971, including 2,000 tons in foreign orders. This rate, little changed from 1970, does not include UF_6 derived from the reprocessing of scrap and irradiated fuels. There was little demand for this service in 1971, although industry planned to develop this capability for future UF_6 recovery.

Table 13.—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	42	43	37	31	25	18	11	6	5	4	4	3	3	3	2	1
Reactor manufacturers	34	23	23	20	14	10	6	4	3	3	1	--	--	--	--	--
Total	76	66	60	51	39	28	17	10	8	7	5	3	3	3	2	1

[1] As of yearend 1971. Includes reactors operating, under construction, and scheduled, totaling 105,600 megawatts. Does not include leases from AEC, which are small, comprising less than 0.5 percent 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.

Enriched uranium shipped from AEC's three gaseous diffusion plants to domestic commercial and foreign buyers was more than 3.5 million pounds, or 6.9 million kilograms SWU, in fiscal 1971, 74 percent above the fiscal 1970 rate.[12] Requirements exceeded capacity during the year, and supplies were drawn from inventories. The AEC projected a cumulative demand for enriched uranium valued at $8.3 billion for the domestic market and $5.8 billion for the foreign market in 1985. Foreign shipments as enriched UF_6 or as processed and fabricated fuels were 1,318,916 pounds, compared with 833,002 pounds in fiscal 1970. The fast growth in demand for enriched uranium was expected to continue as nuclear powerplants proliferate in the United States and abroad.

Substantial quantities of plutonium will be needed for research and development, particularly in fuel assemblies for experimental and demonstration breeder reactors.

According to the AEC, 25 power reactors (11,410 megawatts) were operative, as of the end of 1971, including those at the AEC's Shippingport Atomic Power Station and the "N" reactor at the Hanford facilities, Richland, Wash., both of which are not licensed; 52 units were under construction or in the review process for operating license; 39 units were in review for construction permits; and construction applications were pending for 14 units. The total was 130 units and 108,600 megawatts. A total of 21 new units (20,810 megawatts) was ordered by utility companies from reactor suppliers; two were licensed for full power; four were licensed for fuel loading and/or low-power testing; four construction permits were granted (of eight requested); and 11 companies filed applications to operate 15 plants. The AEC's latest projection of domestic nuclear power capacity, based on specific criteria as to reactor types, load

Table 14.—Enriched uranium supplied to industry
(Pounds uranium)

Year [1]	UF_6	Other forms	Total
1960	190,038	7,496	197,534
1965	336,835	3,177	340,012
1966	630,021	11	630,032
1967	374,748	212	374,960
1968	854,030	139	854,169
1969	1,536,208	--	1,536,208
1970	2,035,016	500	2,035,516
1971	3,547,269	258	3,547,527

[1] Fiscal year ending June 30.

Source: U.S. Atomic Energy Commission.

[12] Page 27 of work cited in footnote 9.

factors, and fuel cycle parameters, indicated a probable capacity of 54,520 megawatts in 1975 and 139,000 megawatts in 1980.[13]

In addition to commercial power, nuclear fuels were used in the AEC's research breeder reactor program; various military applications, including a nuclear-powered fleet and weapons research, development, and maintenance; the Plowshare program; space nuclear systems; and isotopic systems development.[14]

Table 15.—Projected domestic nuclear power capacity

Year [1]	Estimated cumulative capacity (megawatts)		
	Low	High	Most likely
1971	--	--	7,000
1972	9,200	15,700	12,200
1973	19,000	31,700	24,100
1974	32,800	50,200	42,200
1975	46,800	61,400	54,500
1980	121,400	151,900	139,000
1985	254,200	321,400	286,400

[1] Fiscal year ending June 30.

Source: U.S. Atomic Energy Commission.

Increasing quantities of depleted uranium were used by industry, although large supplies continued to accumulate as demand for enriched uranium expanded. Domestic consumption of depleted uranium for nonenergy uses was estimated as follows:[15] ballast and counterweights, 200 tons; catalytic, 100 to 150 tons; radiation shielding materials, 100 tons; and ordnance and miscellaneous uses, 10 to 20 tons. On a worldwide basis, catalytic uses have apparently been the largest.

STOCKS

In October, the AEC announced the terms of a proposed plan for disposal of its stockpile, estimated at 50,000 tons U_3O_8 in concentrates, to domestic and foreign customers. Public comment was requested. According to the plan, deliveries would begin in 1974 and would not exceed, in any one year, one-half of the projected cumulative growth in domestic requirements from 1973 to and including that year nor would they exceed one-fourth of total domestic requirements in any such year. Maximum delivery in any one year was limited to 7,500 tons U_3O_8. Quantities offered for sale during 1974 and 1975 would be reduced, but subsequent sales would be at an increasing rate related to projected growth in uranium demand. The AEC reserved the right to revise the disposal rate, consistent with maintained viability in the domestic uranium industry.[16]

According to the Atomic Industrial Forum, 38 companies and individuals had responded, unanimously critical of the AEC plan, by the yearend deadline.[17] The general opinion was that disposal, as proposed, would hurt the industry and discourage exploration, which already was in decline. Recommendations to the AEC included the conversion of surplus stocks to low-enriched uranium to be held in reserve for future needs and an AEC option to substitute stockpile supply for a percentage of delivery by producers.

At the beginning of the year, the AEC reported private U_3O_8 concentrate inventories as follows, in tons of U_3O_8:

	1971	1972
In ore at mills	145	196
In process at mills	419	467
Inventory at mills	3,401	2,100
Inventory held by utility companies and reactor manufacturers	7,400	7,200
Total	11,365	9,963

In addition, the utilities and reactor companies held inventories of UF_6 and enriched uranium.

Stocks of depleted uranium were estimated at 190,000 tons. By 1980, the annual rate of accession to stockpile was estimated at 45,000 tons, and the stockpile would total 440,000 tons.[18]

[13] U.S. Atomic Energy Commission, Office of Planning and Analysis. The Growth of Nuclear Power, 1972–85. WASH–1139 (Rev. 1), December 1971, 18 pp.

[14] Pages 91–120 and 139–155 of work cited in footnote 3.

[15] National Materials Advisory Board, National Academy of Engineering. Trend in the Use of Depleted Uranium. June 1971, 172 pp.

[16] U.S. Atomic Energy Commission. Disposal of Surplus Uranium. News Release, v. 2, No. 42, week ending Oct. 20, 1971, p. 1.

[17] Atomic Industrial Forum. Comments on AEC Stockpile Disposal Plan. Nuclear Industry, v. 18, No. 12, December 1971, pp. 47–49.

[18] Page 1 of work cited in footnote 15.

PRICES AND SPECIFICATIONS

Domestic and world U_3O_8 prices remained low, owing to the prevailing excessive supplies relative to demand. The average domestic price was generally in the \$6.00-to-\$6.50-per-pound U_3O_8 range; foreign prices, quoted occasionally, were apparently on the order of \$5 to \$6 per pound U_3O_8. Spot sales were probably \$4 to \$5 per pound U_3O_8. Quotations for future sales were \$5.50 to \$6.50 per pound in 1975 and \$7.50 per pound in 1979. The following European Atomic Energy Community (Euratom) Supply Agency contracts for U_3O_8 delivery, per pound, indicate the downward price trend:

	Scheduled delivery (dollars)		
	1971	1972	1973
1967–68	6.56–7.37	6.80–7.80	7.05–8.25
1969–70	6.33	6.40–7.35	6.85–7.50
April–June, 1971	5–5.23	5.20–5.60	5.40–6.40

The Allied Chemical Corp. base charge for conversion of U_3O_8 to UF_6, as escalated to March 1971, was near \$1.25 per pound U. Kerr-McGee Corp. charged a similar, competitive rate, although its quoted price appeared higher because it included U_3O_8 sampling and UF_6 shipping charges. The AEC charge for conversion of highly enriched uranium to UF_6 was increased from \$32 to \$100 per kilogram U. Conversion of slightly enriched uranium to UF_6 remained at \$5.60 per kilogram U.

The AEC price for uranium enrichment services was scheduled to increase from \$28.70 to \$32 per SWU, effective September 6, 1971. The increase was not applied, however, until November 14, 1971, because of the economic controls program (Executive Order 11615), which froze prices during August 15 to November 14, 1971.

The prevailing price for Pu was \$10 per gram (\$4,500 per pound). The AEC-guaranteed price for Pu, derived from uranium leased from the AEC, was terminated at yearend 1970. The AEC estimated that fabrication costs for mixed oxide (PuO_2-UO_2) fuels from recycling would be 20 to 60 percent higher than regular UO_2 fuel fabrication but with anticipated larger recycling capacities of the future the cost differential would probably be reduced to less than 20 percent. The AEC estimated the cost for mixed oxide fuel pins for the fast reactor at \$6,000 to \$8,000 per kilogram contained Pu during the next few years.

Depleted uranium ingot prices were based on custom orders; there were no firm, established prices. The product was custom produced and delivered in semifabricated or finished forms. An engineering-financial study of estimated costs for producing depleted uranium ingot indicated a price of \$1.24 to \$2.67 per pound U under specified operating plant criteria. The relatively high cost limits the use to specialized applications.

The specified price for AEC-owned depleted uranium tails was \$2.50 per kilogram U (\$1.13 per pound U) plus withdrawing and packaging charges. Privately owned tails, where the company paying for the enrichment service has an option to reclaim the tails or relinquish them to the AEC, were available in quantity at prices below the AEC price. With a limited market and no advantage in shipping and storing, the owners may sell the tails at reduced prices rather than relinquish them to the AEC at no credit.[19]

FOREIGN TRADE

Exports of various uranium and nuclear materials continued to expand, surpassing the record high levels of 1970. Increases were pronounced in all sectors, except stable isotopes, which showed the only decline from the previous year. Exports of AEC-produced nuclear materials, including enriched uranium, uranium-233, plutonium, and heavy water, increased substantially, indicating a continuing high level of demand for fuel materials for U.S. reactors in foreign countries.

About 942 tons of U_3O_8 were imported from the Republic of South Africa, Canada, France, and the United Kingdom for enrichment and reexport of the enriched product. Pursuant to provisions of the Atomic Energy Act of 1954, as amended, foreign uranium cannot be enriched in the United States for domestic consumption.

[19] Pages 24–27 of work cited in footnote 15.

Table 16.—Foreign trade in uranium, uranium-bearing materials, and other nuclear materials, by principal country

Product	1970 Quantity	1970 Value	1971 Quantity	1971 Value	Principal sources and destinations, 1971
EXPORTS					
Uranium:					
Ores and concentrate, U_3O_8 content ---- pounds--	40,828	$286,711	89,285	$751,375	Canada 89,065; Argentina 220.
Compounds ---- do----	4,045,549	24,579,293	6,021,148	38,498,069	Canada 3,355,381; United Kingdom 1,951,471; Netherlands 366,323; West Germany 108,293; Japan 88,217; France 86,045.
Metal including alloys [1] --do----	5,503	86,021	65,592	827,744	Canada 59,495; Italy 3,427.
Isotopes (stable) and their compounds ----	NA	34,689,780	NA	28,561,798	Canada $17,010,838; West Germany $10,839,765; Japan $184,487; United Kingdom $161,008.
Radioactive materials: Radioisotopes, elements, and compounds [2] thousand curies--	8,105,520	4,847,247	23,119,895	6,719,185	Republic of South Africa 6,540,020; Canada 3,429,734; Indonesia 3,400,000; West Germany 2,221,092; Japan 1,834,501.
Special nuclear materials [3] ----	NA	79,920,628	NA	160,332,329	West Germany $75,244,883; Japan $47,975,720; Switzerland $20,190,487; France $10,280,262.
IMPORTS					
Uranium:					
Oxide (U_3O_8) ---- pounds--	1,329,367	7,789,367	1,883,358	11,759,589	Republic of South Africa 1,077,484; Canada 484,627; France 168,201; United Kingdom 153,039.
Other compounds ---- do----	2,681,301	20,459,856	7,966,452	55,304,176	Canada 4,223,424; United Kingdom 2,357,933; France 1,384,800.
Isotopes (stable) and their compounds ----	NA	428,375	NA	436,244	Canada $250,028; United Kingdom $80,604; France $22,290; Israel $32,414.
Radioactive materials: Radioisotopes, elements, and compounds [2] thousand curies--	7,769,906	3,471,441	6,142,747	5,670,975	Canada 3,855,193; United Kingdom 376,466; France 304,175; West Germany 168,565 Sweden 136,263.

NA Not available.
[1] Includes thorium.
[2] Includes carbon-14 and cobalt-60.
[3] Includes plutonium, uranium-233, uranium-235, and enriched uranium.

Table 17.—U.S. exports of AEC-produced nuclear materials, by country of destination [1]
(Pounds)

Country [2]	Enriched uranium: Less than 20 percent U-235	Enriched uranium: Greater than 20 percent U-235	Uranium 233	Plutonium
Argentina	(3)	122	--	--
Australia	(3)	119	0.19	14.15
Austria	(3)	44	(3)	.36
Brazil	--	61	(3)	.18
Canada	1,115	1,520	--	12.94
Colombia	--	5	--	.18
Congo, Democratic Republic of	(3)	6	--	--
Denmark	11	113	(3)	.18
Euratom [4]	71,431	13,257	23.16	1,369.82
Finland	(3)	11	--	--
Greece	--	14	--	.25
International Atomic Energy Agency (IAEA)	--	6	--	(3)
India	4,111	--	--	--
Indonesia	--	5	--	--
Iran	--	11	--	.25
Israel	(3)	48	(3)	1.34
Japan	23,272	1,571	.04	245.06
Korea, Republic of (South)	--	14	--	.02
Mexico	--	9	--	.53
Norway	155	4	--	2.33
Pakistan	--	25	--	.25
Philippines	--	9	--	.07
Portugal	--	13	--	--
South Africa, Republic of	--	73	--	.35
Spain	4,981	87	--	.01
Sweden	4,890	409	(3)	17.73
Switzerland	10,556	41	.04	3.27
Taiwan	--	19	--	.21
Thailand	--	11	--	.18
Turkey	2	11	--	.63
United Kingdom	1,245	2,844	1.13	2.17
Venezuela	--	11	--	.02
Vietnam, South	--	6	--	.18
Yugoslavia	--	6	--	(3)
Other	3	50	.05	.95
Total	121,772	20,555	24.61	1,673.61

[1] Cumulative to June 30, 1972.
[2] Initial destination; may not be country of final destination.
[3] Minute quantities.
[4] Includes Belgium, France, West Germany, Italy, Luxembourg, and the Netherlands.

Source: U.S. Atomic Energy Commission, Division of International Programs.

WORLD REVIEW

The United States, Canada, and the Republic of South Africa held the principal uranium resources and continued as the principal world (non-Communist) producers of uranium, although output was at only partial capacity because of the soft world market. Important new mines were under development, particularly in Australia, Canada, Niger, and the Territory of South-West Africa, in anticipation of renewed demand in the near future. Reserves were increased as a result of new assessments in the United States, Australia, and South-West Africa.

Plans for ambitious nuclear power development programs were announced in several of the leading industrialized nations. In addition, initial nuclear power plants were under consideration or under construction among the less-developed nations. During 1971, 19 full-scale commercial nuclear power installations (12 PWR's, 7 BWR's) were ordered.[20] However, the actual status was uncertain because of indefinite data, particularly for Japan. Also, the rated capacities were not definitely established, owing to a lack of agreement between reactor manufacturers, utility companies, and Government agencies.

In Latin America, the first nuclear powerplant was under construction and a second

[20] Atomic Industrial Forum. 1972 Nuclear Plant Orders Look Good Worldwide. Nuclear Industry, v. 19, No. 1, January 1972, pp. 6–9.

Table 18.—Uranium oxide (U_3O_8): Production, by country

(Short tons)

Country [1]	1969	1970	1971 [p]
Argentina	54	50	[e] 55
Australia [e]	330	330	300
Canada	3,855	4,104	4,010
France [2]	[r] 1,770	1,744	1,677
Gabon	536	416	601
Niger	--	42	558
Portugal [e]	105	105	105
South Africa, Republic of	3,979	4,119	4,189
Spain [e]	[r] 96	100	100
Sweden [e]	77	80	80
United States [2]	12,281	12,768	12,907
Total	[r] 23,083	23,858	24,582

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Czechoslovakia, Finland, East Germany, West Germany, Hungary, India, Japan, Mozambique, 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] Content of uranium ore produced.

Table 19.—Estimated world uranium reserves and production capacity in 1971 [1]

(Short tons)

Country	Reserves [2]	Annual Capacity	
		Planned 1973–74	Attainable 1975
Argentina	10,000	88	88
Australia	[3] 100,000	1,500	1,500
Brazil	1,000	--	--
Canada	232,000	5,500	13,000
Central African Republic	10,400	780	780
France	45,000	2,300	2,300
Gabon	13,500	780	780
Italy	1,500	120	120
Japan	2,700	40	40
Mexico	1,300	200	200
Niger	26,000	970	1,940
Portugal	9,600	300	300
South Africa, Republic of	[4] 300,000	6,000	6,000
Spain	11,000	550	550
Turkey	2,300	--	--
United States	[5] 273,000	19,000	23,000
Yugoslavia	1,300	--	--
Total	1,040,600	38,128	50,598

[1] Non-Communist world only. Updated with recent revisions on reserves in Australia, South Africa, and the United States.
[2] U_3O_8 at less than $10 per pound.
[3] Interim estimate; reserves continued under development.
[4] Includes estimated 75,000 tons in the Territory of South-West Africa.
[5] Does not include 90,000 tons of byproduct U_3O_8.

Source: European Nuclear Energy Agency and International Atomic Energy Agency.

planned in Argentina; Brazil and Mexico planned their first installations; and Chile and Cuba were considering nuclear power. In Western Europe, Austria, Greece, Ireland, Luxembourg, the Netherlands, and Portugal announced proposed nuclear reactor programs, and Spain was committed to a program involving several plants. Yugoslavia announced bids for a first nuclear plant. In the Near East, Turkey, Israel, and Kuwait considered nuclear power, the latter in connection with a water desalination program. In the Far East, Taiwan, the Republic of Korea, and Pakistan had already started construction on their first plants; India planned several more plants; and the Philippines and Thailand announced intentions for their first plants. Among the Communist bloc nations, Poland, Czechoslovakia, Bulgaria, Hungary, East Germany, and Romania planned nuclear power development with U.S.S.R. equipment and technical assistance. Because of these programs for nuclear power among both the industrialized and the less-developed nations, projected demand on a worldwide

Table 20.—Orders for nuclear powerplants in foreign countries during 1971

Country	Planned location	Type [1]	Capacity (megawatts, electric)
Austria	Zwentendorf	BWR	700
Brazil	Angra dos Reis	PWR	600
Finland	Loviisa 2	PWR	440
France	Fessenheim 2	PWR	900
Do	Bugey 2 and 3	PWR	930 (each)
Germany, West	Biblis 2	PWR	1,300
Do	Esensham	PWR	1,300
Do	Ohu	BWR	900
Do	Phillipsburg 2	BWR	860
Do	Neckarwestheim	PWR	775
Japan [2]	Tokai 2	BWR	1,100
Do	Fukushima 5	BWR	784
Do	Fukushima 6	BWR	1,100
Spain	Almaraz 1 and 2	PWR	900 (each)
Do	Lemoniz 1	PWR	900
Sweden	Ringhals 2	PWR	900
Do	Forsmark 1	BWR	900

[1] BWR—Boiling Water Reactor, and PWR—Pressurized Water Reactor.
[2] Conservative estimate; status of five additional plants is uncertain.

Source: Atomic Industrial Forum.

basis was expected to expand rapidly during the remainder of this decade.

An International Atomic Energy Agency (IAEA) study indicated the disparity between projected nuclear capacity in 21 industrialized nations and 74 developing nations.[21] As projected to 1985, nearly 90 percent of world nuclear power development (excluding the People's Republic of China) would be among the industrialized nations and about 21 percent of world electrical generating capacity would be nuclear.

The major industrialized nations also sought means of developing uranium-enrichment capacities and assuring future supplies of enriched uranium. International interest was growing as a result of two AEC toll enrichment price increases in 1971. Western Europe considered alternate sources of supply from the U.S.S.R. France planned a gaseous diffusion enrichment plant with or without European partners. A Canadian proposal was for an 8-year, $950 million international project involving gaseous diffusion technology. Progress was made in the United Kingdom-Netherlands-West Germany tripartite organization based on gas-centrifuge technology; operating companies were formed and facilities were under construction. Australia, Canada, and Japan discussed a multinational enrichment venture, based on access to U.S. gaseous diffusion technology. France also negotiated with Japan for uranium enrichment in the Far East.

The AEC announced multilateral discussions with a number of countries interested in U.S. gaseous diffusion technology under appropriate financial and security arrangements.[22] Future demand for enriched uranium, cost data, and safeguards against diversion of enriched uranium to military use were considered. A Euratom study projected non-Communist world production of and demand for enriched uranium to 1985. According to the 1971 activity report of the Euratom Supply Agency, the AEC supplied the Euratom nations with 237 tons of enriched uranium in 1971. At yearend, Euratom had 206.037 tons of U_{235} from rentals, purchases, and enrichment on order. During 1971, Euratom had 12 long-term contracts (to 1990 or 1995), totaling $529

Table 21.—Projected foreign nuclear power capacity [1]

Year [2]	Estimated cumulative capacity (megawatts)
1972	14,100
1973	17,500
1974	21,000
1975	28,900
1980	112,500
1985	259,900

[1] Non-Communist countries only.
[2] Fiscal year data.

Source: U.S. Atomic Energy Commission.

[21] International Atomic Energy Agency, Division of Nuclear Power and Reactors, Economic Studies Section. Potential Demand for Nuclear Power in Developing Countries. No. NPR/71-5-1, 1971, 7 pp. and 5 tables.

[22] American Nuclear Society. Enrichment Talks Open with Other Countries. Nuclear News. V. 14, No. 9, September 1971, p. 41.

million, with the AEC for enrichment services.

In addition to the U_3O_8 and enriched uranium supply, international interest was also growing in nuclear fuel and reactor sales. Five European companies—British Nuclear Fuels Ltd. (United Kingdom), Kraftwerk Union A.G. and Interatom G.m.b.H (both of West Germany), Belgo-nucleaire S.A. (Belgium), and Agip Nucleare S.p.A. (Italy)—discussed a joint nuclear power marketing and manufacturing venture in which they would design, develop, and market nuclear fuels and reactors, specializing in the advanced reactors.

The Fourth United Nations International Conference on the Peaceful Uses of Atomic Energy met in Geneva, Switzerland, in September. There were 4,000 representatives from 79 countries, and 514 papers were presented by representatives from 50 countries. U.S. participants presented 60 papers. Papers were not only scientific and technical; they also covered social and economic problems in nuclear development. An estimated 150,000 megawatts of nuclear capacity were in operation, under construction, or on order throughout the world.

Angola.—Urangesellschaft m.b.H., West Germany, was exploring for uranium in the Dondo and Malange areas and the Moxico district, near the Zaire border, under a joint-venture project with Junta de Energia Nuclear, Portugal. Mozambique also was included in the agreement.

Argentina.—The Comissíon Nacional de Energía Atómica planned to issue calls for tenders for development of uranium deposits at Huemul and Arroyo Seco, Mendoza Province. According to the Ministerio de Industrio, uranium ore production in Mendoza and Salta Provinces was 35,730 tons in 1970, compared with 39,414 tons in 1969. Average grade was about 1 pound U_3O_8 per ton.

Australia.—Exploration continued in the Alligator River district, Northern Territory, where ore reserves were increasing and new

Table 22.—Projected nuclear power capacities in industrialized and developing nations [1]

(Thousand megawatts)

	Electric generating capacity					
	1975		1980		1985	
	Nuclear	Total	Nuclear	Total	Nuclear	Total
Industrialized nations	110	1,336	308	1,890	617	2,672
Developing nations	4	251	30	383	78	562
Total	114	1,587	338	2,273	695	3,234

[1] Does not include People's Republic of China.

Source: International Atomic Energy Agency.

Table 23.—Projected U.S. and world enriched uranium production and demand [1]

(Million kilograms of separative work units)

	1975		1978		1981		1985	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
Production:								
United States	16.7	57.7	24.4	122.3	35.8	217.6	53.8	405.5
Other countries	.8	2.3	2.5	7.6	6.5	22.4	18.7	75.9
Total	17.5	60.0	26.9	129.9	42.3	240.0	72.5	481.4
Requirements:								
United States	11.0	42.0	15.7	83.7	23.4	145.5	38.5	275.2
Western Europe [2]	4.5	12.5	7.7	32.0	13.0	65.3	23.0	141.1
Other countries [3]	2.0	5.5	3.5	14.2	5.9	29.2	11.0	65.1
Total	17.5	60.0	26.9	129.9	42.3	240.0	72.5	481.4

[1] Non-Communist nations only.
[2] Estimated 60 percent in European Communities.
[3] More than 50 percent in Japan.

Source: Commission of the European Communities (Euratom).

companies joined the search for uranium. Early in the year, more than 80 companies were engaged in uranium exploration throughout the country. New reserves were also established in South Australia and in Western Australia, where the first significant uranium discovery was reported late in the year.

In the Northern Territory, reserves of Queensland Mines Ltd. at Nabarlek were reduced to 10,500 tons U_3O_8 from 55,000 tons previously announced, when continued drilling indicated a lack of ore continuity in the mineralized zone. At the Ranger deposit of Peko-Wallsend Ltd. and Electrolytic Zinc Corp., 36 miles southwest of Nabarlek, reserves totaled 78,000 tons U_3O_8 in ore at 0.35 percent U_3O_8.[23] The two partners formed Ranger Uranium Mines Pty. Ltd. as the operating company and Ranger Export Development Co. Pty. Ltd. to promote and develop export markets for uranium.[24] The company planned an operation of 1 million tons of ore and 3,500 tons U_3O_8 per year in 1976.

Noranda Australia Ltd. announced discovery of its Jim Jim deposit, 48 miles southwest of Nabarlek and 12 miles south of Ranger 1. Early drilling indicated a large ore body.

The geology of these deposits in the Northern Territory was briefly described.[25] The Lower Proterozoic Kombolgie sandstone forms a dissected high plateau over Archean schists, in which the uranium deposits occur. The schist series is oxidized to depths of more than 100 feet. Ore minerals in the oxidized zone are gummite, autunite, and sklodowite. The primary ore mineral below the oxidized zone is pitchblende. In exploration, closely spaced drilling was necessary because of the complex geology.

Queensland Mines Ltd. established minimum reserves of 16,000 tons U_3O_8 at Westmoreland, Queensland, near the border with the Northern Territory, and at Valhalla, 28 miles north of Mount Isa.[26] The Mary Kathleen mine of Mary Kathleen Uranium Ltd. (MKU) was scheduled to reopen in mid-1972. MKU contracted for delivery of 3,800 tons U_3O_8—2,700 tons U_3O_8 during 1974–79 in two earlier contracts, and 1,100 tons U_3O_8 during 1977–81 in a later contract with RTZ Mineral Services Ltd.[27]

In the Lake Frome area of South Australia, a combined exploration program by Petromin N.L., Exoil N.L., and Transoil N.L., reportedly established reserves of 12,000 tons U_3O_8 in two ore bodies.

Late in the year, Western Mining Co. announced discovery of uranium in an extensive mineralized area at Yeelirrie, 50 miles southwest of Wilna, in Western Australia. The deposit is near-surface, minable by open pit, and averages about 0.15 percent U_3O_8.

Because of the large established uranium reserves in the country, the Australian Government lifted the ban on uranium exports but maintained control over uranium prices and safeguards on exported uranium. All export contracts must be approved by the Minister for National Development. Limitations also were placed on foreign participation in developing Australian uranium mines. Discussions were underway with foreign nations for multinational uranium enrichment facilities in Australia.

Late in the year, the Government met with the three major potential uranium producers to consider a joint mining and marketing organization in order to avoid competition for available foreign markets. The Government approached consultant firms for an assessment of potential in the Northern Territory.

According to the annual report of the Australian Atomic Energy Commission, demand in Australia was projected at 2,000 to 3,000 tons U_3O_8 in 1990 and 50,000 tons U_3O_8 cumulative to the year 2000. Exports on the order of 20,000 tons per year in 1985 were anticipated at a value of $270 million (1971 prices). Although plans for the country's first nuclear powerplant, at Jervis Bay, New South Wales, were shelved temporarily, nuclear generating capacity of 36,000 megawatts, one-third of total generating capacity from all sources, was projected for the end of the century.

Brazil.—Comissão Nacional de Energia Nuclear (CNEN) produced a small quantity of uranium ore at Agostinho mine, near Poços de Caldas, Minas Gerais. There are no processing facilities, but a small mill

[23] Engineering and Mining Journal. E/MJ Exploration Round-up. V. 172, No. 12, December 1971, pp. 23, 118.
[24] Mining Journal. Bright Uranium Prospects. V. 277, No. 7111, Dec. 3, 1971, p. 508.
[25] Armstrong, C. W. Seeking Uranium in Australia's North. Northern Miner, Toronto, Canada, v. 57, No. 36, Nov. 25, 1971, p. 58.
[26] Engineering and Mining Journal. Uranium Prospects Being Studied in Queensland. V. 172, No. 1, January 1971, p. 32.
[27] Mining Magazine. Uranium Contract. V. 125, No. 6, December 1971, p. 579.

(annual capacity 200 tons U_3O_8) was planned for the area. Exploration has extended reserves to 1,000 tons U_3O_8 contained in the ore, which averages 0.20 percent U_3O_8.

In August, the CNEN announced the establishment of Companhia Brasileira de Tecnologia Nuclear (CBTN), which will operate under the CNEN and will direct uranium mining and milling activities and various phases of nuclear research and development, including construction of the country's first commercial power reactor. CNEN will maintain controlling interest in CBTN by holding at least 51 percent of the voting shares.

Canada.—Three uranium producers—Denison Mines Ltd. and Rio Algom Mines Ltd., both at Elliot Lake in Ontario, and Eldorado Nuclear Ltd. at Uranium City, Saskatchewan—operated at partial capacity because of limited markets. The Dension mine and mill worked at two-thirds capacity; Rio Algom operated two of four mines and one of three mills; and the Eldorado mill was at 50 percent of capacity. Total annual mill capacity was 5,500 tons U_3O_8. Ore reserves at less than $10 per pound U_3O_8 were 232,000 tons U_3O_8, and a similar quantity was considered as potential.[28]

Exploration continued in several provinces, although proposed reductions in foreign ownership of uranium reserves tended to lower exploration levels.[29] Operations were suspended at the Agnew Lake property of Agnew Lake Mines Ltd., west of Sudbury, Ontario, because of depressed uranium prices. Established reserves were 7.75 million tons at 1.8 pounds U_3O_8 per ton.[30]

Construction started on the mine-mill complex of Gulf Minerals Canada Ltd. and Uranerz Canada Ltd. at Wollaston Lake, northern Saskatchewan, late in the year. Completion was scheduled for 1974.

Denison Mines concluded a second agreement with Uranium Canada Ltd., a Government agency, for stockpiling uranium in order to keep the mine in operation until 1974, when private sales contracts are scheduled for uranium delivery. A total of nearly 6.5 million pounds U_3O_8 will be stockpiled during 1971–74 at a rate of $6 per pound. Denison would provide for 25 percent of the stockpiling costs, and the Government the remainder.[31] The annual production rate was 1.35 million tons of millfeed and 4 million pounds U_3O_8. The company planned to gradually expand its output rate to 2.4 million tons of ore and 5 to 6 million pounds U_3O_8 by 1977. According to company officials, reserves at Elliot Lake were 150,000 tons U_3O_8.[32]

Eldorado Nuclear Ltd. completed the first phase of an expansion program, which provided a 25-percent increase in annual capacity at the Port Hope, Ontario, UF_6 plant. Eventually, the rated capacity will be doubled to 5,000 tons UF_6 per year. The company announced a contract with Commonwealth Edison Co., a U.S. firm, for conversion of 2 million pounds U_3O_8 to UF_6 during 1971–74.

British Newfoundland Co. made recommendations to Government authorities regarding a proposed uranium-enrichment project in Canada. Other companies operating in Canada were interested in participating in the project. Several provinces having possible sites with sufficient hydroelectric potential were considered. Cooperation with Japanese utility companies was sought. Plans were contingent on U.S. sharing of gaseous diffusion technology and financial arrangements for as much as $1 billion.

The first of the Pickering four-unit Canadian Deuterium Uranium (CANDU) nuclear power installations, each of 540 megawatts, located east of Toronto on Lake Ontario, went critical in February and on full power in May. Meanwhile, the second unit reached full power in November. Units 3 and 4 were scheduled for completion in 1972 and 1973, respectively, although delays were possible because of the continuing shortage of heavy water.[33]

The 250-megawatt, prototype Gentilly nuclear power station on the St. Lawrence River, Quebec, was operating at full power late in the year. This plant, owned by

[28] Williams, R. M., H. W. Little, W. A. Gow, and R. M. Berry. Uranium and Thorium in Canada: Resources, Production, and Potential. Mineral Bull. MR 117. Dept. of Energy, Mines, and Resources, Mineral Resources Branch, Ottawa, Canada, 1971, 28 pp.

[29] Nuclear Canada. The Canadian Nuclear Assn., Toronto, Canada, v. 10, No. 5, May 1971, p. 7.

[30] American Nuclear Society. Operations Suspended. Nuclear News. V. 14, No. 2, February 1971, p. 34.

[31] Atomic Industrial Forum. Novel Canadian Stockpiling Agreement. Nuclear Industry. No. 1, January 1971, pp. 49–50.

[32] The Mining Record. Denison Mines Increasing its Uranium Production Rate. V. 82, No. 25, June 23, 1971, p. 1.

[33] AECL Review. Atomic Energy of Canada Ltd., Ottawa, Canada. V. 7, No. 2, February 1972, p. 1.

Atomic Energy of Canada Ltd., is the first with natural uranium fuel and light-water cooling.

Finland.—The Finnish Ministry of Industry and Commerce announced plans to create a Government agency for the coordination of uranium prospecting and exploration in the country. Interest in uranium resources was increased as a result of plans to construct a number of nuclear powerplants during the next 20 years. The State-owned power company, Imatran Voima Oy, contracted with the U.S.S.R. for a second nuclear plant, a 440-megawatt PWR, to be sited adjacent to the plant under construction at Loviisa, near Helsinki.

France.—Société Le Nickel (SLN), which has acquired majority ownership in Peñarroya uranium interests, announced acquisition of Compagnie de Mokta, a uranium-mining company with foreign interests. Through this and other mergers, SLN holds a 49.5-percent interest in Uranex, a uranium sales agency established with the Commissariat à l'Énergie Atomique (CEA).

Uranex took over the UF_4 plant at Malvési and the UF_6 plant at Pierrelatte, which reportedly had a backlog of European and Japanese orders.[34] A new $80 million UF_6 sales contract, involving 5,300 tons during 1974–86, was concluded with Kansai Electric Power Co., Japan.

In February the French nuclear industry proposed a plan for a $600 million gaseous diffusion plant and sought support in other European countries. An agreement was made for U.S.S.R. enrichment of 80 tons U_3O_8 to 3 percent U_{235}. The reported price was $28.70 per SWU. The enriched uranium was for fueling the new 900-megawatt Fessenheim PWR, the first commercial nuclear powerplant using enriched uranium fuel in France.[35]

Electricité de France (EDF), the State utility company, and Rheinsch-Westfalisches Electrizitatswerk A. G., West Germany, began joint venture development of two, 1,000-megawatt, sodium-cooled fast breeder reactors. The first was scheduled for construction in France, starting in 1975, with 70-percent French and 30-percent West German participation.

The CEA also planned a nuclear fuels reprocessing plant to be started in 1972.

According to the Sixth Development Plan (1971–75), 10 new nuclear plants, totaling about 8,000 megawatts, were in the program, as recommended by EDF. As of 1971, there were eight operating plants (1,650 megawatts), and five (3,000 megawatts) were under construction.[36] Late in the year, EDF announced a contract for two new LWR's in the 850-megawatt class to be sited at Bugey, near Lyon.

An Interministerial Council projected 50-percent electricity generation based on nuclear power in 1985.

Gabon.—During 1971, 1,404 tons of a magnesium uranate concentrate, containing 42.8 percent U_3O_8, were produced, compared with 1,187 tons at 35 percent U_3O_8 in 1970.

Germany, West.—A budget of $354 million was approved for nuclear research by the Ministry for Education and Science during 1971.[37] Funds for uranium supply were increased from $34 million in 1970 to $67 million in 1971.

In June the Bundestag ratified the tripartite agreement with United Kingdom and Netherlands companies for gas centrifuge research and development. Gesellschaft für Centrifugentechnik m.b.H (CENTEC) was established at Bensberg, jointly owned by British Nuclear Fuels, Ltd., through Urenco, Ltd., Ultra-Centrifuge Nederland N.V., and Gesellschaft für Nukleare Verfahrenstechnik m.b.H. West Germany will contribute $170 million during 1971–76 toward this project.

After 2 years' negotiations, Nordwestdeutsche Kraftwerke A.G. completed arrangements for construction of the world's largest nuclear powerplant, a 1,300-megawatt PWR on the Weser River, north of Bremen. Fuel for the plant will contain 102 tons of enriched uranium.

A prototype 300-megawatt fast breeder will be built at Kalkar on the Rhine River in Westphalia. The project was proposed by a West German-Belgian-Dutch utility group, which will operate the plant and provide most of the capital.[38]

Rheinisch-Westfalisches Elektrizitatswerk A.G. will represent West Germany in a

[34] Atomic Industrial Forum. Second U.S. Order for Eldorado. Nuclear Industry. V. 18, No. 4, April 1971, p. 42.

[35] American Nuclear Society. Nuclear News Briefs. Nuclear News. V. 14, No. 4, April 1971, p. 17.

[36] Chemical and Engineering News. France: Boost to Nuclear Power. V. 49, No. 11, Mar. 15, 1971, p. 12.

[37] U.S. Embassy, Bonn, West Germany. State Department Airgram A–371, Apr. 8, 1971, 2 pp.

[38] Atomic Industrial Forum. European Breeder Site Approved. Nuclear Industry. V. 19, No. 1, January 1972, p. 43.

joint agreement with France for two 1,000-megawatt sodium-cooled fast breeders. The first unit was scheduled for construction in France; the second was planned for West Germany starting in 1977–78. The West German interests will cover 70 percent of the costs of this second unit.

According to Vereinigung Deutscher Elektrizitatswerk, an association of West Germany power companies, nuclear power capacity will exceed 10,000 megawatts by 1976, more than 12 percent of total electric generating capacity.

India.—The Department of Atomic Energy increased reserve estimates in India to 33,000 tons U_3O_8, all in relatively low-grade deposits. At the Jaduguda mine, reserves were increased by 50 percent following the decision to extend the mine workings from 1,500 to 2,000 feet. Exploration was underway on newly discovered deposits at Gondwana, Sarguja, and Durg, all in Madhya Pradesh, the Kolihan copper mine in Rajasthan, and associated with lignites at Tamil Nadu.[39] The Department of Atomic Energy reported underground development continuing at Narwapahar and Bhatin, Bihar.

Development continued on India's planned nuclear power establishment. The Atomic Fuels Division, Bhabha Atomic Research Centre (BARC), will develop and fabricate fuel elements, and the Fuel Reprocessing Division will recover plutonium and other constituents from spent fuels. A fuel-reprocessing plant was under construction at Tarapur. The Nuclear Fuels Complex in Hyderabad was nearing completion at year-end. A Reactor Research Center was under development at Kalpakkam, near Madras, to provide research and development support, particularly on advanced reactors and breeders.

The two-unit, CANDU-type, 200-megawatt (each) reactor station near Kota in Rajasthan was scheduled for 1972 (first unit) and 1974 (second unit). A similar installation at Kalpakkam was behind schedule; completion was expected in 1976 (first unit) and 1977 (second unit). Agro-industrial complexes were planned in connection with nuclear power development.

A joint Department of Atomic Energy-Tata Institute study on total electric power development for 25 years concluded that the northern, western, and southern regions of India were most favorable for nuclear power. Projections were for 2,700 megawatts in 1980, 11,400 megawatts in 1990, and 43,000 megawatts in the year 2000, when 30 percent of total electric power generation was expected to be nuclear.[40] Known uranium resources were considered sufficient to sustain only 10,000 megawatts.

Iran.—Under an agreement between the French CEA and the Iranian Government, CEA engineers conducted uranium reconnaissance and prospecting in conjunction with the Geological Survey of Iran. A total of 50,000 square miles was surveyed. Radiometric anomalies were further investigated.

Israel.—A process of uranium recovery as a byproduct during production of phosphoric acid was announced. This process reportedly was developed at a nuclear research center in the Negev desert.[41]

Italy.—According to the State-owned energy agency, nuclear power capacity was scheduled to reach 5,500 to 6,500 megawatts in 1980 and 40,000 to 50,000 megawatts in 1990, more than 50 percent of total generating capacity from all sources.[42]

Japan.—The Government and the nuclear industry sponsored nuclear research at a cost of $140 million per year and involving 4,000 people. The Power Reactor and Fuels Development Corp., an agency comprising 10 companies and the Government of Japan, reported discovery of uranium minerals in Gifu Prefecture of central Japan and Yamaguchi Prefecture of western Japan.[43]

In seeking future U_3O_8 supplies, Japanese industry has started joint exploration projects in the United States, Canada, Niger (with France), and Somalia (with Italy). The Japanese were also seeking uranium purchases and exploration agreements in Australia. The Japanese Atomic Energy Commission (JAEC) recommended that $140 million be applied to domestic and foreign uranium exploration during 1972–82. An Energy Advisory Committee report to the Ministry of International Trade and Industry (MITI) recommended participation in international ventures to assure supply of enriched uranium. A joint enrichment plant involving Australia, Canada, and possibly India, with Japan, was

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[39] Mining Journal. Recent Mineral Discoveries. V. 277, No. 7111, Dec. 3, 1971, p. 507.

[40] Department of Atomic Energy. Nuclear Industry. V. 10, No. 2, October 1971, pp. 6–8.

[41] Metal Bulletin. No. 5648, Nov. 9, 1971, p. 18.

[42] Chemical and Engineering News. Italy's Nuclear Power. V. 49, No. 37, Sept. 6, 1971, p. 13.

[43] American Nuclear Society. International Briefs. Nuclear News. V. 14, No. 1, January 1971, p. 33.

proposed. Late in the year, the JAEC agreed to joint research, with France, on production of enriched uranium. Kyushu Electric Power Co. concluded contracts with Eldorado Nuclear, Ltd., Canada, for conversion of U_3O_8 to UF_6 and with the USAEC for nearly 27,000 pounds of enriched uranium during a 26-year period.

The Power Reactor and Fuels Development Corp. conducted research and development work on the gas centrifuge. A small centrifuge, capable of enrichment to 1.4 percent U_{235}, was nearly ready for operation at a plant in the village of Tokai.[44] The Atomic Energy Research Institute also studied enrichment technology, presumably the gaseous diffusion method.

The first fuels-reprocessing plant, also at Tokai, will have a daily capacity of 0.7 ton of processed spent fuel. Operations were scheduled for 1974.

Research also was underway on the fast breeder reactor (FBR) and the high-temperature, gas-cooled reactor (HTGR). Atomics International, a division of North American Rockwell Corp., and Kawasaki Heavy Industries, Inc., agreed to promote development and marketing of the FBR in the Far East. The Power Reactor and Fuels Development Corp., Karlsruhe Research Center, West Germany, and also Netherlands and Belgian interests, concluded a 5-year agreement for the exchange of FBR technology.

As of 1971, there were four operating commercial nuclear reactors in Japan (1,300 megawatts) and nine under construction (5,800 megawatts), most in the vicinity of Tokyo and Osaka. Because of limitations on suitable sites for future development, MITI recommended floating and underseas reactors.[45] MITI indicated annual demand for U_3O_8 of 700 tons in 1970, 3,500 tons in 1975, and 9,200 tons in 1980. Demand for enriched uranium was projected at 2,000 SWU's in 1975, 5,000 SWU's in 1980, and 8,500 SWU's in 1985. The Japan Atomic Industrial Forum projected nuclear capacity (only 1 percent of total electric capacity in 1970) of 30,000 megawatts (20 percent) in 1980, 110,000 megawatts (40 percent) in 1990, and 220,000 megawatts (50 percent) in 2000.

Mali.—A Krupp-led West German consortium decided to abandon a uranium exploration project, started in 1970 in the area adjacent to the border with Niger (for possible extensions of the Niger uranium deposits) and north of Kita in western Mali. A West German Government assistance program continued exploration in the latter area.

Niger.—Société des Mines de l'Air (SOMAIR), the operating company, made its initial shipment of uranium concentrate from the Arlit deposit in February. The concentrate is a sodium uranate containing 70 percent U_3O_8. Initial capacity is 750 tons per year of this product. Markets have been provided in France, West Germany, and Italy, all of which are participating in the project. SOMAIR was comprised as follows: Government of Niger, 16.75 percent; the French CEA, 33.5 percent; a Péchiney-Mokta-Société Français des Minerais d'Uranium consortium (French), 33.5 percent; Urangesellschaft m.b.H. (West German), 8.125 percent; and AGIP Nucleare (Italian), 8.125 percent.

The Akokan deposit, 12 miles southwest of Arlit, was under development by joint Government of Niger-CEA-Overseas Uranium Resources Development Co. (Japan) interests. The first stage of exploration was completed, and a second stage for 1971–72 was planned. The ore deposit lies at a depth of 300 feet and will be mined by underground methods.

Other uranium deposits along the same mineralized trend were under investigation.

Pakistan.—Uranium exploration, sponsored under a United Nations Development Program in Dera Ghazi Khan, Sulaiman Mountains area, will cover the Siwalik sandstone and will require access road construction and helicopter support.[46] The Pakistan Atomic Energy Commission conducted laboratory tests on uranium ores discovered in this area and constructed a pilot processing plant with capacity of 1,000 pounds ore per day, at Lahore.[47]

Poland.—The shaft at the Pribram uranium mine was extended to a depth of 5,500 feet to test the ore at depth. Development will continue at seven additional levels if justified by reserve estimates.[48]

Puerto Rico.—A study was made for a 7-year project involving a $650 million nu-

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[44] American Metal Market. V. 79, No. 16, Jan. 24, 1972, p. 11.
[45] Oceanology International. Putting Nuclear Plants Over and Under the Sea. V. 6, No. 4, April 1971, p. 21.
[46] Mining Magazine. Uranium Search. V. 125, No. 4, November 1971, p. 487.
[47] Mining Journal. Pakistan: Uranium Processing. V. 277, No. 7110, Nov. 26, 1971, p. 493.
[48] Mining Journal. Polish Uranium Search. V. 277, No. 7096, Aug. 20, 1971, p. 161.

clear center, or nuplex, based on a 540-megawatt nuclear powerplant. Power would be provided for desalination and for petrochemical, fertilizer, aluminum, and possibly other industrial plants.[49]

Somali Republic.—Somiren S.p.A., a subsidiary of Ente Nazionale Idrocarburi, an Italian national company, continued uranium exploration at a reduced scale. U.S. and West German interests were relinquished in 1970. The Japanese Overseas Uranium Resources Development Co. agreed to a joint exploration project with Somiren and had an option (to be exercised by March 1972) on a joint venture for development in the Bur area.[50]

South Africa, Republic of.—Production of byproduct or coproduct uranium at 11 gold-uranium mines increased slightly in 1971. Overall average grade was 0.7 pounds U_3O_8 per ton, but grade at the one primarily uranium mine, West Rand Consolidated, was 1.6 pounds U_3O_8 per ton. Substantial tonnages of uranium-bearing gold tailings were stockpiled for processing when the uranium market is improved. According to the President of the Atomic Energy Board, the reserve position was slightly improved because of new discoveries and more efficient extractive practices.

The Electricity Supply Commission issued requests for bids on South Africa's first nuclear power installation, sited near Cape Town. Construction would start in 1972; plant operation was scheduled for 1978. Enriched uranium systems reportedly were favored; earlier investigations were confined to systems operating with natural uranium fuels. The steam-generating heavy water reactor also was under consideration.

Early in the year, the Nuclaer Fuels Corp. of South Africa (Pty.) Ltd., a Government agency, negotiated with Japanese companies for uranium sales. A South African newspaper reported a $140 million sale to Kansai Electric Power Co., Japan.

South-West Africa, Territory of.—A pilot plant for testing uranium ores was under construction at Rossing, near Swakopmund, where the world's largest open pit uranium mine was under development. The operating company, Rossing Uranium Ltd. (comprising Rio Tinto South Africa (Pty.) Ltd., General Mining and Finance Corp., and the Industrial Development Corp. of South Africa) was assisted by the South African Atomic Energy Board in metallurgical testing. Western Knapp Engineering Division, Arthur G. McKee & Co., San Francisco, Calif., and another company were awarded a joint venture management contract for design engineering, procurement, and construction of the mining and milling facilities.[51] Planned mill capacity is 5,000 tons of concentrate per year from 20,000 tons of ore millfeed per day.[52] The company has a contract with the United Kingdom Atomic Energy Authority for 7,500 tons U_3O_8 at a total value of $106.4 million, or about $7 per pound, during 1976–82.[53] When in full production, the operation will employ 700 Europeans and 1,000 Africans.

Spain.—The Spanish Nuclear Energy Board was investigating a uranium deposit in shale near Ciudad Rodrigo in Salamanca Province. A national mining plan recommended formation of a corporation under the Instituto Nacional de Industria for mining and processing the ore. A production rate of 400 tons U_3O_8 per year was envisioned.

A paper prepared by the Nuclear Energy Board and the Ministry of Industry indicated the present status and projected plans for nuclear power development.[54] Existing nuclear capacity was 600 megawatts, 3 percent of total generating capacity, and 14,000 megawatts, 25 percent of total capacity, was projected for nuclear development by 1983. Later in the year, Unidad Electrica S.A. increased the 1983 projection to 22,000 megawatts in a national plan.

According to the Nuclear Energy Board, reserves were only 9,000 tons U_3O_8 at less than $10 per pound and 22,500 tons U_3O_8 at $10 to $15 per pound.

Sweden.—In July, an AB Atomenergi report to the Ministry of Industry proposed a tenfold increase, to 1,250 tons U_3O_8 per year, in capacity of the uranium mine at Billengen and the mill at Ranstad. Production has been at a rate of 120 tons per year from low-grade shale at Billingen. Later in the year, the Central Power Supply Management recommended that the entire mine-

[49] Atomic Industrial Forum. Study Favors Nuclear-Powered Puerto Rican Industrial Complex. V. 18, No. 6, June 1971, pp. 42–43.
[50] American Metal Market. Japanese-Italian Uranium Venture. V. 78, No. 155, Aug. 12, 1971, p. 24.
[51] Skillings' Mining Review. New Uranium Project in South-West Africa. V. 60, No. 52, Dec. 25, 1971, p. 28.
[52] Atomic Industrial Forum. Urangesellschaft in Rossing Venture? Nuclear Industry. V. 18, No. 1, January 1971, p. 48.
[53] Mining and Minerals Engineering. V. 7, No. 7, July 1971, p. 32.
[54] U.S. Embassy, Madrid. State Department Airgram A-284, Oct. 8, 1971, 14 pp. and tables.

mill project be abandoned for the time being, because of high operating costs, and that nuclear fuels be obtained from foreign sources. The proposed plan included the possible reopening of the mine and mill during the 1980's, when uranium prices presumably will be higher.

The Swedish Geological Survey announced discovery of a uranium prospect in the Hornavan Lake area, Arjeplog region, of northern Sweden. Details were not available.

AB Atomenergi proposed a budget for research and development on uranium enrichment, including both gaseous diffusion and gas centrifuge technology.[55]

The State Power Board published a study presenting projected needs and siting of nuclear power stations on the east coast, where nine favorable sites were selected. In November, the Board announced the awarding of contracts for two new power reactors and options for two others, all in the 900-megawatt class. Plans call for 2,600 megawatts of nuclear capacity in 1975, 8,600 megawatts from 11 plants in 1980, and 25,500 megawatts nuclear in 1990. By 1985, it was estimated that one-half of total generating capacity would be nuclear. Annual U_3O_8 requirements were projected at 1,700 tons in 1980 and 3,500 tons in 1990.[56]

Switzerland.—A 306-megawatt PWR, one of two scheduled for operation by Berne Power Co. at Mühlenberg in 1972, was damaged by fire in July, causing a 1-year delay. Plans were well advanced for two new installations, when the Government ruled against the use of cooling water from rivers; the projects were modified, at considerable delay, to include the cost for cooling towers.

Plans include eight additional nuclear plants of large capacity (averaging 1,000 megawatts) by 1986. A commission was appointed by the Department of Transport and Power to study environmental effects.

United Kingdom.—Joint field investigations by the Atomic Energy Authority (AEA) and the Institute of Geological Sciences in Scotland resulted in new indications of uranium and other metallic minerals.[57] Uranium was found in arkosic rocks, south of Caithness in northern Scotland, and in veins in southwest Scotland. Late in the year, private companies planned drilling programs in these areas.

Major decisions affecting the AEA and the United Kingdom nuclear industry were made in 1971. The Atomic Energy Act of 1971 was approved in March. On April 1, British Nuclear Fuels Ltd. (BNFL) and Radiochemical Centre Ltd. assumed the duties of the former Production Group and Radiochemical Centre, respectively. The Springfields, Lancashire, plant of BNFL was operated at full capacity for enriched uranium fuel. The UF_6 plant was operated above rated capacity to supply Capenhurst and overseas orders. Output of enriched uranium at Capenhurst increased by 50 percent.

Gas centrifuge research and development continued; early in the year, a larger-size cascade with centrifuges of improved design was brought into operation. Reprocessing of irradiated fuels increased 16 percent at Windscale. Sales of enriched uranium fuels were made to 12 countries during the fiscal year (ending March 31, 1971). The AEA also had three U.S. contracts and two European (Sweden and Switzerland) contracts for conversion of U_3O_8 to UF_6.[58] Under the reorganization of the AEA, shares were to be sold privately for 49 percent of BNFL.

Urenco Ltd. was formed under the tripartite agreement with West Germany and the Netherlands for uranium enrichment development. Its functions will include acquisition and operation of centrifuge-based enrichment plants at Almelo, Netherlands, and Capenhurst; the planning, installation and operation of future plants; the selling of enrichment services; and centrifuge research and development.[59]

The "First 5000" program for nuclear power development was completed with the installation of the Wylfa Head first unit, the ninth and last in the program, at Anglesey, Wales.[60] The final design capacity of two units planned at this site is 1,180 megawatts.

Five advanced gas-cooled reactors (AGR) of commercial size were under construction, and one more was planned. It appeared

[55] Engineering and Mining Journal. Swedes Pushing Uranium Enrichment and Mining. V. 172, No. 10, October 1971, p. 48.

[56] U.S. Embassy, Stockholm. State Department Airgram A-506, Dec. 30, 1971, 9 pp.

[57] Gallagher, M. J., V. McL. Michie, R. T. Smith, and L. Haynes. New Evidence of Uranium and Other Mineralization in Scotland. Institute of Mining and Metallurgy, v. 80, No. 777, August 1971, pp. B150–B174.

[58] United Kingdom Atomic Energy Authority, (London). Atom 1971. 23 pp.

[59] Mining Magazine. U.K. Uranium Venture. V. 125, No. 5, November 1971, p. 405.

[60] American Nuclear Society. International Briefs. Nuclear News. V. 14, No. 4, April 1971, p. 44.

that this program would then be abandoned, owing to high costs, and that LWR's of U.S. design were favored for future nuclear development.[61]

The AEA planned a 1,300-megawatt FBR, with construction starting in 1974. A prototype 250-megawatt FBR at Dounreay, Scotland was scheduled for criticality in 1972.[62]

BNFL concluded a tripartite agreement with French and West German interests to combine fuel-reprocessing capacity. A joint company will market U_3O_8 from reprocessed oxide fuels and uranyl nitrate for UF_6 production. Capacity at the plant at Windscale will be expanded; French and West German plants will be enlarged at a later date.

According to the AEA, three-fourths of United Kingdom electric generating capacity will be nuclear by the end of the century, and more than one-half will be based on the FBR.

U.S.S.R.—A contract was concluded with French industry for enrichment of 80 tons of U_3O_8 at a reported cost of $28.70 per kilogram SWU. This was the first such contract with a western nation. Similar negotiations were underway in West Germany, Sweden, and Finland.[63]

A U.S. delegation visiting Soviet nuclear power installations reported development of a number of large capacity nonbreeding types, differing in design from U.S. commercial types.[64] They are graphite-moderated, with fuel rods embedded in the graphite and cooling water circulating through minute tubes.

The world's first commercial FBR, a 350-megawatt plant for electric generation and desalination, was completed at Shevchenko on the Caspian Sea. Full power was expected in 1972.[65]

According to the Soviet plan for nuclear power development during 1971–75, two plants were being enlarged, three were under construction, and two new starts were planned.

Zaire.—Zaire expressed interest in development of a gaseous diffusion uranium-enrichment plant in connection with the Inga hydroelectric industrial complex, 25 miles from Matadi, on the lower Congo River. A report prepared by the Belgian Syndicat d'Etude de l'Industrie Atomique was favorable to the project. Hydroelectric development would reach 26,000 megawatts in three stages. The enrichment plant would be part of the second stage. Estimated investment is $500 million for hydroelectric development and $1 billion for industrial development through the second stage.[66]

TECHNOLOGY

The AEC-sponsored basic research program was conducted at national laboratories, other AEC-owned and contractor-operated research and development facilities, and private facilities. Increasing emphasis was placed on environmental aspects. Work on reactor technology included nuclear fuels and reactor materials, physics, and safety.[67]

The continuing search for uranium established a demand for exploration instruments that are easy to use, portable, and measure quickly and accurately. Ekco Instruments, Ltd., United Kingdom, announced development of a portable radon counter in conjunction with the United Kingdom Atomic Energy Authority and the Institute of Geological Studies. Whereas a few feet of overburden can effectively conceal detection of radioactivity by conventional geiger and scintillation instruments, the Ekco instrument reportedly monitors the air above concealed deposits for presence of radon gas, which may diffuse through overburden to the surface. A sample hole may be drilled 1½ feet, and the monitor inserted for measurement.[68]

A portable spectrometer also was used in the field to measure the abundance and

[61] The Economist (London). Killing the AGR. V. 6672, July 10, 1971, pp. 82–85.
[62] Chemical and Engineering News. U. K. Fast Breeder Reactor. V. 49, No. 38, Sept. 13, 1971, p. 34.
[63] Chemical and Engineering News. Enrichment in U.S.S.R. V. 49, No. 12, Mar. 22, 1971, p. 37.
[64] Gillette, R. Nuclear Power in the U.S.S.R.: American Visitors Find Surprises. Science, v. 173, No. 4001, Sept. 10, 1971, pp. 1003–1006.
[65] Chemical Engineering. V. 79, No. 2, Jan. 24, 1972, p. 46.
[66] American Nuclear Society. Enrichment Plant Is Key to Congo Plan. Nuclear News, V. 14, No. 8, Aug. 1971, p. 28.
[67] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1971. January 1972, 159 pp.
[68] Mining Journal. V. 276, No. 7082, May 14, 1971, p. 379.

distribution of uranium and thorium.[69] Measurements were made with a lead-collimated detector in a grid pattern in an area with uneven distribution of radioelements. On the basis of specific rock types having characteristic uranium content, contouring for uranium corresponded to the rock types and followed structural trends.

A neutron activation analysis technique was employed for estimating grade of uranium ore in the field.[70] The technique is based on measurement of gamma emissions from U_{239}, produced by neutron irradiation from californium (Cf) $_{252}$, a source of prodigious neutrons. Thorium and vanadium are complicating factors. Although not of high precision, the method was considered simple and rapid, with accuracy within 10 percent, for uranium concentrations as low as 0.01 percent U_3O_8.

A high-sensitivity gamma-ray spectrometer, employed in airborne geochemistry, was used to trace hydrothermal dispersion patterns. The instrument measured small variations in concentrations of potassium (as K_{40}), thorium (as Th_{208}), and uranium (as Bi_{214}). Recordings of anomalous measured values of these three isotopes, or their values, were aids in mapping metamorphic terrain and in sedimentary terrain with igneous intrusions.[71]

In U_3O_8 processing, Oak Ridge National Laboratory (ORNL) reported on solvent extraction of uranium from wet-process phosphoric acid. As much as 2,000 tons of uranium are dissolved annually when phosphate rock is digested in sulfuric acid to produce phosphoric acid. Small-scale tests on uranium recovery were underway.[72] Recently, more emphasis has been placed on development of continuous counter-current ion exchange processes for uranium extraction rather than the batch processes. The continuous process for uranium recovery from a dilute sulfate solution permitted a product of more uniform purity and required less water and resin. The flow rate was periodically modulated to a cascade of contacting stages. The solids were transferred in a direction counter-current to the net flow of the fluid. The ratio of solid and liquid flow rate was adjustable by a cycle timer.[73]

More stringent standards (reduced from 12 Working Level Months (WLM) to 4 WLM, effective July 1, 1971, subject to compliance-variance review) pending for levels of radiation in mines resulted in new ventilation systems and new methods of removing radon and its disintegration products from the air. Union Carbide Corp. experimented with electronic air cleaners in conjunction with the ventilation system at its mines in the Uravan Mineral Belt on the Colorado Plateau, with favorable results.[74] Each precipitator is of 2,000-cubic-feet-per-minute capacity. They function on an ionization principle; contaminated particles in the air were given an electric charge and were then captured by an opposite charge. The mines selected were types where orderly development and normal venting systems were not practiced because of the highly irregular distribution of the ore deposits. One-year experiments with banks of precipitators indicated their usefulness for spot applications, particularly in sections of the mine farthest from vent shafts. If velocity does not exceed 300 feet per minute, 90 percent of particulates can be removed. In a multibank system, air entering at 0.7 to 1.0 Working Level (WL), a measure of radiation, was exhausted at 0.1 WL. Typically, a system of units was placed in a drift connecting the main vent path and a new working area. The main problem is that radon gas that has not decayed to more dangerous daughter products is unaffected by the precipitator.

A liquid styrene plastic was considered as a sealant against radon gas in homes and buildings in Grand Junction, Colo., where uranium mill tailings had been used as fill and cement aggregate. This is an alternative to actual removal of the tailings fill, which would cost substantially more. However, the plastic is highly flammable and emits toxic fumes in liquid form and,

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[69] Lovborg, L., H. Wollenberg, P. Sorensen, and J. Hansen. Field Determination of Uranium and Thorium by Gamma-Ray Spectrometry, Exemplified by Measurements in the Ilimaussaq Alkaline Intrusion, South Greenland. Econ. Geol., v. 66, No. 3, May 1971, pp 368–384.

[70] Philbin, P., and F. E. Senftle. Field Activation Analysis of Uranium Ore Using CF_{252} Neutron Source. Soc. Mng. Eng. Trans., v. 250, No. 2, June 1971, pp. 102–106.

[71] Bennett, R. Exploration for Hydrothermal Mineralization with Airborne Geochemistry. Soc. Mng. Eng. Trans., v. 250, No. 2, June 1971, pp. 109–113.

[72] Chemical Week. V. 108, No. 14, Apr. 7, 1971, p. 59.

[73] Javed, N. A. Uranium Recovery from a Dilute Sulfate Solution by Using a Continuous Ion Exchange Technique. Jour. Metals, v. 23, No. 8, August 1971, pp. 33–37.

[74] Atomic Industrial Forum. Electrostatic Precipitators Help Control Mine Radiation. Nuclear Industry, v. 18, No. 12, December 1971, pp. 40–43.

when hardened, has little effect on gamma rays.[75]

The Bureau of Mines continued research on improving radiation control methods in uranium mines. The Pittsburgh Mining and Safety Research Center was performing experimental work on a Whitby aerosol analyzer to investigate attachment of radon daughters to natural Pittsburgh aerosol particles. A computer program for calculating radon daughter concentrations will be adapted to the Whitby system. At the Denver Mining Research Center, health and safety research was underway to develop quantitative data on the relation of radon emanations to natural uranium and to radium compounds in domestic uranium deposits. Included in the project were the design and assembly of radiometric instrumentation for radon quantitative data and assembly of a mobile field laboratory which will measure not only radiation but also such data as temperature and air pressure, velocity, and humidity in mines.

Jersey Nuclear Co., a subsidiary of Standard Oil Co. (New Jersey) and Avco Corp., announced development of a new uranium enrichment technique, based on laser technology. Details were not revealed, but it was claimed that results of research were favorable and that the process was lower cost than established processes. The technique is based on the principle that isotopes can absorb light at slightly different energy levels.

A test centrifuge was described by Comitato Nazionale Energia Nucleare (CNEN), Italy. The centrifuge is 3 feet long, 7 inches in diameter, and of fiberglass construction. It has a peripheral velocity of 1,150 to 1,970 feet per second.

A Zippe centrifuge, named after the consultant, is under development in the West Germany-United Kingdom-Netherlands tripartite plan. It is a light-weight bowl, supported on a pin-and-cup bottom and magnetic bearing on top. A high-frequency alternating current induction motor drives the bowl, which is contained in a small pressure vessel. Pilot tubes feed UF_6 gas in and out of the bowl.[76]

Research continued on nuclear fuels and their performance. A PuO_2-UO_2 fuel was developed for the AEC's Fast Flux Test Facility (FFTF) at the Hanford project, Richland, Wash. The fuel was tested on a pilot line as part of the LMFBR development program. The fuel design consisted of 217 fuel pins, 7 feet long, each containing a column of mixed oxide fuel pellets. The pellets are 0.1945 inch ± 0.015 inch in diameter and 0.205 to 0.283 inch ± 0.020 inch in length. Other specifications requiring close control included oxygen-to-metal ratio, density, fissile content, impurity level, gas and moisture content, homogeneity, surface condition, grain size, and porosity. The PuO_2 and UO_2 are mixed, and an organic binder added, followed by prepressing, granulating, cold pressing, binder removal, and sintering. Pore-forming organic binders and presintering the blended oxides before binder addition were under evaluation. Care must be taken to prevent accumulation of a critical mass of fissile material in the pilot facility. A computerized data system was under development for monitoring the movement of all fissile material. Toxicity was controlled by performing all PuO_2 processing steps inside gloveboxes.[77]

Gulf Energy and Environmental Systems reported discovery of a nuclear fuel having a lifespan several times that of previous fuels. It is a blend of U_{235} and erbium; the latter absorbs excess neutrons.[78]

Another new nuclear fuel, especially adapted to the HTGR, consisted of tiny microspheres of uranium, oxygen, carbon, and sulfur, derived from ion exchange resins. Tiny spheres of resin were exposed to uranyl nitrate; the resin absorbed uranium, forming uranium-loaded spheres, which were dried and then roasted in inert gas at about 1,800° C, forming the fuel particles. The particles were then coated with a dense layer of carbon to prevent escape of fission products into the gas inside the reactor.[79]

Uranium mononitride (UN) was considered attractive as a nuclear fuel in applications requiring high density of fissile atoms, high thermal conductivity, and high melting point. UN has high affinity for oxygen; therefore, the material must be synthesized, fabricated, and sintered under rig-

[75] Atomic Industrial Forum. Use of Plastic Sealant to Control Radon from Mill Tailings. Nuclear Industry, v. 19, No. 1, January 1972, pp. 29–31.

[76] Chemical Engineering. Atoms-for-Peace Group Eyes Gas Centrifuges. V. 78, No. 25, Nov. 1, 1971, p. 38.

[77] Ceramic Age. Nuclear Power: FFTF Fuel Development Facility. V. 87, No. 6, June 1971, pp. 28–29.

[78] Chemical Week. V. 109, No. 1, July 7, 1971, p. 27.

[79] Am. Ceramic Soc. Bull. New Nuclear Fuel Developed. V. 50, No. 2, February 1971, p. 234.

idly controlled conditions to avoid oxidation.[80]

Studies were conducted on uranium and plutonium carbide fuels with tungsten additive up to 2 percent by weight, for swelling tests.[81] Preparation methods included arc melting and casting of mixtures, float zone melting, and precipitation annealing of solid solutions. In earlier work on reducing fuel swelling, tungsten (1.5 to 3 percent by weight) was dispersed as fine particles in the uranium carbide fuel structure. During irradiation, the tungsten reduced swelling when uniformly dispersed, and the fine particles helped contain fission gases.[82]

Another report suggested that surface energy of UO_2 is important to studies of diffusion-controlled processes involving fuel behavior, such as sintering and swelling caused by fission gases. This energy was calculated directly by measuring the interfacial equlibrium angles that developed between phases.[83]

UN also was selected as fuel material possibly for a small liquid-cooled fast reactor, maximum power 10 megawatts, for developing electric power in space exploration.[84] The UN fuel has high thermal conductivity, high melting point, ease of handling and fabrication, and satisfactory nuclear properties. The objective of the study was the determination of chemical activity of uranium in UN as a function of pressure and phase composition, and phase equilibria. UN pellets were tested for spalling, cracking, and expansion.

Future nuclear power reactors were expected to be increasingly larger in capacity; advanced concepts; sited offshore, undersea, and underground; and nuclear complexes (nuplex), or nuclear-based energy centers. A 3,600-megawatt, $1 billion installation, a record capacity, was planned by Carolina Power and Light Co.[85] Westinghouse Electric Corp. and Tenneco, Inc., announced a technical-economic feasibility study for an offshore, platform-mounted nuclear plant, within the 3-mile limit. Offshore siting would permit construction near load centers, would pose no land acquisition problems, and would lessen siting and thermal pollution controversy since heat would be absorbed by the sea. Another offshore plant of 1,100-megawatt capacity, proposed by Public Service Electric and Gas Co., Newark, N.J., would be mounted on steel or concrete floating barges in a breakwater area, with cables buried in the ocean floor.[86] Nuplexes were envisioned as optimizing possible mixes of capital-intensive industries. They could include desalination, fertilizers and chemicals, coal gasification (reducing gas for the blast furnace), methane reforming, ammonia production, and methanol production.[87]

A contract was awarded for the first application of a nuclear heat source for gas from coal. An HTGR will provide conversion temperatures of 1,600° C. The study was directed toward a plant producing 250 million cubic feet per day of pipeline-quality gas and 400 megawatts of electricity generation.

AEC-sponsored and private research continued on advanced reactor concepts, mainly the fast breeder. The HTGR, an advanced converter using a U_{235}-Th_{232}-U_{233} fuel cycle, was further researched by GGA, ORNL, and Pacific Northwest Laboratory. It affords improved fuel utilization through a high conversion ratio and high thermal efficiency, reduced thermal discharge, long fuel lifetime, good safety characteristics, and minimum release of radioactive effluents.

Further emphasis was placed on development of the LMFBR as plans for two demonstration plants, joint AEC-industry projects, were announced. The program is committed to development of a safe, reliable, and economic breeder reactor system. The transition from research to design, engineering, and testing on a commercial scale was underway. Construction continued on the 400-megawatt (thermal) FFTF at Richland, Wash., for irradiation testing of fuels and materials. The FFTF fuel is PuO_2-UO_2 pellets, 1/4-inch in diameter, in

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[80] Tennery, V. J., T. G. Godfrey, and R. A. Potter. Sintering of UN as a Function of Temperature and N_2 Pressure. Jour. Am. Ceramic Soc., v. 54, No. 7, July 1971, pp. 327-331.

[81] Ervin, G., Jr. Uranium and Plutonium Carbides with Tungsten Additive. Am. Ceramic Soc. Bull., v. 50, No. 8, August 1971, pp. 659-661.

[82] Ervin, G., Jr. Swelling Control in Uranium Carbide. Jour. Am. Ceramic Soc., v. 54, No. 1, January 1971, pp. 46–50.

[83] Bratton, R. J., and C. W. Beck. Surface Energy of Uranium Dioxide. Jour. Am. Ceramic Soc., v. 54, No. 8, August 1971, pp. 379–381.

[84] Hoenig, C. L. Phase Equilibria, Vapor Pressure, and Kinetic Studies in Uranium-Nitrogen System. Jour. Am. Ceramic Soc., v. 54, No. 8, August 1971, pp. 391–398.

[85] Engineering News Record. Around the World —Biggest Nuclear Plant. V. 186, No. 21, May 27, 1971, p. 13.

[86] Chemical Engineering. V. 78, No. 11, May 17, 1971, p. 75.

[87] Chemical and Engineering News. Nuplexes Seek Optimum Mix of Industries. V. 49, No. 13, Mar. 29, 1971, pp. 35–36.

stainless steel cladding. Testing will be in a controlled and instrumented environment, up to and including failure of materials. Emphasis was placed on supporting technology, complementing the LMFBR demonstration program, in work on fuels, materials, safety reactor physics, components, instrumentation, and fuel cycle.[88] Research in the United Kingdom indicated that high neutron doses in the FBR can cause swelling of structural materials over periods of several years, posing a threat to the safety and economic viability of the FBR.[89] Examination of irradiated stainless steel cladding from fuel pins by electron microscope showed that the steel contained a large number of small cavities, 100 atoms in diameter, resulting from swelling, or an increase in size. Irradiation damage was more pronounced where the neutron flux was the greatest. The fast neutrons interact with atoms of structural materials, displacing atoms from their equilibrium lattice.

Other breeder concepts under continuing study were the light water breeder reactor (LWBR), the gas-cooled fast breeder reactor (GCBR), and the molten salt breeder reactor (MSBR). At the AEC's Bettis Atomic Power Laboratory, Pittsburgh, Pa., where Westinghouse Electric Corp. is the operating contractor, work continued on a reactor core to demonstrate the potential for breeding in the LWR system, with the objective of improving LWR fuel utilization, which is only 1 to 2 percent of the energy potential of natural uranium. Breeding could possibly utilize up to 50 percent of the energy potential of thorium, which would be used in the seed-blanket concept. A demonstration plant, under construction at Shippingport, Pa., will assess the technical feasibility of this concept. The GCBR, closely related to the HTGR in that both are gas-cooled, was under development by GGA, ORNL, and 40 private company participants. A conceptual design was completed; cost data and a demonstration plant program were under study. Research and development on the MSBR was centered at ORNL with private participation. This concept has potential for long life of fuels and materials at high temperatures, good neutron economy, and onsite fuel reprocessing if the complex technology for reprocessing and recovery can be developed. The fluid fuel necessitates no fabrication of fuel elements. A six-company group was granted a subcontract with ORNL for a conceptual design study on a 1,000-megawatt facility.[90]

In fuels reprocessing, AEC research was directed toward recovery of fuels from the advanced converters and breeders. The aqueous technology, used extensively in both Government and private reprocessing plants, was emphasized for LMFBR fuels.[91] U and Pu were recovered by solvent extraction with hydroxylamine nitrate added.[92] The scrap was dissolved, purified, and fed to the solvent extraction column. The nitrate reduced the U and Pu, which separated into two layers in the column. The Pu was removed from the top, and the U from the bottom.

At the General Electric plant, Morris, Ill., a combination aqueous-anhydrous process, called Aquaflour, was practiced. The process is complex, involving 28 steps, but reportedly has certain advantages.[93] Ion exchange is used to partition Pu, Np, and U. Uranyl nitrate is converted to UF_6, the compound required for enrichment.

The Purex solvent extraction process was considered capable of recovering 99.8 percent U from spent fuels with decontamination factors on the order of 10^7. An aqueous nitrate solution containing the U and Pu was contacted with an organic solution of tributyl phosphate (TBP), the extracting agent. The valuable nitrates, complexed with the TBP, flowed overhead; wastes were eliminated with the aqueous phase. Pu and U were separated in a subsequent extraction column. Several stages were necessary for purification.[94]

Other research and development on fuels reprocessing involved the preparation of the spent fuel rods. They are usually mechanically broken and then leached with nitric acid. Two innovations were an electrolytic dissolver for stainless steel cladding rods and a graphite burner for uranium-thorium fuels.

Quantities of gaseous, liquid, and solid radioactive wastes increased with new nu-

[88] Pages 99–104 of work cited in footnote 9.
[89] Nelson, R. S. Filling the Voids in Fast Reactor Technology. New Scientist and Science Jour. V. 49, No. 3, Mar. 25, 1971, pp. 664–667.
[90] Chemical and Engineering News. Molten Salt Breeder Reactor. V. 49, No. 31, Aug. 2, 1971, p. 27.
[91] P. 139 of work cited in footnote 9.
[92] Chemical Week. V. 108, No. 25, June 23, 1971, p. 35.
[93] Chemical Week. Small Plant Tries to Make It Big in Nuclear Fuel. V. 109, No. 7, Aug. 18, 1971, pp. 91–98.
[94] Chemical Engineering. Reprocessing Plants Rev-Up. V. 78, No. 19, Aug. 23, 1971, pp. 34–38.

clear power development. These waste materials require collection, transportation, treatment, and disposal by permanent burial or by storage for release to the environment under controlled conditions. The AEC estimated that a 1,000-megawatt BWR produces 1,500 to 5,000 cubic feet per year of waste materials, and a PWR produces 1,000 cubic feet per year, depending on method of plant operation and waste solidification system.[95] These include high-level wastes (intense, penetrating radiation and high thermal power) and alpha wastes (principally solid materials, contaminated with Pu, of low thermal power and penetrability but extremely toxic), both of which must be contained outside the biosphere for thousands of years.

The objective of the AEC's waste management program was long-term storage of AEC-generated high-level and plutonium wastes, establishment of a Federal repository for wastes from commercial nuclear operations, and the reduction and control of radioactivity to the environment from waste management activity. AEC-generated wastes were stored at the Hanford facilities, Richland, Wash.; Savannah River, S.C.; and the NRTS, Idaho Falls, Idaho. At Hanford, in-tank concentration and solidification were practiced, reducing the volume and mobility of the wastes. A new heating system converted wastes to solid granules occupying 10 percent of the space required for the liquid form. At Savannah River, liquid wastes were converted to a high-density slurry for deep underground storage. Storage in solid granular form was also practiced at the NRTS Waste Calcining Facility.

AEC and private research continued on waste solidification. Four methods were under consideration: fluid bed calciner, pot calcination, spray calcination, and phosphate glass solidification. Technology has been developed with full-activity-level wastes and commercial-scale equipment. At West Valley, N.Y., Nuclear Fuel Services, Inc., disposes of high-level wastes in concrete-enclosed steel tanks, 600,000 gallon capacity. General Electric planned waste conversion to solids by the fluid bed calciner process at its Morris, Ill., processing plant. In this method, the waste is concentrated in an evaporator, then fluid-bed calcined to solid form, and then placed in corrosion-resistant steel containers submerged in water-filled basins for cooling and shielding pending shipment to a Federal repository.

The AEC had tentatively selected an abandoned salt mine near Lyons, Kans., for permanent storage of high-level solids and transuranium radioactive wastes, although late in the year new data indicated a possible future problem with entry of water into the storage site. Disposal site selection in salt formations should meet the following criteria:[96] depths of 500 to 2,000 feet, thickness of at least 200 feet for adequate heat dissipation and isolation above and below storage chamber, horizontal extent of several tens of miles, tectonic stability, relative isolation from large population centers, access by rail and motor freight, social acceptance, and presence of an existing mine (to expedite construction and reduce costs).

The AEC was investigating deep, long-term storage of high-level wastes in crystalline bedrock, 1,500 to 2,000 feet deep, near its Savannah River Operations Office. Two drill cores were obtained in basalt, 4,500 feet deep, testing the feasibility of storage in deep underground openings near the AEC's Hanford operations, Richland, Wash.[97] The U.S. Geological Survey conducted research to evaluate the effects of wastes injected into the ground on subsurface water supplies. Data were obtained on effects of these wastes on rock structures, rock stresses, hydraulic stresses, and chemical reactions.[98]

[95] Pages 158–162 of work cited in footnote 9.
[96] Blomeke, J. O., and W. C. McClain. A Salt Mine Repository for Radioactive Wastes. Nuclear News, v. 14, No. 4, April 1971, pp. 35–38.
[97] Chemical and Engineering News. Radioactive Waste. V. 49, No. 32, Aug. 9, 1971, p. 81.
[98] Chemical and Engineering News. Underground Waste Study. V. 49, No. 34, Aug. 23, 1971, p. 37.

Vanadium

By Harold A. Taylor, Jr.[1]

The domestic supply of vanadium was more than adequate to meet the domestic demand. Demand abroad was also weak. Domestic production was down somewhat from that in 1970. Exports of both ferrovanadium and oxide were only a fraction of those in 1970, whereas imports of ferrovanadium were higher although nowhere near the levels of 1969 and 1968.

Legislation and Government Programs.—The President imposed a 10-percent ad valorem surcharge on all dutiable imports up to the statutory limit from August 16 to December 20, 1971. This applied to all forms of vanadium except ore and concentrate. The simultaneously declared price controls posed no problems, because the adequate supply and shrinking demand for vanadium in 1971 would have kept the prices down in any event.

The Government made no offerings or sales of the surplus vanadium in its stocks in 1971. On August 11, the President signed Public Law 92–112 authorizing the disposal, preferably by publicly advertised bid, of 1,200 short tons of vanadium contained in material held in the national stockpile.

As of December 31, 1971, the Government's inventory included 3,329 short tons of vanadium, all of which was in the national stockpile. Of the 3,329 tons, ferrovanadium comprised 1,200 tons, and vanadium pentoxide 2,129 tons.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1967	1968	1969	1970	1971
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium [1]	4,963	6,483	5,577	5,319	5,252
Value ... thousands	$21,331	$23,143	$26,334	$34,923	$37,690
Vanadium pentoxide recovered	5,921	6,149	5,906	5,594	5,293
Consumption	5,245	5,495	6,154	5,134	4,802
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	351	278	644	2,155	676
Vanadium ores, concentrates, oxides, and vanadates	788	463	258	973	260
Imports (general):					
Ferrovanadium (gross weight)	14	626	449	21	89
Ores and concentrates	42	31	--	--	--
World production	10,266	13,331	18,581	20,805	20,894

[1] Measured by receipts of uranium and vanadium ores and concentrates at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

DOMESTIC PRODUCTION

The Colorado Plateau uranium-vanadium ores were still the principal domestic source of vanadium, but not by a large margin. The amount of vanadium recovered from Arkansas vanadium ore increased, and the amount of vanadium recovered from ferrophosphorus also increased. In addition, some of the mills processed vanadium residues, spent catalysts, and foreign vanadiferous slag. The recovered vanadium pentoxide figures in tables 1 and 4 do not include vanadium recovered from imported vanadiferous slag.

The mill of Union Carbide Corp. at Rifle, Colo., was the only mill recovering significant quantities of vanadium from domestic uranium-vanadium ores in 1971. The Kerr-McGee Corp. plant at Soda Springs, Idaho, recovered vanadium from byproduct ferrophosphorus, as did the Union Carbide Corp. plant at Hot Springs, Ark. The Hot Springs plant also recovered all of the vanadium that was recovered from Arkansas vanadium ore.

Table 2.—Recoverable vanadium of domestic origin produced in the United States, by States

(Short tons of contained vanadium)

State	1967	1968	1969	1970	1971
Colorado	3,317	3,492	W	W	W
Utah	471	563	W	257	226
Other States [1]	1,175	2,428	W	W	W
Total	4,963	6,483	5,577	5,319	5,252

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Includes Arizona 1967–69, Arkansas 1968–71, Idaho 1967–71, New Mexico 1967–71, South Dakota 1967 and 1970, Wyoming 1967.

Table 3.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons)

Year	Mine production [1]	Recoverable vanadium [2]
1967	5,088	4,963
1968	7,105	6,483
1969	5,737	5,577
1970	5,793	5,319
1971	5,547	5,252

[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 4.—Production of vanadium pentoxide in the United States [1]

(Short tons)

Year	Gross weight	V_2O_5 content
1967	10,915	10,569
1968	12,105	10,976
1969	12,120	10,542
1970	11,035	9,986
1971	10,492	9,448

[1] Includes vanadium pentoxide and metavanadate produced directly from all domestic sources, plus small byproduct quantities from imported chromium ores.

CONSUMPTION AND USES

Domestic consumption of vanadium contained in ferrovanadium, alloys, and other forms declined again in 1971. The decline was in all end-use categories except alloy steels and cast irons.

Foote Mineral Co. marketed a new vanadium ferroalloy under the trade name Ferovan. Ferovan contains a minimum of 42 percent vanadium; typically it contains 42.6 percent vanadium, 6.5 percent silicon, 6.4 percent chromium, 3.6 percent manganese, and 0.75 percent carbon. Compared to vanadium carbide products, it was claimed to have the advantages of dissolving more rapidly and dispersing throughout the steel more uniformly.

A strike in October by the United Steelworkers of America closed down the ferroalloy plants of Foote Mineral Co. for 2 weeks.

The Simonds Abrasive Div. of Wallace-Murray Corp. announced a new abrasive, trade named Emrald, which was said to be harder and stronger than other forms of aluminum oxide. The new abrasive is produced by adding vanadium to molten aluminum oxide.

Table 5.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1970 Consumption	1970 Ending stocks	1971 Consumption	1971 Ending stocks
Ferrovanadium [1]	4,325	903	4,171	544
Oxide	138	19	143	24
Ammonium metavanadate	44	11	35	9
Other [2]	627	91	453	68
Total	5,134	1,024	4,802	645

[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 6.—Consumption of vanadium in the United States, by end uses

(Short tons of contained vanadium)

End Use	1971
Steel:	
Carbon	830
Stainless and heat resisting	30
Alloy (excluding stainless and tool)	2,530
Tool	441
Cast irons	56
Superalloys	14
Alloys (excluding alloy steels and superalloys):	
Cutting and wear-resistant materials	8
Welding and alloy hard-facing rods and materials	10
Nonferrous alloys	363
Other alloys [1]	7
Chemical and ceramic uses:	
Catalysts	114
Other [2]	W
Miscellaneous and unspecified	399
Total	4,802

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' inventory reported in table 5, producers' stocks of vanadium as fused oxide, precipitated oxide, metavanadate, metal, alloys, and chemicals totaled 3,775 short tons of contained vanadium at yearend 1971, compared with 2,787 tons at yearend 1970.

PRICES

The price for export merchant technical-grade vanadium pentoxide continued to be quoted by Metals Week at its December 1970 level of $2.00 per pound of contained V_2O_5, until late March. From late March to the end of June, the quote was $1.55 per pound, then dropping to $1.50 per pound where it held through the end of the year.

The producer price for technical-grade, air-dried, vanadium pentoxide stayed at the late 1970 level of $2.02 per pound of contained V_2O_5, f.o.b. plant, until April 1. From April 1 through the end of the year, it was $2.21. The late 1970 producer price for 98 percent fused vanadium pentoxide, $1.94 per pound of contained V_2O_5, held until April, when Foote Mineral Co. and Union Carbide Corp. raised the price for their material to $2.12. This material goes mostly to the chemical industry. At the same time, Kerr-McGee Chemical Corp. set its new price for 98 percent fused at $1.55, lowering it in July to $1.50. This material is not as highly refined and goes primarily to the metallurgical market. These producer prices for 98 percent fused were maintained throughout the rest of the year.

The price for standard domestic ferrovanadium began and ended the year at

$4.12 per pound of contained vanadium, f.o.b. shipping point (usually the producer's plant). Similarly, the price of Carvan stayed at $3.48 per pound of contained vanadium during the entire year. Solvan was priced at $3.48 until phased out of the market in late April, to be replaced by Ferovan at a price of $3.68, holding from its introduction in May through the end of the year. The price quoted by Metals Week for ferrovanadium exported by dealers began the year at $4.50, stayed at this level until late March, and then dropped to a nominal $4.25 until early July. For the rest of the year Metals Week quoted no price but just listed it as nominal.

FOREIGN TRADE

Throughout all of 1971 the general monthly trend was downward for exports of both ferrovanadium and vanadium ores, concentrates, and oxides. The average declared value for exports of ore, concentrates, and technical-grade oxides was $1.98 per pound of contained vanadium pentoxide in 1971, as compared with $1.67 in 1970. The average declared value for exports of ferrovanadium in 1971 was $2.58 per pound of alloy, as compared with $2.81 in 1970.

No imports of vanadium ore and concentrates arrived in 1971. Imports of vanadium pentoxide for consumption totaled 108,238 pounds valued at $163,542, almost all from West Germany. The 138,000 pounds of ferrovanadium imported for consumption shown in table 8 contained 110,232 pounds of vanadium.

Imports of vanadiferous slag, classified as metal bearing residues, were estimated to be on the order of 4 million pounds of contained vanadium in both 1971 and 1970. They came from Chile, the Republic of South Africa, and the U.S.S.R. in both years.

Table 7.—U.S. exports of vanadium, by countries

(Thousand pounds and thousand dollars)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)				Vanadium ore, concentrates, pentoxide, vanadic acid, vanadium oxide and vanadates (except chemically pure grade) (vanadium content)			
	1970		1971		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	44	$139	9	$30	5	$12	--	--
Australia	20	70	5	13	(1)	(1)	--	--
Austria	--	--	--	--	91	298	127	$360
Belgium-Luxembourg	132	358	--	--	14	41	--	--
Brazil	28	85	8	23	--	--	20	49
Canada	912	2,161	450	1,178	22	62	48	217
Chile	--	--	2	5	1	3	16	21
Colombia	(1)	2	--	--	--	--	--	--
Czechoslovakia	--	--	--	--	123	328	121	633
Dominican Republic	--	--	(1)	1	--	--	--	--
France	125	372	80	234	172	456	12	29
Germany:								
East	275	812	--	--	--	--	--	--
West	402	1,269	9	12	662	2,130	2	6
Hungary	32	51	--	--	--	--	--	--
India	156	418	172	493	15	48	57	208
Iran	--	--	--	--	35	64	--	--
Israel	--	--	4	9	--	--	--	--
Italy	72	220	--	--	45	151	27	88
Japan	1,102	3,044	312	772	307	828	29	86
Korea, Republic of (South)	--	--	6	9	--	--	--	--
Mexico	254	726	137	300	8	31	24	50
Netherlands	335	1,036	132	391	165	430	--	--
New Zealand	--	--	--	--	1	2	--	--
Poland	--	--	--	--	2	6	--	--
South Africa, Republic of	--	--	--	--	(1)	1	--	--
Spain	108	363	--	--	--	--	--	--
Sweden	220	739	--	--	187	663	--	--
Switzerland	--	--	25	20	--	--	--	--
United Kingdom	71	191	--	--	87	248	37	87
Yugoslavia	21	71	--	--	--	--	--	--
Zambia	--	--	--	--	4	6	--	--
Total	4,309	12,127	1,351	3,490	1,946	5,808	520	1,834

[1] Less than ½ unit.

Table 8.—U.S. imports of ferrovanadium, by countries

(Thousand pounds and thousand dollars)

Country	General imports				Imports for consumption			
	1970		1971		1970		1971	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Germany, West	31	$86	177	$439	47	$114	138	$360
Sweden	11	29	--	--	--	--	--	--
Total	42	115	177	439	47	114	138	360

WORLD REVIEW

In addition to the nations listed in table 9, some others had relatively small vanadium production from secondary, waste, or byproduct sources. The Japanese recover vanadium from several different sources. Canada recovered vanadium from secondary and byproduct sources. West Germany probably recovered vanadium from such sources as vanadiferous slag and South-West African lead vanadate concentrate.

The world market for vanadium in 1971 was very weak.

Australia.—Garrick Agnew Pty., Ltd. has discovered a large deposit of vanadiferous magnetite-bearing ore at Coates, Western Australia, only 47 miles from Perth. Their 370-hole drilling program has revealed reserves of over 140,000 short tons of vanadium to a depth of 600 feet. About 80 percent of the vanadium would come from the primary ore, which would be beneficiated magnetically to yield a concentrate containing over 1.1 percent vanadium, and 20 percent would come from weathered rock amenable to direct extraction. Subject to further metallurgical testing and the satisfactory completion of tentative sales agreements, they are proposing an initial plant capacity of 840 and a possible ultimate plant capacity of 2,800 short tons of vanadium per year.

Ferrovanadium Corp. N.L. has begun to delineate what could be a large vanadium-bearing titanomagnetite ore body at Barrambie, 285 miles northeast of Geraldton, Western Australia. Indicated reserves to date from limited drilling are about 100,000 short tons of vanadium in ore averaging 0.26 percent vanadium to a depth of 200 feet over a tested strike length of 6,700 feet. The deposit may be deeper than 700 feet and outcrops along a strike length of over 11 miles.

Canada.—In early 1971, Masterloy Products Ltd. of Ottawa started up a new plant, adjacent to its ferroalloy plant, which will recover vanadium pentoxide from secondary raw material. At present, Masterloy uses most of the pentoxide recovered in its new plant to make ferrovanadium, but when it reaches the envisioned annual output of 560 short tons of contained vanadium as pentoxide, the firm plans to sell a significant amount of the excess pentoxide. Presently the raw material includes a vanadium-rich flue dust from a nearby powerplant and a vanadium-rich waste that Aluminium Company of Canada, Ltd. (Alcan), had to recover from the recirculating barren liquor at its Arvida alumina plant.[2]

The vanadium byproduct plant of Petrofina Canada, Ltd., was reportedly not operating in 1971.

Germany, West.—According to West German trade statistics, West Germany imported 31,016 short tons (gross weight) of vanadium-containing ashes, residues, and slag in 1970, compared to 30,706 tons in 1969. Of the 1970 total, 11,421 short tons came from the Republic of South Africa (8,279 tons in 1969), 8,502 tons from the U.S.S.R. (16,609 tons in 1969), 2,825 tons from France, 2,578 tons from Belgium-Luxembourg, and the balance from other nations—all European except for the United States (79 tons).

India.—The Iron and Steel Ministry of the Government of India estimated that domestic demand for ferrovanadium for use in alloy steel should be 1,000 short tons by 1973–74.[3] In 1970, 9 short tons of

[2] Metal Bulletin Monthly. Masterloy. No. 7, July 1971, p. 58.

[3] Mining Journal (London). India: Ferro-Vanadium Complex. V. 277, No. 7108, Nov. 12, 1971, p. 437.

Table 9.—Vanadium: World production from ores and concentrates, by countries

(Short tons of contained vanadium)

Country	1969	1970	1971 p
Chile e	600	610	660
Finland (in vanadium pentoxide product)	1,484	1,450	1,222
France e 1	100	100	100
Norway e	r 1,110	1,190	1,160
South Africa, Republic of:			
Content of pentoxide and vanadate products	2,859	2,665	e 2,800
Content of vanadiferous slag product	3,300	5,434	e 5,550
Total	6,159	8,099	e 8,350
South-West Africa, Territory of: (in lead-vanadate concentrate)e	500	660	650
U.S.S.R. (in slag exports)2	3,051	3,377	3,500
United States (recoverable vanadium)	5,577	5,319	5,252
Total	r 18,581	20,805	20,894

e Estimate. p Preliminary. r Revised.
1 Byproduct from bauxite.
2 Partial figure representing only that vanadium contained in exported slags; does not include vanadium produced for domestic consumption or for export in any other form.

ferrovanadium was produced, compared with 26 tons in 1969. India exported 22 short tons (gross weight) of low-grade vanadium ore valued at $936 in 1970, and 5,236 short tons (gross weight) valued at $258,967 in 1969.

The Industrial Development Corp. of Orissa Ltd., a state-owned corporation, is making preliminary plans to set up a complex with a capacity of 530 short tons of ferrovanadium which will use the vanadiferous titanomagnetite ores of Mayurbhanj District as raw materials.[4] In addition, a move is afoot in the private sector to recover vanadium pentoxide from local ores.

Japan.—According to Japanese Ferro Alloy Association figures, Japan purchased 2,846 tons and consumed 2,517 tons of vanadium pentoxide in 1970. Of this 2,517 tons, Nippon Denko consumed 1,064 tons, Awamura Kinzoku 555 tons, Japan Metals 416 tons, Taiyo Koko 319 tons, and other companies the remainder.[5] Japan produced 2,833 short tons of ferrovanadium in 1970, while stocks increased from 179 short tons at the end of June 1970, to 510 short tons at the end of June 1971.[6]

NGK Insulator completed its plant to produce vanadium metal and aluminum-vanadium alloys by a new process which involves using vanadium residue from titanium sponge production as a raw material.[7]

New Zealand.—Consolidated Mining Co. of New Zealand reported discovering near the Lake Manapouri power project a large vanadium-bearing titanomagnetite ore body which is estimated to contain about 50 million tons of ore.

South Africa, Republic of.—The Otavi mining group of West Germany has reportedly decided to set up a joint venture company with Vereinigte Aluminium-Werke A.G. which would build a plant to recover 840 tons of contained vanadium per year as pentoxide from magnetite containing 0.9 percent vanadium. The new company would be known as Transvaal Alloys Ltd.[8]

Highveld Steel and Vanadium Corp., Ltd., had an output of 31,736 short tons of vanadium-bearing slag in the fiscal year ending June 30, 1971, as compared to 30,383 short tons in the previous fiscal year. The increase in output of vanadium-bearing slag was the result of a substantial rise in the amount of vanadium-containing scrap iron used in the steel plant, and occurred in spite of lost hot metal production in the iron plant caused by problems with electrode failure in the furnaces.

The company's Vantra Division commissioned its plant expansion on schedule and increased its vanadium pentoxide production by 4.8 percent over that of the previous fiscal year. The company's high-grade rubble ore at Kennedy's Vale was almost exhausted, and future feed for the Division will be of lower average grade. Opening of the new Northam mine in the Rustenburg district was postponed because of poor market conditions for vanadium. The new mine was designed to take up the slack caused by the drop in ore grade at Kennedy's Vale.

4 Work cited in footnote 3.
5 Metal Bulletin (London). V Consumption in Japan. No. 5612, July 2, 1971, p. 22.
6 ———. Japanese Production, Stock Statistics. No. 5636, Sept. 28, 1971, p. 17.
7 ———. New Vanadium Process. No. 5633, Sept. 17, 1971, p. 20.
8 ———. New Vanadium Production. No. 5616, July 16, 1971, p. 18.

TECHNOLOGY

The Bureau of Mines and other research organizations continued to investigate topics relating to the possible use of vanadium alloys as a structural material in fast-breeder reactors. In the course of this work, the Bureau developed an electrochemical process for the preparation of vanadium from a commercially available vanadium carbon alloy (Carvan). Electrolysis of the vanadium carbon alloy in a $BaCl_2$-KCl-NaCl-VCl_2 electrolyte at 670° C using a helium-atmosphere, molten-salt electrolytic cell yields a ductile vanadium metal with a purity of 98 to 99.6 percent. This vanadium metal could be easily electrorefined to a 99.96-percent purity.[9]

The Bureau has also prepared high-purity vanadium by molten salt electrorefining a crude feed material obtained by the carbothermic reduction of vanadium pentoxide. The crude feed material was a mixture of vanadium and V_2C containing 90.2 percent vanadium, and the product was vanadium metal with a purity of 99.9 percent.[10]

The Bureau determined calorimetrically the enthalpy and free energy of formation of vanadium subnitride from 298° to 1,800° K, and showed similar data on the mononitride for comparison.[11] The solubility of nitrogen in alpha vanadium as a function of temperature at equilibrium pressure also was determined.[12]

The proposal of a new phase diagram for the V-VO system clarified the points of disagreement in earlier investigations.[13]

The Bureau developed and evaluated a processing method for recovering vanadium from weathered Nevada dolomitic shales containing about 0.6 percent vanadium as finely disseminated hewettite. After beneficiating the weathered shale by attrition grinding and rejecting the coarse low-vanadium fraction, salt roasting and subsequent leaching with dilute sulfuric acid extracted 75 percent of the vanadium contained in the beneficiated shale. Over 92 percent of the vanadium is concentrated by solvent extraction with ditridecylamine, stripped, and precipitated as recoverable ammonium metavanadate. Application of the processing method to the unweathered carbonaceous shale gave much poorer results than that obtained by using weathered shale.[14]

Some proposed processes for separating vanadium from various crude materials received patents during 1971. Mixing ground vanadiferous slag with a carbonaceous material, agglomerating the mixture, and then heating it at 1,260° to 1,540° C to drive off gases gives a dense high-vanadium material usable in vanadium steel production.[15] Vanadium oxide can be separated from the oxides of iron, titanium, and chromium by reducing ground vanadiferous slag or residue at 600° to 1,300° C while in contact with water vapor and oxygen, which entrains the vanadium hydroxide in the gas, and then cooling the gas below 600° C to deposit vanadium oxide.[16] Preheating vanadiferous slag in an inert atmosphere and then contacting the hot slag with oxygen to form soluble vanadium compounds renders these compounds leachable.[17] One process for recovering vanadium from its ore involves leaching the ore with an equimolar sodium carbonate-sodium bicarbonate solution at 60° to 250° C for 30 minutes to 8 hours; while the vanadium enters the leach solution, iron does not.[18]

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[9] Lei, K. P. V., and T. A. Sullivan. Electrolytic Preparation of Vanadium from V_2C-Type Carbide. BuMines Rept. of Inv. 7484, 1971, 17 pp.

[10] Lei, K. P. V., and T. A. Sullivan. Electrorefining of Vanadium Prepared by Carbothermic Reduction of V_2O_5. Met. Trans., v. 2, No. 8, August 1971, pp. 2312–2314.

[11] Pankratz, L. B., J. M. Stuve, H. O. Poppleton, L. L. Oden, and A. D. Mah. Enthalpy and Free Energy of Formation of Vanadium Subnitride ($VN_{0.465}$), 298° to 1,800° K. BuMines Rept. of Inv. 7585, 1971, 13 pp.

[12] Henry, J. L., S. A. O'Hare, R. A. McCune, and M. P. Krug. Solubility of Nitrogen in Alpha Vanadium From 600° to 1,200° C. J. Less-Common Metals, v. 25, No. 1, September 1971, pp. 39–47.

[13] Alexander, D. G., and O. N. Carlson. The V-VO Phase System. Met. Trans., v. 2, No. 10, October 1971, pp. 2805–2811.

[14] Brooks, P. T., I. L. Nichols, and G. M. Potter. Vanadium Recovery From Dolomitic Nevada Shale. Met. Soc. AIME, Paper A71–51, 1971, 10 pp.

[15] Merrill, T. W., T. J. McLeer, and D. O. Baker (assigned to Foote Mineral Co.). Recovery of Metallic Values From Metallurgical Slags. Canadian Pat. 860,866, Jan. 21, 1971.

[16] Chambers, G. H. Process of Extracting Vanadium. U.S. Pat. 3,607,005, Sept. 21, 1971.

[17] Vojkovic, M. (assigned to Masterloy Products Ltd.). Beneficiation of Vanadium-Containing Slags. Canadian Pat. 872,165, June 1, 1971.

[18] Bauer, W. C., and C. K. Amano (assigned to FMC Corp.). Extracting of Metals. Canadian Pat. 860,863, Jan. 12, 1971.

Vermiculite

By Frank B. Fulkerson [1]

Production of crude vermiculite in the United States in 1971 was 6 percent higher than in 1970, while value of production advanced 11 percent. Output of exfoliated vermiculite decreased 5 percent, but the value of this lightweight material gained 11 percent. The average unit value of crude vermiculite increased $1.10 per ton, and the average unit value of exfoliated vermiculite increased $14.82 per ton.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output increased 6 percent in 1971 to 301,000 tons. Two companies operating three mines supplied the entire domestic production. W. R. Grace & Co., Construction Products Division, with mines in Lincoln County, Mont., and Laurens County, S.C., was the principal producer. Patterson Vermiculite Co. also produced, from its mine in Laurens County, S.C. A new mill was being built by W. R. Grace & Co. at Libby, Mont. The $6.75 million wet processing plant was scheduled for completion in 1973. The facility will have a production capacity of 1,000 tons per day and will utilize a new beneficiation process to handle lower grade ores.[2]

Exfoliated Vermiculite.—Production of exfoliated vermiculite decreased 5 percent to 209,000 tons. The lightweight material was produced at 49 plants in 31 States. The major producing States were as follows, listed in order of output and with the respective number of plants in each State: California, three; Florida, five; Texas, three; South Carolina, two; Illinois, three; and New Jersey, three. The six States supplied 46 percent of the exfoliated vermiculite production. W. R. Grace & Co. selected Pompano Beach, Fla., as the site for a new exfoliating plant. The $560,000 plant will replace two at Boca Raton and Hialeah. The company also planned to erect a new plant at Atlanta, Ga.[3]

[1] Industry economist, Division of Nonmetallic Minerals.
[2] Rock Products. V. 74, No. 8, August 1971, p. 18.
[3] Rock Products. V. 75, No. 1, January 1972, p. 17.

Table 1.–Salient vermiculite statistics

	1967	1968	1969	1970	1971
United States:					
Sold and used by producers:					
Crude thousand short tons	255	290	310	285	301
Value thousand dollars	$4,974	$5,684	$6,805	$6,501	$7,198
Average value per ton	$19.51	$19.60	$21.95	r $22.81	$23.91
Exfoliated thousand short tons	180	213	250	221	209
Value thousand dollars	$14,278	$16,845	$19,916	$18,809	$20,885
Average value per ton	$79.32	$79.08	$79.66	$85.11	$99.93
World: Production, crude thousand short tons	371	421	466	431	457

r Revised.

CONSUMPTION AND USES

Producers of exfoliated vermiculite reported the following end-use pattern for 1971: Aggregates (concrete, plaster, cement), 40 percent; insulation (loose fill, block, pipe covering, packing), 38 percent; agriculture (horticulture, soil conditioning, fertilizer carrier, litter), 15 percent; and miscellaneous and unspecified, 7 percent. Three uses consisting of concrete aggregate (74,000 tons), loose fill insulation (71,000 tons), and horticulture (28,000 tons) totaled 173,000 tons and comprised 82 percent of the reported end use.

PRICES

The average value of crude vermiculite, screened and cleaned, at the mine, was $23.91 per short ton, compared with $22.81 in 1970. The average value of exfoliated vermiculite was $99.93, compared with $85.11 in 1970. The Engineering and Mining Journal quoted yearend prices for crude vermiculite beneficiated at the mine, as follows: Per short ton, f.o.b. mines, Montana and South Carolina, $21 to $35; and the Republic of South Africa, c.i.f. Atlantic ports, $29.55 to $40.15.

FOREIGN TRADE

The Republic of South Africa continued to be the only important source of vermiculite imports. The crude vermiculite was imported duty-free into the United States.

WORLD REVIEW

Canada.—Six companies operating 10 plants imported crude vermiculite from the United States and South Africa and produced 301,500 cubic yards of exfoliated vermiculite in 1970. Grace Construction Materials, Ltd., acquired four exfoliating plants at Vancouver, B.C.: Calgary, Alta.; Regina, Sask.; and Winnipeg, Man.; from Eddy Match Co., Ltd., Grant Industries Div. The following end-use percentages were reported by exfoliated vermiculite producers in 1970: Loose fill insulation, 63 percent; insulating plaster, 14 percent; insulating concrete, 11 percent; and minor uses, 12 percent.[4]

South Africa, Republic of.—Crude vermiculite production by Palabora Mining Co., the only major supplier of this mineral outside North America increased 11,200 short tons over production in 1970. The company began to expand the production capacity of its dry processing plant from 140,000 tons to approximately 175,000 tons per year. It was also modifying its processing method to permit milling lower grade ores while at the same time controlling pollution more effectively. The $1.5 million project was scheduled to be completed in 1972.

[4] Wilson, H. S. Lightweight Aggregates, 1970. Dept. of Energy, Mines, and Resources, Ottawa, July 1971, 4 pp.

Table 2.—Vermiculite: Free world production by country

(Short tons)

Country	1969	1970	1971 p
Argentina	5,023	3,917	e 3,900
Brazil e	4,240	4,240	4,240
India	4,388	801	273
Kenya	855	1,839	1,498
South Africa, Republic of	142,184	134,367	145,582
Tanzania	136	165	--
United States (sold or used by producers)	309,467	285,331	301,483
Total	466,293	430,660	456,976

e Estimate. p Preliminary.

Table 3.—Republic of South Africa: Exports of vermiculite by country

(Short tons)

Country	1969	1970	1971
Australia	3,666	3,276	NA
Belgium	1,449	1,246	
Canada	4,892	7,147	
Finland	977	884	
France	9,381	11,736	
Germany, West	14,947	14,927	
Ireland	--	1,443	
Italy	27,021	21,196	
Japan	7,343	9,634	
Netherlands	1,348	958	
Spain	4,096	4,787	
Sweden	2,521	2,865	
Switzerland	716	765	
United Kingdom	27,335	31,970	
United States	6,497	12,083	
Undisclosed	3,395	2,695	
Total	115,584	127,612	136,290
Total value [1]	$2,409,697	$3,150,288	$3,147,050
Average value per ton [1]	$20.85	$24.69	$23.09

NA Not available.

[1] Converted to U.S. currency at the rate of 1 rand equals US$1.40.

TECHNOLOGY

A patent was reported that included crude vermiculite as one of the ingredients in a core composition for use in fire resistant gypsum board.[5]

A batch composition was patented in 1971 for the manufacture of phosphate-bonded magnesia refractories and included phosphoric acid absorbed in exfoliated vermiculite.[6]

A fire-resistant asphaltic composition was patented in 1971 that utilized crude vermiculite as an intumescing agent.[7]

A patent was issued for a process using exfoliated vermiculite to produce asbestos wallboard and paper of improved dielectric strength. The vermiculite is distributed through an asbestos-binder composition, the mixture formed into sheets, the sheets wetted with aqueous solutions of aluminum phosphate, the wet sheets pressed to improve their density, and the pressed sheets dried.[8]

A heat insulating filling for the walls of safes, vaults, and record containers was patented. The filling consists of wax capsules containing water and enclosed in exfoliated vermiculite.[9]

A method of making seed capsules using thin blanks pressed from a mixture of exfoliated vermiculite and a binder was patented. The seeds are placed on indentations formed on the upper surface of the blanks and then covered with an additional increment of the mixture.[10]

A method was patented for cooling steel ingots under a layer of exothermic material which in turn is covered by an insulating slab 1 to 3 inches thick and composed of exfoliated vermiculite and a binder.[11]

[5] Green, G. W., and D. G. Sundberg (assigned to Georgia-Pacific Corp.). Fire Resistant Wallboard. U.S. Pat. 3,616,173, Oct. 26, 1971.

[6] Criss, G. H. (assigned to Dresser Industries, Inc.). Phosphate-Bonded Monolithic Refractory Batch. U.S. Pat. 3,615,774, Oct. 26, 1971.

[7] Koons, R. E. (assigned to Monsanto Co.). Asphaltic Based Fire-Resistant Compositions Utilizing Vermiculite Ore Intumescing Agent. U.S. Pat. 3,556,819, Jan. 19, 1971.

[8] Breiner, R. C. (assigned to Nicolet Industries Inc.). Asbestos Materials of High Dielectric Strength. U.S. Pat. 3,576,708, Apr. 27, 1971.

[9] Bohland, R. J. (assigned to Diebold, Inc.). Heat Insulating Material for Insulated Containers, U.S. Pat. 3,600,312, Aug. 17, 1971.

[10] Brink, E. H. (assigned to FMC Corp.). Seed Capsules and Method of Making Same. U.S. Pat. 3,555,730, Jan. 19, 1971.

[11] Copeland, E. (assigned to Hoben Davis, Ltd.). British Pat. 1,253,232, Nov. 10, 1971.

Table 4.—Vermiculite exfoliating plants in the United States in 1971

Company	State	County
Arizonolite Co	Arizona	Maricopa.
Carolina Wholesale Florist Co	North Carolina	Lee.
Cleveland Gypsum Co., Division of Cleveland Builders Supply Co.	Ohio	Cuyahoga.
Construction Products Division, W. R. Grace & Co.	Arkansas	Pulaski.
	California	Alameda, Los Angeles.
	Colorado	Denver.
	Florida	Dade, Duval, Hillsborough, Palm Beach.
	Illinois	Cook.
	Kentucky	Campbell.
	Louisiana	Orleans.
	Maryland	Prince Georges.
	Massachusetts	Hampshire.
	Michigan	Wayne.
	Minnesota	Hennepin.
	Missouri	St. Louis.
	Nebraska	Douglas.
	New Jersey	Mercer.
	New York	Cayuga.
	North Carolina	Guilford.
	Oregon	Multnomah.
	Pennsylvania	Lawrence.
	South Carolina	Greenville.
	Tennessee	Davidson.
	Washington	Spokane.
	Wisconsin	Milwaukee.
Coralux Perlite Corp. of New Jersey	New Jersey	Middlesex.
Hyzer & Lewellen	Pennsylvania	Bucks.
International Vermiculite Co	Illinois	Macoupin.
La Habra Products, Inc	California	Orange.
McArthur Co	Minnesota	Ramsey.
Mica Pellets, Inc	Illinois	De Kalb.
The B. F. Nelson Manufacturing Co	Minnesota	Hennepin.
Patterson Vermiculite Co	South Carolina	Laurens.
Robinson Insulation Co	Montana	Cascade.
	North Dakota	Ward.
Schmelzer Sales Associates, Inc	Florida	Hillsborough.
Southwest Vermiculite Co	New Mexico	Bernalillo.
Supreme Perlite Co	Oregon	Multnomah.
Texas Vermiculite Co	Oklahoma	Oklahoma.
	Texas	Bexar, Dallas.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu.
Vermiculite Industrial Corp	New Jersey	Essex.
Vermiculite-Intermountain	Utah	Salt Lake.
Vermiculite Products, Inc	Texas	Harris.

Zinc

By Albert D. McMahon[1]

Mine and smelter closures, the cost-price squeeze, imposition of the surcharge on imports, ceiling price controls, and devaluation of the dollar all combined to make 1971 a difficult year for the zinc industry. Ten mines were shut down during the year with a loss of approximately 30,000 tons of recoverable zinc at the 1970 rate of production. Operations at four slab zinc producing plants, one electrolytic plant, one horizontal retort smelter, and two vertical retort smelters were terminated, and the United States lost 255,000 tons of zinc smelting capacity. Reported consumption was about 6 percent higher in 1971 with all the increase accruing in the first 6 months reflecting some additional inventory accumulation in anticipation of a possible steel strike. Strong demands for galvanized products in construction, and diecastings for the automobile and appliance markets, were evident in the first half of the year. Galvanizing of steel receded some in the second half, but brass and bronze rebounded after the vacation season in June and July, and zinc alloys remained strong after a slow month of July. However, the firm zinc position after July was attributed to the shortage of special high-grade zinc and lost production from The Anaconda Company's strikebound refinery at Great Falls, Mont.

General Services Administration (GSA) sales of zinc continued during the year on an off-the-shelf basis. New legislation for release of an additional 515,200 tons of zinc from the stockpile was held in abeyance by the House Armed Services Committee pending agreement between producers and GSA on the means of disposal over an extended period.

Net imports (general) in 1971 at 662,000 tons were 15 percent lower than those of 1970; the zinc content of imported concentrates fell 183,000 tons, and imports of metal rose 49,000 tons. The import surcharge, effective from August 16 to December 20, 1971, was limited to 1.0 cent per pound on the zinc content of imported concentrates and 1.05 cents per pound on imported metal.

The pricing of prime western zinc was changed to a delivered basis from f.o.b. East St. Louis, Ill., on January 5, 1971. Three increases raised the price from 15 cents per pound on March 22, 1971, to 17 cents on July 27, 1971, which held through the end of the year.

Legislation and Government Programs.—The GSA continued sales of zinc to industry for domestic consumption under authority of Public Law 89–322 enacted November 4, 1965, for disposal of 200,000 tons of zinc from the national stockpile. Transfers for Government use were made under Public Law 89–9 passed April 2, 1965. Sales through December for commercial use amounted to 2,017 tons and 20,580 tons remained of the quantity authorized for industry. Government transfers amounted to 90 tons leaving a balance of 22,097 tons of the 50,000 tons approved in Public Law 89–9. New legislation, Senate Bill 766, to authorize the disposal of approximately 515,200 tons of zinc from the national and supplemental stockpiles was introduced in the Senate February 11, 1971. The Senate passed the bill June 21, and it was referred to the House Armed Services Committee June 23 where consideration was deferred 90 days pending the outcome of a proposed "buy-back" agreement between GSA and producers. Hearings were held before the House Armed Services Sub-Committee December 2, and the bill was approved for full committee action. The Bill was signed by the President and became Public Law April 26, 1972.

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The International Lead and Zinc Study Group held its 15th annual meeting in Torremolinos, Spain, October 27–November 7, 1971. Early in the session statistical and other committees met to prepare reports for the plenary meetings starting November 2. The forecast estimates submitted for 1971 zinc mine and metal production and zinc consumption were revised downward reflecting the closing of smelters and refineries and the retarded economic conditions, particularly in the United States. Forecasts for 1972 indicate increases in all segments of the industry with the probability of a slight worldwide supply shortage. Other topics discussed at the meeting included liberalization of trade, the U.S. import surcharge, stimulation of consumption, and U.S. stockpile disposals.

The President's economic stabilization program, effected August 16, 1971, froze the price of zinc at 17 cents per pound and imposed a surtax on all imports of zinc amounting to 1 cent per pound on the zinc content of concentrates, 1.05 cents per pound on zinc metal, and an additional 10 percent of the ad valorem duties on zinc alloys and compounds. This additional tariff was imposed on all articles exported to the United States after 12:01 A.M. August 16, 1971. Warehouse entries and imports placed in foreign trade zones were exempt from the surtax providing they were withdrawn from warehouses or foreign trade zones for consumption prior to October 1, 1971. This surcharge was removed by presidential proclamation effective December 20, 1971.

Table 1.—Salient zinc statistics

	1967	1968	1969	1970	1971
United States:					
Production:					
Domestic ores, recoverable content____short tons__	549,413	529,446	553,124	534,136	502,543
Value________thousands__	$151,562	$142,950	$161,512	$163,650	$161,819
Slab zinc:					
From domestic ores short tons__	438,553	499,491	458,754	403,953	403,750
From foreign ores__do____	500,277	521,400	581,843	473,858	362,683
From scrap________do____	73,505	79,865	70,553	77,156	80,923
Total___________do____	1,012,335	1,100,756	1,111,150	954,967	847,356
Secondary zinc [1]________do____	247,254	276,092	307,714	264,074	279,508
Exports of slab zinc________do____	16,809	33,011	9,298	288	13,346
Imports (general):					
Ores (zinc content)______do____	534,092	543,366	602,120	525,759	342,521
Slab zinc______________do____	222,112	304,576	324,776	270,413	319,568
Stocks, December 31:					
At producer plants_____do____	81,916	65,379	65,788	98,314	41,285
At consumer plants_____do____	102,535	101,818	102,007	r 92,674	104,292
Consumption:					
Slab zinc______________do____	1,250,673	1,350,656	1,385,380	1,186,951	1,254,059
All classes_____________do____	1,605,862	1,745,357	1,814,167	1,571,596	1,650,585
Price: Prime Western, East St. Louis______cents per pound__	13.85	13.50	14.65	15.32	16.13
World:					
Production:					
Mine_____________short tons__	5,330,400	5,483,540	5,888,298	6,008,150	6,077,981
Smelter_______________do____	4,547,754	5,100,953	5,482,489	5,378,705	5,082,705
Price: Prime Western grade, London________cents per pound__	12.37	11.89	12.96	r 13.36	14.08

r Revised.
[1] Excludes redistilled slab zinc.

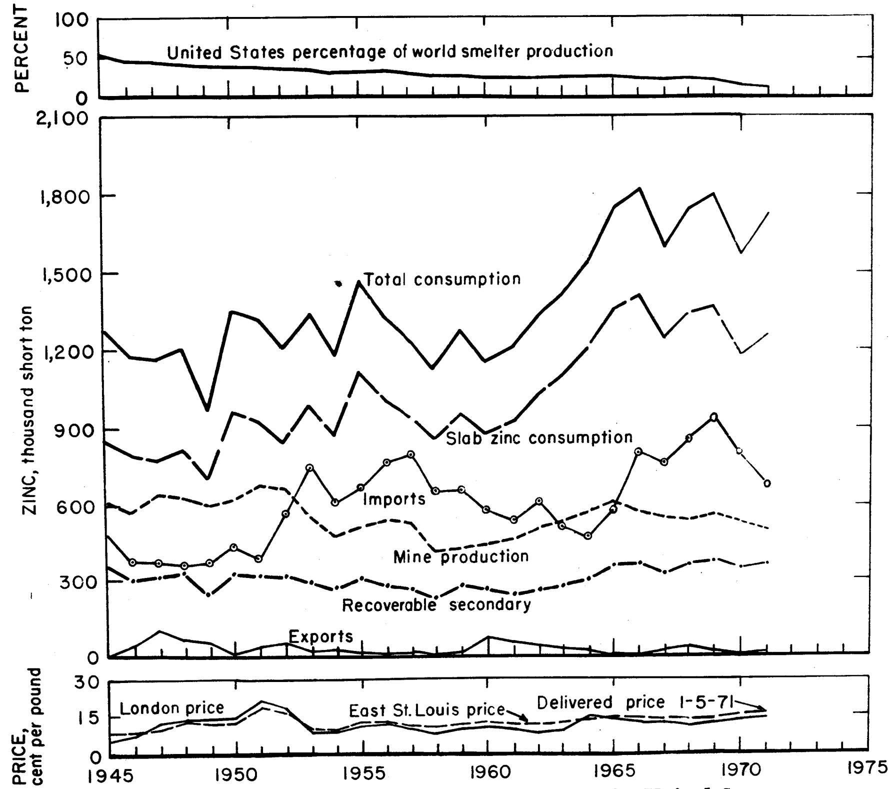

Figure 1.—Trends in the zinc industry in the United States.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mine production of recoverable zinc in the United States declined 6 percent in 1971 to 502,543 tons, the lowest annual output since 1961, reflecting several mine closures. Production was reported for only 19 States (22 in 1970) with six showing increases for 1971 over 1970 and 13 recording decreases; no production was reported for Kansas, Oklahoma, and South Dakota. Tennessee continued to rank first with an increase of 1 percent more zinc than in 1970. New York held on to second place with an 8 percent increase to 63,400 tons and Colorado was a close third at 61,200 tons, also showing an increase of 8 percent. Missouri with 48,200 tons of coproduct zinc mined in the southeast section, a decrease of 5 percent below 1970 production, ranked fourth. Idaho was fifth with a 10 percent increase from last year to 45,100 tons. The eastern States, consisting of Illinois, Kentucky, Maine, New Jersey, New York, Pennsylvania, Tennessee, and Virginia, accounted for approximately 58 percent of the U.S. mine production for 1971.

The sources of zinc production in 1971 are shown in table 4 according to the principal metal or combination of metals extracted. The percentage distribution is as follows: 51 percent from zinc ores; 30 percent from lead-zinc ores; 10 percent from lead ores; 7 percent from copper-lead-zinc ores; and 2 percent from all other sources. The average zinc content of the 6.8 million tons of zinc ore mined in 1971 was 3.74 percent, compared with 7.3 million tons of ore averaging 3.67 percent in 1970.

The 25 leading mines listed in table 5 accounted for 83 percent of domestic recoverable mine production. The five leading mines produced 32 percent and the first 10 contributed 53 percent. Fifteen mines that produced approximately 26,000 tons in 1970 and 20,000 tons in 1971 were shut down during the year principally because the smelters treating their concentrates were closed.

Tennessee accounted for 24 percent of the National total in 1971 extending its succession in the leading position among the States to 13 years. In fiscal 1971 American Zinc Co. milled 2,485,000 tons of crude ore from the Coy, Immel, New Market, and Young mines. The estimated proven and probable ore reserves for these four mines as of September 14, 1971, totaled 26,343,900 tons of ore averaging 3.76 percent zinc. All of the American Zinc Co. plants and mineral properties, including the mining properties and mill of the New Market Zinc Co. and other real estate interests in Tennessee were included in an "Agreement of Sale" between the American Zinc Co. and American Smelting and Refining Co. (ASARCO), which was dated March 25, 1971,[2] and which became effective November 20, 1971.[3]

The Flat Gap and Jefferson City mines of New Jersey Zinc Co., a subsidiary of Gulf & Western Industries, Inc., and the Zinc Mine Works of the United States Steel Corp. in the east Tennessee complex operated throughout the year. The New Jersey Zinc Co. completed the 1,325-foot prospecting shaft at Elmwood and began evaluation of the ore's commercial quality. Joint-venture partners may be sought to explore other sites of the middle Tennessee property controlled by New Jersey Zinc.[4] Occidental Minerals Corp. (Oxymin), a subsidiary of Occidental Petroleum Corp., controls approximately 10,000 acres near Carthage, Tenn., where exploration drilling has indicated flat-lying zinc deposits. Drilling was initiated in a new area late in 1971 for the possible existence of additional zinc deposits similar to that found previously.[5] Production of zinc concentrates at Copperhill, Tenn., by Cities Service Co. was 30-percent lower than in 1970. Several new units were placed in operation during 1971 as part of the major modernization and expansion of the mines and chemical plant at Copperhill. Product output is expected to increase up to 40 percent when the project is completed in 1972.[6]

Mine production in New York, all from the Balmat-Edwards Division mines of St. Joe Minerals Corp., was 8 percent higher than in 1970. The new Balmat No. 4 mine and mill, started in 1965, was opened on September 1971. The 1971 zinc concentrate production for the division was 118,679 tons, up from 110,494 tons in 1970. In 1972, zinc concentrate production is expected to reach 145,000 tons, 29,000 tons of which will be from the new mine. Mechanical mining methods are being installed to reduce manual operations in the older mines.[7] The corporation's No. 1 mine is at Edwards where the ore is mined at the rate of 600 tons per day from below 3,200 feet. Mining at Balmat extends from near surface to a depth of 2,200 feet. Balmat No. 2 mine produces 1,400 tons per day, and No. 3 produces 700. The new mine, No. 4, will have a daily capacity of 2,200 tons. Ore from Nos. 2, 3, and 4 is hoisted through one shaft to the surface and the central concentrator.

Production in New Jersey, Pennsylvania, and Virginia by the New Jersey Zinc Co. was 2,000 tons or 2.7 percent below that of 1970. Work on a hydraulic fill system at the Sterling, N.J. mine and additional mechanization is scheduled for 1972. The shaft at the Friedensville, Pa. mine is being deepened.

In Wisconsin the New Jersey Zinc Co. closed its three mines, Elmo No. 1, Elmo No. 2, and Kopp No. 3 when smelter operations were stopped at Depue, Ill.[8] State production was almost halved with a decline of 10,000 tons from the 1970 level. A large 24 percent reduction to 12,700 tons was also registered for Illinois in 1971.

Mine output in Colorado established a new record of 61,000 tons, an increase of 8 percent over that of 1970. New Jersey Zinc's Eagle mine produced the largest tonnage of zinc although somewhat less than last year. Newmont Mining Corp.'s Idarado mine was next, the new Resurrection mine was third, and the Sunnyside mine of Standard Metals Corp. ranked fourth. The zinc content of ore mined and milled from the Idarado mine increased 14 percent over 1970 but lower prices for metals other than zinc, rising costs, and a

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[2] American Zinc Co. Annual Report. 1971, p. 7.
[3] American Smelting and Refining Co. Fourth Quarter Report. 1971, p. 2.
[4] Gulf & Western Industries, Inc. Annual Report. 1971, p. 22.
[5] Occidental Petroleum Corporation. Annual Report. 1971, p. 12.
[6] Cities Service Co. Annual Report, 1971, p. 23.
[7] St. Joe Minerals Corp. Annual Report. 1971, p. 13.
[8] Gulf & Western Industries Inc. Annual Report. 1971, p. 22.

continuing shortage of skilled labor caused a sharp reduction in Idarado's net income. The new sublevel stopping method was continued during 1971 and an improvement in mining efficiency was evident as the year ended. Ore reserves at the end of 1971 were 2,785,000 tons averaging 4.91 percent zinc. The Resurrection mine, near Leadville, Colorado, a joint venture owned equally by Resurrection Mining Co., and ASARCO began production in April 1971 but had not reached full operating capacity by the end of the year. Ore reserves were estimated at 2,717,543 tons averaging 9.94 percent zinc.[9] Five small producing mines closed in the period May through August 1971. The Rico Argentine Mining Co. produced 18,000 tons of lead-zinc ore from the 700-foot level of the Argentine mine and concentrates produced contained approximately 1,000 tons of zinc and 10,000 pounds of cadmium. Mining and milling operations were suspended in May 1971, after nearly 32 years of continuous production because the price-cost squeeze made mining of small ore bodies unprofitable. Exploration is being continued in known mineralized areas in search of a large ore body.[10] The Dixilyn Corporation closed its four mines, the Old Hundred, Oceola Pride, Henrietta, and Ransome in June, July, and August 1971.

Mine production of zinc in Maine, entirely from the Penobscot mine of the Callahan Mining Corp., dropped 36 percent below the total for 1970. Continuing efforts to find ore have been disappointing and the operation should terminate in mid-1972.

Missouri continued in fourth place among the States although experiencing a 5 percent decrease in mine production for 1971. Byproduct zinc production by St. Joe Minerals Corp., Southeast Mining and Milling Division was 20 percent lower than in 1970. The Buick mine, a joint operation of AMAX Lead and Zinc Co. and the Homestake Mining Co. produced 40 percent more ore in 1971 than in 1970 and the improved grade resulted in approximately a 61 percent increase in lead and zinc concentrates. The Ozark Lead Company's zinc output in 1971 was somewhat lower than in 1970 as production at the Ozark lead-zinc mine was reduced because of the strike at ASARCO's lead smelter which buys Ozark's lead concentrates. The strike began in September 1970 and was not settled until April 1971. During 1971 Ozark continued to operate on a reduced schedule as the smelter processed lead concentrates accumulated during the strike.[11] The Magmont mine at Bixby, Mo., operated by Cominco-American Inc., a joint venture of Cominco and Dresser Industries, Inc., produced 1,040,000 tons of ore averaging 8.5 percent combined lead and zinc. In accordance with the long-term mining plan the grade of ore extracted was somewhat lower than in 1970 resulting in a 14 percent drop in metal content. Reserves estimated at the end of 1971 were 12.6 million tons containing 1,000,000 tons of lead and zinc.[12]

Neither Kansas nor Oklahoma recorded any mine production of zinc in 1971. Mine output of zinc in Idaho for 1971 increased 10 percent to 45,000 tons. The Bunker Hill mine operated by the Bunker Hill Co., a subsidiary of Gulf Resources & Chemical Corp., produced a larger tonnage of ore in 1971 and the average grade of zinc increased. The company continued its development of new zinc ore zones in the upper levels of the mine. Production from the first of these zones should be underway in the first half of 1972.[13] The Star-Morning mine, 70 percent owned by the Bunker Hill Co. and 30 percent owned by the Hecla Mining Co., but operated by the latter, produced 246,000 tons of ore in 1971, 14 percent more than in 1970, that averaged 6.72 percent zinc.[14] Day Mines Inc.'s Monitor mine was operated by independent contractors who produced and milled 18,750 tons of ore averaging 11.3 percent zinc. Ore reserves at yearend were sufficient for more than two years production.[15]

Mine output of zinc in Utah dropped 26 percent to 25,700 tons in 1971. The United States Smelting, Refining and Mining Co. terminated their lead-zinc operations as of September 30, 1971. These operations had been reporting losses since the last quarter of 1969. The loss in the first nine months of 1971 was over $2 million. The Utah units involved were the U.S. and Lark

[9] Newmont Mining Corp. Annual Report. 1971, p. 11 and 13.
[10] Rico Argentine Mining Company. Annual Report. 1971, p. 1.
[11] Kennecott Copper Corp. Annual Report. 1971, p. 22.
[12] Cominco Ltd. Annual Report. 1971, p. 2.
[13] Gulf Resources & Chemical Corp. Annual Report. 1971, p. 6.
[14] Hecla Mining Co. Annual Report. 1971, p. 8.
[15] Day Mines, Inc. Annual Report. 1971, p. 2.

mine, the Ophir mine, and the Midvale flotation mill.[16] Other Utah properties closed in 1971 were the Deer Trail mines and Arundel Mining Co.'s Deer Trail mine, McFarland and Hullenger's Silver Eagle mine and United Park City Mines Co.'s United Park City mine. Kennecott Copper Corp.'s Tintic Division continued to lower the ground water table in the Burgin mine to make high-grade ore accessible but mud flows and heavy ground delayed mining in some areas. Development work in the Ballpark area indicates that reserves there are fairly high grade and additional reserves were discovered in the Trixie area. The shortage of underground miners hindered mine development work during the year.[17] The Mayflower mine leased by Hecla Mining Co. from New Park Mining Co. produced 7 percent more ore in 1971 but the grade was lower causing an 8 percent drop in zinc content. Development work was curtailed as a result of previous poor showings in 1970 and continued production is rapidly depleting developed ore reserves.

In New Mexico ASARCO negotiated a lease with the Black Hawk Consolidated Mines Company to mine known ore bodies extending from the Ground Hog mine into the leased property.[18] United States Smelting, Refining and Mining Co. produced a small amount of byproduct zinc concentrates from their Continental copper mine near Bayard, N.M.[19]

Cyprus Mines Corp.'s Bruce mine near Bagdad, Ariz., operated near capacity in 1971 producing almost 7,000 tons of zinc in zinc concentrates. Mill heads averaged 12.4 percent zinc and 3.75 percent copper. Inclined tunnels are being driven in the ore body below the 2,150 level for development of the 2,300 and 2,450-foot levels. Known reserves are sufficient for 5 years' operation and the increase expected from exploration below the 2,150 level should add at least another year's operation.[20] The Callahan Mining Corp. purchased a mine and mill near Colville, Wash. early in 1971 and a study to determine the feasibility of developing a low-cost underground zinc-lead mine was started. The first stage, including 750 feet of access tunnel and drilling from this adit should be completed during the first quarter of 1972.[21]

Pend Oreille Mines and Metals Co. mined 252,492 tons of ore in 1971 and produced 10,206 tons of zinc concentrate, a 30 percent increase over 1970 production. Smelter environmental control costs deducted from payments for concentrates reduced returns for Pend Oreille by $3.50 to $4.00 per ton of concentrate shipped.

SMELTER AND REFINERY PRODUCTION

Production of slab zinc at smelters and electrolytic refineries in the United States declined 11 percent in 1971 to 847,356 tons reflecting the closure of four plants from April through August. Monthly data published by the Zinc Institute showed production rising each month from December 1970 through April. There was a slight drop in May and larger ones in June and July resulting from the termination of operations at two plants and another becoming strikebound. The low for the year was reached in September as two other smelters closed in August. Output from the remaining eight plants rose substantially in the last quarter of the year. Shipments followed the production trend, and, as demand remained fairly high through the year, producers' stocks declined 60 percent from 127,000 tons to 50,000 tons.

On February 12, 1971, the American Zinc Co. announced plans to close its electrolytic refinery at Sauget, Ill., and the horizontal retort smelter at Dumas, Tex., effective sometime after midyear. Approximately two weeks later the Matthiessen & Hegeler Zinc Co. reported they would phase out their vertical retort smelter at Meadowbrook, W. Va., sometime before August. On May 3, 1971, New Jersey Zinc Co. reported operations at Depue, Ill., would be terminated. The actual closings were effected in April for Matthiessen & Hegeler's Meadowbrook plant; in June for American Zinc's electrolytic plant at Sauget, Ill.; and both the American Zinc Co.'s smelter at Dumas and New Jersey Zinc Co.'s smelter at Depue stopped producing in August. The Anaconda Co.'s electrolytic refinery at Great Falls, Mont., with an annual production capacity of

[16] United States Smelting, Refining and Mining Co. Annual Report. 1971, p. 3.
[17] Kennecott Copper Corp. Annual Report. 1971, p. 22.
[18] ASARCO. Annual Report. 1970, p. 8.
[19] United States Smelting, Refining and Mining Co. Report to Stockholders. Mar. 15, 1972, p. 22.
[20] Cyprus Mines Corp. Annual Report. 1971, p. 6.
[21] Callahan Mining Corp. Annual Report. 1971, p. 5.

163,000 tons of slab zinc was strikebound from July 1 through September 22, 1971.

Refined zinc production by primary smelters and electrolytic refineries was derived from the following: Domestic ore, 48 percent; foreign ores, 43 percent; and scrap, 9 percent. The quantity of slab zinc produced from domestic ores in 1971 was approximately the same as that of 1970; but that from foreign ores was 23 percent lower and from scrap 5 percent more. Primary zinc refined at electrolytic plants was down 18 percent from that of 1970 and accounted for 38 percent of the total slab zinc produced; smelter production of primary zinc was 8 percent lower than in 1970 and made up 53 percent of the total. Redistilled secondary slab zinc produced from scrap by primary smelters increased 4 percent over 1970 and contributed 8 percent of the total; the increase from secondary smelters was 8 percent for only 1 percent of the total. Production of all grades of zinc declined except for an 11-percent increase in the intermediate class. The percentage distribution of the total was, by grades: Special high, 43 percent; high, 9 percent; intermediate, 7 percent; brass special, 8 percent; and prime western, 33 percent.

The American Zinc Co.'s East St. Louis refinery (Sauget, Ill.) was shut down in June 1971 for economic reasons. The company purchased the refinery in 1940 and operated it continuously since 1941. Production for the fiscal year ending June 1971 was 58,790 tons, which, was 23 percent lower than that for 1970. On July 1, 1971, the company granted AMAX an "Option Agreement" to purchase the refinery for $3 million. Throughout the balance of 1971 and into 1972, AMAX was engaged in a feasibility study to justify purchase of the plant. American Zinc Co.'s horizontal retort smelter in Dumas was shut down because of unprofitability in August 1971. Production of zinc metal in fiscal 1971 was 44,000 tons, 11,100 tons less than that of 1970.[22] The New Jersey Zinc Co. reported a sizeable loss in sales compared with 1970, but operating income more than doubled. One of the most significant actions was the closing of the unprofitable agricultural chemical and zinc smelting operations at Depue. Although this action benefitted earnings in fiscal 1971, the full effect of the closings will show up in fiscal 1972 earnings. Zinc metal production from all sources dropped 22 percent to 108,000 tons in 1971 from 128,000 tons in 1970.[23] Matthiessen & Hegeler Zinc Co. released plans to shut down their vertical retort smelter at Meadowbrook on February 24, 1971, and cease operations in April. This plant had been purchased from the DuPont Co. in 1950. Production in 1970 amounted to approximately 41,000 tons of slab zinc and zinc dust. The facility was later sold to T. L. Diamond & Co., which formed a new subsidiary, Meadowbrook Corp., to operate the plant. The new subsidiary will manufacture zinc dust and other zinc products from zinc drosses, ashes, and residues.

St. Joe Minerals Corp. produced 213,275 tons of zinc metal at their electrothermic smelter at Monaca, Pa., an increase of 11 percent from that of 1970. Zinc oxide production was up 8 percent from that of 1970 because of the recent expansion of zinc oxide facilities. Initial preparation work was completed for the installation of a new sulfuric acid unit to replace those in operation since 1931. The Southeast Missouri Mining and Milling Division recorded a 20 percent decrease in zinc concentrate production to 25,315 tons.[24] ASARCO's Amarillo, Tex. horizontal retort zinc smelter continued to operate under a variance issued by the Texas Air Control Board governing particulate emissions. Investigations by an outside engineering contractor are being conducted to determine if there is any practical way to control emissions from horizontal retort smelters. Zinc production for 1971 at this plant was 100 tons more than in 1970. The sulfuric acid plant at the Corpus Christi, Tex. zinc refinery has operated 29 years recovering the sulfur dioxide from the roaster gas streams. Installation of the new $3.5 million Lurgi fluidbed roasters was begun and will replace present roasting facilities in 1972. Production of special high grade zinc at Corpus Christi increased 3 percent to 87,100 tons in 1971.[25] AMAX's smelter at Blackwell, Okla., produced 85,000 tons of slab zinc in 1971, up from 81,000 tons in 1970. A substantial drop in the price of byproduct cadmium, together with higher costs of labor and supplies and lower zinc recoveries, reduced total profitability, although zinc metal sales were larger than

[22] Page 7 of work cited in footnote 2.
[23] Page 22 of work cited in footnote 8.
[24] Page 13 of work cited in footnote 7.
[25] Pages 10 and 11 of work cited in footnote 3.

in 1970. AMAX has an option to purchase American Zinc Co.'s electrolytic zinc refinery at Sauget, Ill. Reactivation of this plant would give the company 75,000 to 85,000 tons of special-high-grade zinc capacity.[26] In 1971, The Anaconda Co.'s zinc operations in Montana were curtailed 3 months because of a strike. Total production of slab zinc for the year was 119,418 tons, compared with 152,000 tons in 1970. Because of decreasing profitability and the inability to obtain sufficient feed material, the decision was made to shut down the zinc operations in Montana by mid-1972.[27] The Bunker Hill Co. produced 94,000 tons of zinc in 1971, 1,600 tons less than in 1970. Metallurgical difficulties with the electrolyte purification adversely affected scheduled production for several months, but by the end of the year these problems were resolved and zinc plant performance was improving. The company produced 5,700 tons of prime western zinc in order to broaden their markets to include galvanizing.[28]

In November, Eagle-Picher Industries, Inc., closed their Galena, Kan., zinc concentrate roasting plant and sulfuric acid unit, discontinuing roasting of zinc ores, refining cadmium, and producing sulfuric acid. Sales were reduced, but earnings improved by eliminating losses from these operations.[29]

Secondary Zinc Smelters.—Zinc recovered from processing zinc bearing scrap amounted to 359,200 tons compared with 339,500 tons in 1970. New scrap consisting of that generated in processing semimanufactured forms and shapes of alloys, primarily zinc-base and copper-base alloys, accounted for 78 percent of the new and old scrap processed. Increases were registered for all categories of new and old scrap except aluminum-base new scrap which was down 300 tons or 10 percent from 1970. Most of the zinc recovered (48 percent) was accounted for in reconstituted copper-base alloys (brass and bronze); slab zinc was next with 22 percent; zinc dust, 8 percent; and chemical products, 13 percent.

Slag-Fuming Plants.—Slag fuming plants process hot and cold lead blast-furnace slags containing from 7–15 percent zinc to produce a zinc oxide fume. This zinc oxide product is sent to zinc smelters or electrolytic refineries for recovery of the contained zinc and some is delivered to other consumers of zinc oxide. For years there were five of these plants in the U.S. but the ASARCO plant at Selby, Calif. closed at the end of 1970 and International Smelting & Refining Co.'s unit at Tooele, Utah was shut down along with the Tooele lead smelter at the end of November 1971. The following four plants were operating in 1971:

ASARCO	El Paso, Tex.
The Anaconda Company	East Helena, Mont.
The Bunker Hill Co	Kellogg, Idaho
International Smelting & Refining Co	Tooele, Utah

During the year, the material processed consisted of 552,727 tons of new hot slags and 50,867 tons of old cold slags. The yield of zinc oxide fume was 114,201 tons containing 81,313 tons of recoverable zinc, compared with 126,400 tons of fume and 87,560 tons of zinc in 1970.

Byproduct Sulfuric Acid.—In 1971 there were 16 plants with facilities for roasting zinc sulfide concentrates, and 10 were equipped with sulfuric acid producing units. Four of these plants were solely roasting operations producing zinc oxide for delivery to zinc smelters or electrolytic refineries for recovery of zinc or for sale to other consumers of zinc oxide; three of these had sulfuric acid plants. Six plants, one electrolytic refinery, 3 horizontal retort smelters, one vertical retort smelter, and one roasting plant did not have sulfuric acid producing facilities. In 1971, production of byproduct sulfuric acid from the zinc plants and two lead smelters was 971,946 tons, compared with 1,090,817 tons (revised) in 1970.

Zinc Dust.—Production of zinc dust was 50,259 tons in 1971 or 2 percent lower than that of 1970. Of this total, approximately 28,500 tons was produced from metal distilled from scrap.

[26] American Metal Climax. Annual Report. 1971, pp. 23, 24.
[27] The Anaconda Company. Annual Report. 1971, p. 11.
[28] Page 6 of work cited in footnote 13.
[29] Eagle-Picher Industries, Inc. Annual Report. 1971, p. 2.

CONSUMPTION AND USES

The consumption of slab zinc in the United States during 1971 totaled 1,254,059 tons, an increase of 6 percent over that of 1970. The zinc content of ore and concentrate used directly (without first producing metal) to make pigments and salts and in galvanizing was 119,254 tons (124,781 in 1970); and the zinc content of scrap processed to make alloys, zinc dust, and salts totaled 277,272 tons, up 7 percent from 1970. The overall total was 1,650,585, an increase of 5 percent above that of 1970.

The slab zinc consumption of 1,254,059 tons was reported by nearly 600 users in 1971. Galvanizing accounted for 38 percent of the total slab zinc consumed; brass products, 12 percent; die casting alloys, 40 percent; other zinc base alloys, 1 percent; rolled zinc, 3 percent; zinc oxide, 3 percent; and other uses, 3 percent. The total 67,000-ton increase reflects a 23,000-ton gain for brass and bronze, a 52,500-ton rise for zinc-base alloys, and a 9,000-ton loss for the three small-use categories. The use for galvanizing was very close to that of 1970.

The distribution by grade of slab zinc consumed in 1971 is as follows: Special high grade, 50 percent; high grade, 9 percent; intermediate, 1 percent; brass special, 9 percent; prime western, 31 percent; and remelt less than one-tenth of 1 percent. Compared with 1970, consumption of special-high-grade zinc rose 11 percent; high grade, 10 percent; intermediate, 118 percent; brass special dropped 6 percent and prime western was off 1 percent.

The slab zinc consumed by rolling mills in 1971 was 38,852 tons, a 5.4 percent decrease from 1970. Production of rolled zinc products dropped 2.5 percent to 38,263 tons most of which was strip and foil (66 percent) and photoengraving plate (30 percent). Imports decreased 183 tons to 509 tons and exports were up 274 tons to 1,686 tons. Under 2,000 tons were rerolled from scrap in 1971 and the total rolled was 40,181 tons compared to 57,310 tons in 1970.

The lead in consumption of slab zinc by States was regained by Ohio with 15 percent of the total; Illinois dropped to second place with 13 percent. Pennsylvania held on to third place with 12 percent and was followed in order by Michigan, Indiana, and New York. The industries using zinc in these six States accounted for 68 percent of the total slab zinc consumed, the same as last year. Michigan was first in the use for die castings, Ohio for galvanizing, and Connecticut for brass mill products.

ZINC PIGMENTS AND SALTS

Production.—The publishing of data for zinc pigments and compounds has been reduced to the two major items, zinc oxide and zinc sulfate. Statistical information for leaded zinc oxide and zinc chloride would reveal individual company quantities and has been withheld. Production of zinc oxide in 1971 at 214,952 tons was 4 percent below that of 1970; however, shipments increased 7 percent to 227,503 tons. Zinc sulfate was down on both counts; production declined 14 percent to 45,929 tons and shipments 9 percent to 49,303 tons. The average unit value of zinc oxide for the year rose 17 percent to $320 per ton and of zinc sulfate declined 4½ percent to $128.

Zinc pigments and compounds were made from various zinc-bearing materials including ore, slab zinc, and scrap. Lead-free zinc oxide was made by the following processes: 61 percent was produced from ores by the American process, 23 percent from metal by the French process, and 16 percent was derived from secondary materials. The zinc content of zinc oxide produced directly from ores totaled 104,962 tons of which 76 percent was from domestic ores and 24 percent from foreign ores. The zinc sulfate produced from ores contained 5,707 tons of zinc; 33 percent was from domestic ores, and 67 percent was from foreign ores.

Consumption and Uses.—Total shipments of zinc oxide for various uses in 1971 was 7 percent higher than that of 1970. Rubber accounted for 55 percent of the total using 13,000 tons more than last year. The quantities for ceramics, chemicals, agriculture, and other uses were below those of last year, 10, 3, 28, and 15 percent, respectively. Paints required 14 percent more than in 1970, and consumption for photocopying continued upward, rising 8 percent to 34,500 tons. The total of zinc sulfate shipments was 9 percent lower than that of 1970 as agriculture and other shipments declined 5 and 10 percent, respectively.

Prices.—The prices for lead-free zinc oxide established October 1, 1970, at 17 cents per pound for American process and for French process lead-free, high-purity, and electrophotographic at 17.5 cents, 18.0 cents, and 19.75 cents per pound, respectively, remained in effect until July 1, 1971, when the prices for all grades were raised 0.5 cent per pound. The prices for the three grades of leaded zinc oxide moved up 0.5 cent at the same time to 14.5 cents per pound for 12-percent grade, 15.5 cents for 18-percent grade, and 17.25 cents for 35-percent grade. These quotations continued through the end of 1971.

Zinc sulfate, granular monohydrate, industrial-grade, 36-percent, in 100-pound bags, was quoted at 10 cents per pound throughout the year. Agricultural-grade, powdered, for carload lots in 100-pound bags, was 9.75 cents per pound all year. The price of zinc chloride, 50 percent, in tank cars, continued at 6.40 cents per pound for the full year. Zinc-ammonium-chloride, for carload lots in 100-pound bags, was quoted at 12.65 cents per pound; less than a carload lot, 13.75 cents per pound.

Foreign Trade.—Exports of zinc oxide rose almost 6 percent to 6,684 tons, the fourth yearly increase, which almost doubled those of 1967. Lithopone exports declined 65 percent to 545 tons, the lowest since 1962.

Total imports of zinc pigments and compounds increased only 150 tons to 20,920 tons with zinc oxide accounting for 63 percent; zinc sulfate, 26 percent; zinc chloride, 6 percent; and other, 5 percent.

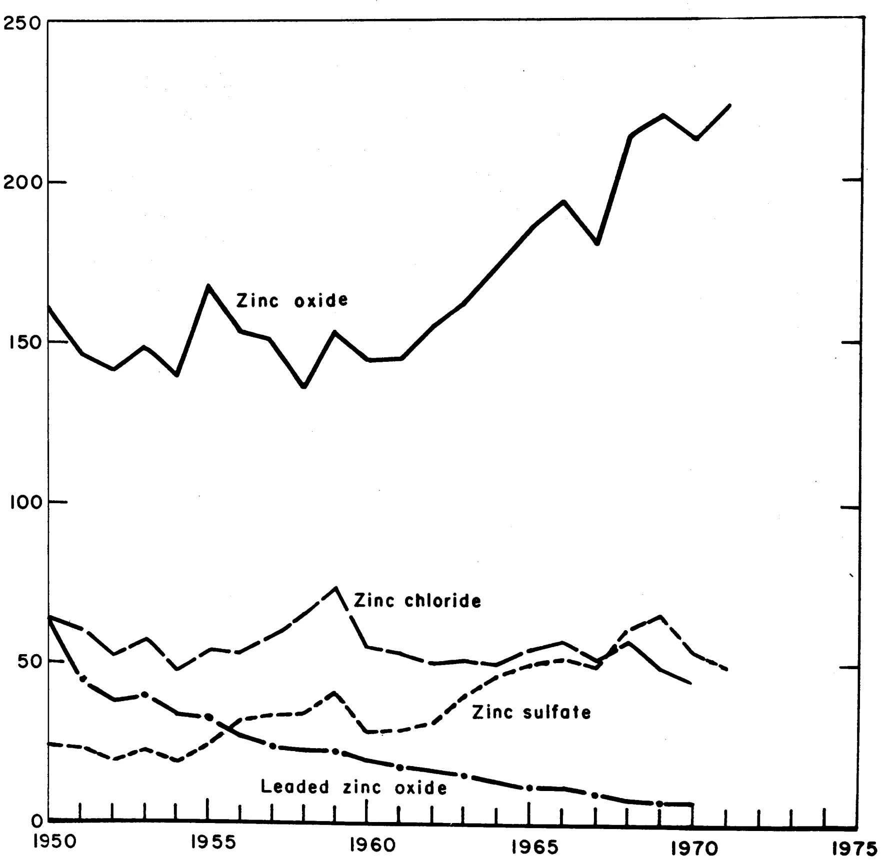

Figure 2.—Trends in shipments of zinc pigments.

STOCKS

Producer Stocks.—According to American Zinc Institute monthly data increases in stocks in the last quarter of 1970 continued for 1 month through January 1971 when production again exceeded shipments. This trend changed in February when shipments rose over production and stocks started a steady decline that continued through October. Total inventory increased approximately 3.5 percent in November, then receded to just under 41,000 tons at the end of December, a decline of 42 percent for the year and the lowest yearend inventory since 1965. Stocks at secondary smelters increased during the first 2 months of 1971 to 1,000 tons then with some monthly fluctuations fell to 249 tons in October and finished the year at 407 tons, the lowest yearend stock recorded since first reported in 1928.

Consumers Stocks.—Slab zinc inventories at consumer plants at the end of 1971 totaled 104,292 tons up approximately 13 percent over the ending stock for 1970. Special-high-grade and brass special stocks rose 31 percent and 33 percent to account for the net increase of total stocks.

PRICES

At the beginning of 1971 the East St. Louis quoted price of prime-western-grade slab zinc was 15 cents per pound as established August 24, 1970. However, the East St. Louis, basing point for pricing prime-western-grade zinc was eliminated January 5, 1971, when a major producer announced its price for this grade would be 15 cents per pound delivered. This change to a delivered basis canceled the usual charge for freight and was equivalent to reducing the quotation by 0.5 cent. The price for the other grades remained the same at 15.85 cents for high grade and 16 cents for special-high-grade as they have always been priced on a delivered basis. Two one-half cent increases on March 23 and May 14 and a 1 cent raise on July 27, 1971, established the 17.00 cents per pound quotation that held through the end of the year. The average monthly London Metal Exchange price varied between 12.33 cents and 13.05 cents per pound (U.S. equivalent) January through June and between 14.05 cents and 14.62 cents per pound July through December. The foreign producers' price was £127.95 per metric ton (13.93 cents per pound U.S. equivalent) from the first of the year until June 17, 1971, when it was raised to £150.00 per metric ton (16.46 cents per pound U.S. equivalent). This producers' quotation is that charged by most non-U.S. producers in foreign markets, as published by the Metal Bulletin of London, for Good Ordinary Brand (GOB) zinc (prime-western equivalent), c.i.f. European ports subject to premiums to cover duties, grades, and geographical charges.

FOREIGN TRADE

Exports of slab zinc rose sharply to 13,300 tons from 300 tons in 1970 with most all shipped to the United Kingdom and Turkey. Exports of rolled zinc products, sheet, plate, strip, etc., increased almost 20 percent to 1,700 tons. Canada received 1,065 tons, and the balance went to 16 other countries and some unidentified destinations. An unknown amount of zinc concentrate was exported in 1971.

General imports of zinc in ore declined 35 percent to 342,500 tons in 1971 reflecting smelter closures and the decreasing availability of foreign concentrates. Canadian supplies fell from 318,000 to 209,000 tons; receipts from Mexico were 90,000 tons, down from 129,000 tons; and Peru furnished only 15,000 tons compared with 48,000 tons last year. General imports of metal increased to 320,000 tons, 18 percent more than those of 1970. Canada was the largest supplier with 151,000 tons, about half of the total. Australia, Finland, Peru, Netherlands, and Mexico furnished about 36 percent and 14 other countries furnished the balance.

Imports of metal for consumption were slightly higher than general imports of metal, but imports of zinc in ores for consumption were 36 percent higher than those of 1970 owing to the decision by the Secretary of the Treasury to exempt all warehouse entries prior to August 16, 1971 from the surtax, if withdrawn from the warehouse before October 1, 1971. Imports of ore for consumption jumped from a decrease of 22 percent for the year at the end of August to a plus of 32 percent in September when 204,445 tons of zinc in ore was withdrawn from bonded warehouses to escape the surcharge.

Except for imposition of the surcharge there were no changes in the basic tariff rates in 1971. 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, 0.75 cent per pound; and zinc dust, 0.7 cent per pound. The duty rate for unwrought alloys of zinc, which included die casting alloys, is 19 percent ad valorem.

The surcharge on all dutiable imports imposed by the Government effective August 16, 1971, was removed by presidential proclamation effective December 20, 1971. This surcharge was limited to the difference between current rates and the statutory rates of duty if the difference was 10 percent of the value or less. If the difference was greater, then the surcharge of 10 percent of the value would apply. The surcharge for zinc in concentrates was limited to 1.0 cent per pound and to 1.05 cents per pound on imported metal.

WORLD REVIEW

Mine production of zinc in the free world for 1971 was just slightly higher than 1970 with increases for some countries offsetting decreases for others. Output in Europe was up 2 percent, Africa was up 5 percent, Asia advanced 4 percent, North and South America increased 4 percent, and Australia dropped 8 percent. The total reported for the communist countries showed a 5 percent increase over 1970 and total world production rose 1 percent. Free world smelter production decreased 6 percent in 1971 with the United States, Canada, Belgium, France, West Germany, and the United Kingdom accounting for most of the loss; the communist countries registered an increase of approximately 6 percent. Free world consumption was down very little as that for Soviet countries advanced and total world use increased 1 percent.

Algeria.—Construction of the new electrolytic zinc refinery at Ghazaouet is under way. The washing and flotation facilities at the El Abed mines were near completion at midyear.

Argentina.—Compañía Minera Aguilar, an affiliate of St. Joe Minerals Corp., operated with its new facilities for the full year of 1971 and produced a record 94,801 tons of zinc concentrate, compared with 10,525 tons in 1970. The zinc plants in which Aguilar has substantial interests also produced at capacity levels. Compañía Metalurgica Austral's smelter at Comodoro Rivadavia, produced 15,795 tons of zinc; Compañía Sulfacid's electrolytic plant at Rosario produced 17,707 tons of zinc. Expansion at the Rosario plant will increase zinc production in 1972.[30]

Australia.—Mine production of zinc in Australia declined 8 percent in 1971 to 494,000 tons, and refined zinc production was only marginally lower at 285,000 tons. Depressed prices and demand for lead forced a reduction in lead output that also affected mine production of zinc. At Mount Isa, ore treated during the year decreased 10 percent, but zinc in concentrates fell only 6 percent because the zinc grade in ore was higher than last year. The amount of ore treated at Broken Hill and the grade of zinc were lower for each producer and the production of zinc dropped nearly 10 percent. The new Jarosite Plant at the Risdon refinery of E. Z. Industries Ltd. treated about 200 tons of new residue produced each day and 150 tons from the residue stockpile. The recovery rate of zinc from concentrates at Risdon has been increased from 87 percent to as high as 97 percent. Consumption of zinc in Australia increased nearly 2 percent with sales for galvanizing providing a significant increase.[31]

Canada.—Mine production in 1971 increased 2 percent over that of 1970 to 1,397,246 tons. Three new mines were opened that will add about 50,000 tons of

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[30] Page 13 of work cited in footnote 7.
[31] Australian Mineral Industry. Quarterly Review, v. 24, No. 3, March 1972, p. 63.

zinc annually to Canadian production. Three mines closed in 1971 owing to exhaustion of ore; the Delbridge at Noranda, Quebec, the Copperline in southeast British Columbia, and the Venus at Carcross, Yukon Territory. Output was further reduced by two long strikes, one closing mines and smelters of Hudson Bay Mining and Smelting Co., Ltd., from January to July, the other closing the Buchans mine in Newfoundland from June to November.[32]

The Anvil Mining Corp. Ltd., a Canadian corporation operating an open pit lead-zinc mine in the Yukon Territory, produced 97,000 tons of zinc in concentrates during 1971. The ore mined averaged 11.7 percent combined lead and zinc. The mill reached 7,000 tons per day after a 20-percent expansion. Recoveries improved and are expected to be better next year. Concentrates are sold to smelters in Japan and West Germany.[33]

In 1971, Cominco Ltd. produced 211,000 tons of zinc (222,000 tons in 1970), 191,000 tons of lead, 597 tons of cadmium, 5.6 million ounces of silver, and 394,000 ounces of indium (898,000 ounces in 1970). The Bluebell mine at Riondel, British Columbia, was shut down near the end of the year ending operations at British Columbia's oldest zinc-lead mine, which had produced nearly 5 million tons of ore during the last 20 years. Mining and milling operations were suspended at the Caribou mine in New Brunswick as a result of metallurgical problems. A major zinc-lead ore body was discovered on Little Cornwallis Island in the Canadian Artic where drilling indicated substantial thicknesses of more than 20 percent combined zinc and lead. Reserves at the Pine Point and Sullivan mines in terms of lead and zinc were down 400,000 tons to 10.52 million tons in 1971.

The zinc modernization and expansion program was completed and the two new large fluid-bed roasters with an annual capacity in excess of 300,000 tons of contained zinc were operating successfully at yearend.[34]

Noranda Mines Ltd.'s Geco mine produced 1.76 million tons of ore in 1971 containing 79,200 tons of zinc. Ore reserves at the end of the year were up 300,000 tons to 29.5 million tons averaging 4.37 percent zinc. Noranda has substantial interests in other mining companies including Brunswick Mining and Smelting Corporation Ltd., Mattagami Lake Mines Ltd., and Orchan Mines Ltd. Brunswick Mining and Smelting Corp. Ltd. owns and operates two zinc-lead mines and two concentrators south of Bathurst, New Brunswick. East Coast Smelting and Chemical Co. Ltd., a wholly owned subsidiary operates a lead-zinc smelter, lead and zinc refineries and a sulfuric acid plant at Belledune, New Brunswick. Production of zinc and lead increased 10 percent and 22 percent, respectively. In order to handle all its own lead concentrates, a decision was made in the latter part of 1971 to convert the Imperial zinc-lead smelter to a lead smelter; it is estimated that this conversion will take 18 months and cost $10 million. The zinc concentrates will be shipped to Europe. Ore milled at the Orchan mine totaled 409,500 tons averaging 10.7 percent zinc. Ore reserves were 2,263,000 tons averaging 9.3 percent zinc. The Mattagami mill treated 1.386 million tons of ore in 1971, compared with 1.431 million tons in 1970. The ore grade averaged 9.3 percent zinc, slightly higher than it was last year. Ore reserves were 15,893,000 tons at yearend. Mattabi Mines, owned 60 percent by Mattagami, has ore reserves of 12,866,000 tons averaging 7.60 percent zinc. Of this, 8,000,000 tons will be mined by open pit methods. Production of 3,000 tons per day is scheduled for mid-1972 at a cost of approximately $40 million. Two other areas on Mattagami ground have been drilled and are promising. Canadian Electrolytic Zinc, Ltd., owned by Mattagami Lake, Orchan, Kerr Addison, and Noranda produced 119,600 tons of zinc in 1971, compared with 124,100 tons in 1970.[35]

Heath Steele Mines, a wholly owned subsidiary of AMAX, has a 75-percent interest in a joint venture with International Nickel Co. of Canada, Ltd., in a lead-zinc-copper mine and mill in New Brunswick. Ore production was 972,000 tons, just under that for 1970; ore grade was slightly less but was offset by higher recoveries of metals in the concentrates. Increased production and recoveries are expected from a 4-year program to treat mine and surface

[32] Fraser, D. B. Zinc. The Canadian Mineral Industry in 1971. Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa, Canada, p. 47.

[33] Page 2 of work cited in footnote 20.

[34] Page 2 of work cited in footnote 12.

[35] Noranda Mines, Ltd. Annual Report. 1971, pp. 10–15.

drainage waters. Cost of the program is estimated at $10.7 million.

Hudson Bay Mining and Smelting Co. Ltd.'s northern Manitoba base-metal mines and metallurgical plants in the Flin Flon-Snow Lake area were shut down from January 27, 1971, to June 21, 1971. Full production was resumed in July. Zinc production for the year was down to 41,000 from 78,622 tons in 1970. Reserves averaging 3.3 percent zinc declined from 19.1 million tons to 18.3 million tons. The zinc producing mines are the Anderson, Osborn, Dickstone, Flexar, Schist, and Stall. The refinery treated 45,000 tons of Hudson Bay concentrates, 28,000 tons of purchased concentrates, and 23,000 tons of slag fuming furnace oxides.[36]

Texas Gulf Sulphur Co.'s wholly owned subsidiary, Ecstall Mining Ltd., produced and processed more than 3,684,000 tons of ore at the Kidd Creek mine and concentrator, compared with 3,586,000 tons in 1970. The mill produced 591,000 tons of 52 percent zinc concentrates up from 583,000 tons in 1970. Construction of the electrolytic zinc plant was delayed by strikes against the contractor and was scheduled for completion in April 1972. The plant is designed to process about one-half of Kidd Creek's zinc concentrates and produce 120,000 short tons of refined zinc metal and 1,000,000 pounds of cadmium per year. The sulfuric acid plant will have a capacity of 230,000 tons of sulfuric acid per year.[37]

Wilroy Mines Ltd. milled 427,589 tons of ore averaging 3.33 percent zinc and 1.36 ounces of silver per ton, which was mined at its three Manitouwadge area operations. Ore reserves for the Wilroy mines are 940,507 tons containing 3.93 percent zinc. In September operations were suspended at the Big Nama Creek mine owing to depletion of all known ore reserves. Concentrates were sold to Noranda Sales Corp. Ltd.[38]

Finland.—Recessionary conditions in Finland affecting overall mining was reflected in the 17 percent decrease in the production of zinc concentrates by Outokumpu Oy in 1971 compared with 1970. However in 1971, the second year the new electrolytic refinery operated, slab zinc output rose 14 percent over that of 1970.[39]

Honduras.—The New York and Honduras Rosario Mining Co. completed Phase V of its expansion program and milled a record 311,310 tons of ore—an increase of 15.3 percent over 1970. The ore averaged 8.51 percent zinc and 12.3 ounces of silver per ton. The increased tonnage was accompanied by improved metallurgy and a slight decrease in mining costs per ton. However, the improvements were more than offset by decreased silver prices, increased smelter charges, the U.S. surcharge on lead and zinc concentrates that cost the company $225,000, and the first full year of production taxes imposed by the mining code of Honduras enacted in August 1970. Ore reserves are 2.085 million tons containing 11.7 percent zinc.[40]

Mexico.—Mine production of zinc in Mexico during 1971 declined less than 1 percent to 292,081 tons, and smelter production declined 3 percent to 85,828 tons.

The Fresnillo Co. produced 47,291 tons of zinc in concentrates in 1971, which was about the same rate as that of 1970. However, lower metal prices and zinc concentrate sales and indemnities paid to workmen caused a decrease in income. The closing of the American Zinc Co. plants in the United States, which for many years purchased Fresnillo concentrates, forced the company to stockpile most of the production from May to the end of the year. Satisfactory contracts were made with European and Japanese smelters, and the stockpile is being disposed of at acceptable prices. Substantially all concentrates will be purchased by Industrias Peñoles, S.A., for its electrolytic zinc plant when it is completed in 1973.[41]

Peñoles reports that construction of its electrolytic zinc plant is being accelerated to meet the original date operations were scheduled to start. Peñoles has been licensed to use Austuriana's electrolytic zinc production process. Production of zinc is scheduled to start in May 1973 with capacity output of 115,000 tons expected in 1974.[42]

ASARCO Mexicana, S.A., produced

[36] Hudson Bay Mining and Smelting Co. Ltd. Annual Report. 1971, pp. 17–19.
[37] Texas Gulf Sulphur Co. Annual Report. 1971, p. 4.
[38] Wilroy Mines Ltd. Annual Report. 1971, pp. 3–4.
[39] U.S. Embassy. Helsinki, Finland. State Department Dispatch A–161, June 27, 1972, 6 pp., encl. 1.
[40] New York and Honduras Rosario Mining Co. Annual Report. 1971, p. 4.
[41] The Fresnillo Co. Annual Report. 1971, pp. 2, 10.
[42] Industrias Peñoles, S.A. Annual Report. 1971, pp. 15, 33.

58,960 tons of zinc in 1971, an increase of 1,000 tons from 1970 output. Plans for erecting an electrolytic refinery are being reevaluated in consideration of the convenience of locating the plant at Puerto Tampico and to conduct a feasibility study of the new methods and automatic systems in the refining of zinc, in preparation for negotiations to obtain financing.[43]

Minero Frisco, S.A., produced 49,059 tons of zinc concentrates in 1971 (57.79 percent zinc) up from 47,805 tons in 1970. The zinc concentrates were sold to Zincamex, S.A., and AMAX Lead and Zinc, Inc.[44]

Peru.—Production of 63,265 tons of refined zinc by Cerro de Pasco Corp., in 1971 was 17 percent less than that of 1970, but concentrate production for export and refining increased 30 percent to 88,109 tons (zinc content). Cerro's operations in Peru were unprofitable in 1971 principally owing to labor developments and the decline in nonferrous metals prices. There were 35 strikes by various unions in 1971 causing the loss of 375,000 man-days of production.[45]

Compañía Minerales Santander, Inc., St. Joe Minerals Corp.'s subsidiary in Peru produced 73,759 tons of zinc concentrates in 1971, compared with 75,370 tons in 1970. Most of these concentrates was exported.[46]

TECHNOLOGY

Zinc Abstracts, a monthly publication, prepared jointly by the Zinc Development Association (London) and the Zinc Institute, Inc. (New York), reviews all current world literature on the uses of zinc and its products and all published research work. These abstracts are available, free of charge, from the Zinc Institute, Inc., 292 Madison Avenue, New York, N.Y. 10017.

The International Lead Zinc Research Organization (ILSRO) sponsors a research program, which is reviewed twice a year in its Research Digest. Three parts of this program published in the Research Digest are related to zinc: Part I—Die-cast and wrought zinc; Part II—Zinc for conversion protection; and Part III—Zinc chemistry. The ILSRO Research Digests are also available from the Zinc Institute. Results of several research investigations and professional papers were published by the Bureau of Mines[47] and the Geological Survey.[48]

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[43] ASARCO Mexicana, S.A. Annual Report. 1971, pp. 15, 36.

[44] Minero Frisco. Annual Report. 1971, pp. 8, 33.

[45] Cerro Corp. Annual Report. 1971, p. 9.

[46] Page 13 of work cited in footnote 7.

[47] Petersen, N. S., F. W. Carrillo, and R. Charles Vars. Materials Substitution Study. General Methodology and Review of U.S. Zinc Die-Casting Markets. BuMines Inf. Circ. 8505, 1971, 42 pp.

Neumeier, L. A., and J. S. Risbeck. Effects of Rolling Temperature and Titanium Content on Creep and Other Properties of Zinc-Titanium and Zinc-Copper-Titanium Alloys. BuMines Rept. of Inv. 7522, 1971, 31 pp.

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Fulkerson, Frank B., Gulf Coast Export-Import of Mineral Commodities. BuMines Inf. Circ. 8508, 1971, 90 pp.

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[48] Bergendahl, M. H. and A. H. Koschmann. Ore Deposits of the Kohomo-Tenmile District, Colo. U.S. Geol. Survey Prof. Paper 652, 1971, 53 pp.

Klepper, M. R., E. T. Ruppel, V. L. Freeman, and R. A. Weeks. Geology and Mineral Deposits, East Flank of the Elkhorn Mountains, Broadwater County, Mont. U.S. Geol. Survey Paper 665, 1971, 66 pp.

Table 2.—Mine production of recoverable zinc in the United States, by State

(Short tons)

State	1967	1968	1969	1970	1971
Arizona	14,330	5,441	9,039	9,618	7,761
California	441	3,525	3,327	3,514	3,003
Colorado	52,442	50,258	53,715	56,694	61,181
Idaho	56,528	57,248	55,900	41,052	45,078
Illinois	20,416	18,182	13,765	16,797	12,706
Kansas	4,765	3,012	1,900	1,186	--
Kentucky	6,317	4,603	4,988	4,189	5,268
Maine	--	5,099	7,639	9,114	5,850
Missouri	7,430	12,301	41,099	50,721	48,215
Montana	3,341	3,778	6,143	1,457	361
Nevada	3,035	2,104	941	127	71
New Jersey	26,041	25,668	25,076	28,683	29,977
New Mexico	21,380	18,686	24,308	16,601	13,959
New York	70,555	66,194	58,728	58,577	63,420
Oklahoma	10,670	6,921	2,744	2,650	--
Pennsylvania	35,067	30,382	33,035	29,554	27,438
South Dakota	--	--	--	1	--
Tennessee	113,065	124,039	124,532	118,260	119,295
Utah	34,251	33,153	34,902	34,688	25,701
Virginia	18,846	19,257	18,704	18,063	16,829
Washington	21,540	13,884	9,738	11,956	5,782
Wisconsin	28,953	25,711	22,901	20,634	10,645
Other States	--	--	--	--	3
Total	549,413	529,446	553,124	534,136	502,543

Table 3.—Mine production of recoverable zinc in the United States, by month

(Short tons)

Month	1970	1971	Month	1970	1971
January	44,137	43,654	August	45,266	41,009
February	44,754	42,538	September	42,478	39,329
March	47,677	44,959	October	42,192	40,769
April	47,144	42,754	November	42,360	41,803
May	44,534	43,869	December	42,397	39,995
June	45,305	43,880			
July	45,892	37,984	Total	534,136	502,543

Table 4.—Production of zinc and lead in the United States in 1971, 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	--	--	--	3,250	69	124	5	1	1
California	(1)	(1)	(1)	(1)	(1)	(1)	[1] 89,042	[1] 3,003	[1] 2,284
Colorado	311,099	32,239	3,612	143	--	46	425,701	16,034	12,306
Idaho	973	69	22	274,716	2,506	28,479	780,970	41,854	36,848
Maine	--	--	--	--	--	--	--	--	--
Missouri	--	--	--	8,624,668	48,215	429,634	--	--	--
Montana	4,027	265	30	6,190	12	373	217	6	10
Nevada	74	10	3	197	2	10	532	54	81
New Jersey	172,179	29,977	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	119,021	13,473	2,971
New York	171,533	15,585	--	--	--	--	606,978	47,835	877
Oklahoma	--	--	--	--	--	--	--	--	--
Pennsylvania	628,408	27,438	--	--	--	--	--	--	--
Tennessee	4,244,715	111,992	--	--	--	--	--	--	--
Utah	--	--	--	(2)	(2)	(2)	[2] 363,216	[2] 22,974	[2] 33,462
Virginia	614,721	16,829	3,386	--	--	--	--	--	--
Washington	425	8	--	621	--	25	252,492	5,774	5,151
Wisconsin	413,760	10,645	752	--	--	--	--	--	--
Other States	281,955	11,190	486	--	--	--	--	--	--
Total	6,843,869	256,247	8,291	8,909,785	50,804	458,691	2,638,174	151,008	93,991
Percent of total zinc-lead	--	51	2	--	10	79	--	30	16

See footnotes at end of table.

Table 4.—Production of zinc and lead in the United States in 1971, 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	95,034	7,672	102	37,661,651	19	632	37,759,940	7,761	859
California	--	--	--	--	--	--	89,042	3,003	2,284
Colorado	391,250	11,515	8,037	99,622	1,393	1,745	1,227,815	61,181	25,746
Idaho	--	--	--	304,652	649	1,261	1,361,311	45,078	66,610
Maine	179,751	5,850	--	--	--	--	179,751	5,850	--
Missouri	--	--	--	--	--	--	8,624,668	48,215	429,634
Montana	--	--	--	25,474	78	202	35,908	361	615
Nevada	--	--	--	838	5	17	1,641	71	111
New Jersey	--	--	--	--	--	--	172,179	29,977	--
New Mexico	--	--	--	1,101,859	486	--	1,220,880	13,959	2,971
New York	--	--	--	--	--	--	778,511	63,420	877
Oklahoma	--	--	--	220,104	(4)	--	220,104	(4)	--
Pennsylvania	--	--	--	--	--	--	628,408	27,438	--
Tennessee	1,703,575	7,304	--	--	--	--	5,948,290	119,295	--
Utah	124,354	2,727	4,790	2,594	--	18	490,164	25,701	38,270
Virginia	--	--	--	--	--	--	614,721	16,829	3,386
Washington	--	--	--	71,118	--	1	324,656	5,782	5,177
Wisconsin	--	--	--	--	--	--	413,760	10,645	752
Other States	--	--	--	--	6,787	772	281,955	17,977	1,258
Total	2,493,964	35,068	12,929	39,487,912	9,417	4,648	60,373,704	502,543	578,550
Percent of total zinc-lead	--	7	2	--	2	1	--	100	100

[1] Lead and zinc ores combined with lead-zinc ore to avoid disclosing individual company confidential data.
[2] Lead and lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Lead and zinc recovered from copper, gold, silver, and fluorspar, and from mill tailings and miscellaneous cleanups.
[4] Less than ½ unit.

Table 5.—Twenty-five leading zinc-producing mines in the United States in 1971 in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, N.Y.	St. Joe Minerals Corp	Lead-zinc ore.
2	Eagle	Eagle, Colo	The New Jersey Zinc Co	Zinc ore.
3	Sterling Hill	Sussex, N.J	do	Do.
4	Friedensville	Lehigh, Pa	do	Do.
5	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore, lead-zinc tailings.
6	Buick	Iron, Mo	Missouri Lead Operating Co	Lead ore.
7	Young	Jefferson, Tenn	American Zinc Co.[1]	Zinc ore.
8	New Market	do	New Market Zinc Co.[1]	Do.
9	Zinc Mine Works	do	United States Steel Corp	Do.
10	Immel	Knox, Tenn	American Zinc Co.[1]	Do.
11	Austinville and Ivanhoe.	Wythe, Va	The New Jersey Zinc Co	Do.
12	Edwards	St. Lawrence, N.Y.	St. Joe Minerals Corp	Do.
13	Star Unit	Shoshone, Idaho	Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
14	Ground Hog	Grant, N. Mex	American Smelting and Refining Co.	Do.
15	Jefferson City	Jefferson, Tenn.	The New Jersey Zinc Co	Zinc Ore.
16	Burgin	Utah, Utah	Kennecott Copper Corp	Lead, lead-zinc ores.
17	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
18	U.S. and Lark	Salt Lake, Utah	United States Smelting, Refining Mining Co.	Lead, lead-zinc ores.
19	Flat Gap	Hancock, Tenn	The New Jersey Zinc Co	Zinc ore.
20	Bruce	Yavapai, Ariz	Cyprus Mines Corp	Copper-zinc ore.
21	Shullsburg	Lafayette, Wis	Eagle-Picher Industries, Inc	Zinc ore.
22	Leadville	Lake, Colo	American Smelting and Refining Co.	Lead-zinc ore.
23	Coy	Jefferson, Tenn	American Zinc Co.[1]	Zinc ore.
24	Magmont	Iron, Mo	Cominco American, Inc	Lead ore.
25	Ozark	Reynolds, Mo	Ozark Lead Co	Do.

[1] Purchased by the American Smelting and Refining Co., November 29, 1971.

Table 6.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1967	1968	1969	1970	1971
Primary:					
From domestic ores	438,553	499,491	458,754	403,953	403,750
From foreign ores	500,277	521,400	581,843	473,858	362,683
Total	938,830	1,020,891	1,040,597	877,811	766,433
Redistilled secondary	73,505	79,865	70,553	77,156	80,923
Total (excludes zinc recovered by remelting)	1,012,335	1,100,756	1,111,150	954,967	847,356

Table 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

Method of reduction	1967	1968	1969	1970	1971
Electrolytic primary	371,267	398,265	453,539	393,280	321,517
Distilled	567,563	622,626	587,058	484,531	444,916
Redistilled secondary:					
At primary smelters	58,341	67,101	60,607	65,776	68,612
At secondary smelters	15,164	12,764	9,946	11,380	12,311
Total	1,012,335	1,100,756	1,111,150	954,967	847,356

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Short tons)

Grade	1967	1968	1969	1970	1971
Special high	436,849	449,659	468,792	401,273	367,609
High	92,956	117,224	136,416	109,025	73,314
Intermediate	26,522	56,686	57,180	52,480	58,240
Brass special	91,079	75,840	89,306	71,811	71,100
Prime western	364,929	401,347	359,456	320,378	277,093
Total	1,012,335	1,100,756	1,111,150	954,967	847,356

Table 9.—Primary slab zinc produced in the United States, by State where smelted

(Short tons)

State	1967	1968	1969	1970	1971
Idaho	92,134	102,946	105,700	95,637	94,012
Illinois	115,659	119,657	131,243	110,835	46,389
Montana	111,834	142,929	174,034	148,697	115,480
Oklahoma	163,826	172,174	143,575	124,811	126,908
Pennsylvania and West Virginia	271,192	302,884	286,164	222,096	228,651
Texas	184,185	180,301	199,881	175,735	154,993
Total	938,830	1,020,891	1,040,597	877,811	766,433

Table 10.—Primary slab zinc plants by group capacity in the United States in 1971

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
American Smelting and Refining Co	Corpus Christi, Tex	452,000
American Zinc Co.[1]	Sauget, Ill	
The Anaconda Company	Great Falls, Mont	
The Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		629,400
American Smelting and Refining Co	Amarillo, Tex	
American Zinc Co.[2]	Dumas, Tex	
Blackwell Zinc Co., American Metal Climax, Inc	Blackwell, Okla	
National Zinc Co	Bartlesville, Okla	
Vertical-retort plants:		
Mathiessen & Hegeler Zinc Co.[3]	Meadowbrook, W. Va	
The New Jersey Zinc Co.[4]	Depue, Ill	
Do	Palmerton, Pa	
St. Joe Minerals Corp	Josephtown, Pa	

[1] Plant closed June 1971.
[2] Plant closed Aug. 1971.
[3] Plant closed April 1971.
[4] Plant closed Aug. 23, 1971.

Table 11.—Secondary slab zinc plants by group capacity in the United States in 1971

Company	Plant location	Slab zinc capacity (short tons)
American Smelting and Refining Co	Sand Springs, Okla	34,040
Do	Trenton, N.J	
American Zinc Co	Hillsboro, Ill	
Apex Smelting Co	Chicago, Ill	
Arco Die Cast Metals Co	Detroit, Mich	
W. J. Bullock, Inc	Fairfield, Ala	
Gulf Reduction Co	Houston, Tex	
H. Kramer Co	El Segundo, Calif	
Pacific Smelting Co	Torrance, Calif	
Sandoval Zinc Co	Sandoval, Ill	
Superior Zinc Corp.[1]	Bristol, Pa	

[1] Plant closed Aug. 27, 1971.

Table 12.—Stocks and consumption of new and old zinc scrap in the United States in 1971

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and distillers:						
New clippings	43	468	420	--	420	91
Old zinc	739	8,437	--	8,020	8,020	1,156
Engravers' plates	287	2,758	--	2,738	2,738	307
Skimmings and ashes	10,771	61,605	62,238	--	62,238	10,138
Sal skimmings	219	2,410	2,528	--	2,528	101
Die-cast skimmings	2,165	6,132	6,186	--	6,186	2,111
Galvanizers' dross	23,386	67,650	68,059	--	68,059	22,977
Diecastings	2,960	41,765	--	40,668	40,668	4,057
Rod and die scrap	859	3,375	--	3,666	3,666	568
Flue dust	2,427	4,888	5,513	--	5,513	1,802
Chemical residues	8,531	10,767	13,694	--	13,694	5,604
Total	52,387	210,255	158,638	55,092	213,730	48,912
Chemical plants, foundries, and other manufacturers:						
New clippings	--	--	--	--	--	--
Old zinc	11	26	--	33	33	4
Engravers' plates	--	--	--	--	--	--
Skimmings and ashes	3,372	9,100	10,219	--	10,219	2,253
Sal skimmings	7,982	3,600	5,640	--	5,640	5,942
Die-cast skimmings	--	--	--	--	--	--
Galvanizers' dross	--	--	--	--	--	--
Diecastings	14	385	--	391	391	8
Rod and die scrap	7	45	--	48	48	4
Flue dust	1,019	3,447	4,192	--	4,192	274
Chemical residues	3,546	32,321	32,573	--	32,573	3,294
Total	15,951	48,924	52,624	472	53,096	11,779
All classes of consumers:						
New clippings	43	468	420	--	420	91
Old zinc	750	8,463	--	8,053	8,053	1,160
Engravers' plates	287	2,758	--	2,738	2,738	307
Skimmings and ashes	14,143	70,705	72,457	--	72,457	12,391
Sal skimmings	8,201	6,010	8,168	--	8,168	6,043
Die-cast skimmings	2,165	6,132	6,186	--	6,186	2,111
Galvanizers' dross	23,386	67,650	68,059	--	68,059	22,977
Diecastings	2,974	42,150	--	41,059	41,059	4,065
Rod and die scrap	866	3,420	--	3,714	3,714	572
Flue dust	3,446	8,335	9,705	--	9,705	2,076
Chemical residues	12,077	43,088	46,267	--	46,267	8,898
Total	68,338	259,179	211,262	55,564	266,826	60,691

[1] Figures partly revised.

Table 13.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Product	1967	1968	1969	1970	1971
Redistilled slab zinc	73,505	79,865	70,553	77,156	80,923
Zinc dust	32,801	37,903	33,747	29,605	29,095
Remelt spelter	4,831	3,580	3,978	3,494	1,590
Remelt die-cast slab	14,520	14,570	16,979	16,686	18,339
Zinc-die and diecasting alloys	3,882	4,128	4,401	4,361	3,316
Galvanizing stocks	1,690	2,107	1,849	762	633
Secondary zinc in chemical products	38,289	45,654	45,298	40,668	43,301

Table 14.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1970	1971	Form of recovery	1970	1971
New scrap:			As metal:		
Zinc-base	131,859	140,854	By distillation:		
Copper-base	132,159	135,201	Slab zinc [1]	75,453	79,754
Aluminum-base	3,145	2,833	Zinc dust	29,191	28,542
Magnesium-base	211	222	By remelting	4,210	2,127
Total	267,374	279,110	Total	108,854	110,423
Old scrap:			In zinc-base alloys	19,703	24,307
Zinc-base	41,255	44,876	In brass and bronze	r 162,055	171,949
Copper-base	27,868	31,308	In aluminum-base alloys	6,242	6,535
Aluminum-base	2,959	3,587	In magnesium-base alloys	435	627
Magnesium-base	71	272	In chemical products:		
			Zinc oxide (lead-free)	20,186	22,179
Total	72,153	80,043	Zinc-sulfate	9,171	10,335
			Zinc chloride	10,606	10,111
Grand total	339,527	359,153	Miscellaneous	r 2,275	2,687
			Total	230,673	248,730
			Grand total	339,527	359,153

r Revised.
[1] Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 15.—Zinc dust produced in the United States

Year	Short tons	Value: Total (thousands)	Value: Average per pound
1967	50,273	$18,098	$0.180
1968	61,566	22,041	.179
1969	55,055	21,361	.194
1970	51,136	20,045	.196
1971	50,259	19,691	.196

Table 16.—Consumption of zinc in the United States

(Short tons)

	1967	1968	1969	1970	1971
Slab zinc	1,250,673	1,350,656	1,385,380	1,186,951	1,254,059
Ores (recoverable zinc content) [1]	114,301	124,109	126,712	124,781	119,254
Secondary (recoverable zinc content) [2]	240,888	270,592	302,075	259,864	277,272
Total	1,605,862	1,745,357	1,814,167	1,571,596	1,650,585

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Table 17.—Slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1967	1968	1969	1970	1971
Galvanizing:					
Sheet and strip	250,000	273,276	268,682	253,155	255,335
Wire and wire rope	36,745	36,089	32,348	30,857	29,895
Tubes and pipe	61,792	63,621	65,898	64,479	65,122
Fittings (for tube and pipe)	11,768	13,801	11,418	9,498	10,240
Tanks and containers	4,137	3,815	5,561	3,924	2,759
Structural shapes	18,779	20,238	19,454	18,761	18,589
Fasteners	4,234	4,826	5,536	5,318	5,159
Pole-line hardware	9,985	9,050	9,409	9,938	8,358
Fencing, wire, cloth, netting	16,544	15,984	17,984	18,114	20,232
Other and unspecified uses	58,486	58,074	57,091	60,205	59,063
Total	472,470	498,774	493,381	474,249	474,752
Brass products:					
Sheet, strip, and plate	67,237	86,185	90,777	61,672	78,929
Rod and wire	40,759	49,888	56,989	41,459	46,514
Tube	8,884	9,818	10,928	9,086	9,399
Castings and billets	2,295	2,286	5,958	4,606	4,479
Copper-base ingots	8,121	12,153	13,642	9,946	10,440
Other copper-base products	4,241	1,576	1,175	978	725
Total	131,537	161,906	179,469	127,747	150,486
Zinc-base alloy:					
Die casting alloy	525,960	551,896	565,839	453,490	504,823
Dies and rod alloy	420	807	504	87	270
Slush and sand casting alloy	8,738	10,243	10,048	10,059	11,018
Total	535,118	562,946	576,391	463,636	516,111
Rolled zinc	45,443	48,943	48,650	41,065	38,852
Zinc oxide	29,774	34,937	41,447	43,829	40,043
Other uses:					
Light-metal alloys	8,805	8,422	7,562	3,985	4,575
Other [1]	27,526	34,728	38,480	32,440	29,240
Total	36,331	43,150	46,042	36,425	33,815
Grand total	1,250,673	1,350,656	1,385,380	1,186,951	1,254,059

[1] Includes zinc used in making zinc dust, wet batteries, desilverizing lead, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 18.—Slab zinc consumption in the United States in 1971, by grade and industry use

(Short tons)

Industry	Special high	High	Intermediate	Brass special	Prime [1] western	Remelt	Total
Galvanizing	25,320	27,651	1,434	104,686	315,253	408	474,752
Brass and bronze	39,596	75,801	123	6,182	28,715	69	150,486
Zinc-base alloys	513,882	1,221	4	207	563	234	516,111
Rolled zinc	16,587	993	15,560	--	5,712	--	38,852
Zinc oxide	7,823	5,518	--	--	26,702	--	40,043
Other	16,998	3,786	375	18	12,554	84	33,815
Total	620,206	114,970	17,496	111,093	389,499	795	1,254,059

[1] Includes select grade.

Table 19.—Rolled zinc produced and quantity available for consumption in the United States

	1970			1971		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per pound		Total (thousands)	Average per pound
Production: [1]						
Photoengraving plate	10,364	$7,812	$0.377	11,290	$8,259	$0.390
Other plate over 0.375 inch thick	W	W	W	W	W	W
Sheet zinc less than 0.375 inch thick	W	W	W	W	W	W
Strip and foil	23,570	12,052	.256	25,342	13,656	.269
Rod and wire	W	W	W	W	W	W
Total rolled zinc	39,234	25,447	.324	38,263	23,399	.306
Imports	692	419	.303	509	237	.233
Exports	1,412	1,173	.415	1,686	1,486	.441
Available for consumption	38,016	--	--	38,390	--	--

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Figures represent net production. In addition, 18,076 tons in 1970 and 1,918 tons in 1971 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills.

Table 20.—Slab zinc consumption in the United States in 1971, by industry and State
(Short tons)

State	Galvanizers	Brass mills [1]	Diecasters [2]	Other [3]	Total
Alabama	38,151	W	--	W	39,491
Arizona	W	--	--	W	W
Arkansas	--	--	--	W	W
California	33,830	3,333	16,150	1,053	54,366
Colorado	W	W	W	W	3,558
Connecticut	3,042	33,229	W	W	42,016
Delaware	W	W	W	--	W
Florida	W	--	W	--	3,509
Georgia	W	--	W	--	1,722
Hawaii	W	--	--	--	W
Idaho	--	--	22,055	1,101	23,156
Illinois	47,053	24,158	73,537	14,229	158,977
Indiana	53,697	W	37,766	W	120,085
Iowa	W	--	--	W	1,094
Kansas	--	W	W	--	W
Kentucky	W	W	--	W	W
Louisiana	W	--	--	W	1,487
Maine	W	--	--	--	W
Maryland	W	--	--	W	W
Massachusetts	2,891	W	--	W	8,764
Michigan	3,921	W	123,583	W	144,555
Minnesota	W	--	W	--	2,751
Mississippi	W	--	--	--	W
Missouri	8,656	W	4,930	W	15,390
Montana	--	--	--	W	W
Nebraska	1,943	W	--	W	2,521
New Hampshire	--	W	--	--	W
New Jersey	2,202	5,010	W	W	17,028
New York	11,489	W	74,071	W	96,336
North Carolina	W	--	W	W	W
Ohio	96,890	W	77,070	W	183,638
Oklahoma	7,863	--	W	W	10,815
Oregon	682	W	W	W	880
Pennsylvania	60,066	12,785	23,787	56,813	153,451
Rhode Island	W	--	--	W	W
South Carolina	W	--	--	--	W
Tennessee	W	--	W	W	W
Texas	13,856	W	W	W	49,502
Utah	W	W	--	--	W
Virginia	W	W	W	W	283
Washington	852	--	--	759	1,611
West Virginia	30,792	W	--	W	32,709
Wisconsin	1,302	6,469	7,075	37	14,883
Undistributed	55,166	65,433	55,853	38,634	68,686
Total [4]	474,344	150,417	515,877	112,626	1,253,264

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 21.—Production and shipments of zinc pigments and compounds[1] in the United States

Pigment or compound	1970				1971			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total (thousands)	Average per ton			Total (thousands)	Average per ton
Zinc oxide[3]	223,769	213,283	$58,531	$274	214,952	227,503	$72,910	$320
Zinc sulfate	53,170	54,069	7,225	134	45,929	49,303	6,333	128

[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 percent or more lead is classed as leaded zinc oxide.

Table 22.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers, by source

(Short tons)

Pigment or compound	1970					1971				
	Zinc in pigments and compounds produced from—				Total zinc in pigments and compounds	Zinc in pigments and compounds produced from—				Total zinc in pigments and compounds
	Ore		Slab zinc	Secondary material		Ore		Slab zinc	Secondary material	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	82,446	24,827	43,829	27,851	178,953	79,732	25,230	39,942	27,158	172,062
Zinc sulfate	3,548	4,730	--	8,156	16,434	1,891	3,816	--	10,262	15,969

[1] Excludes leaded zinc oxide, zinc sulfide, and lithopone; figures withheld to avoid disclosing individual company confidential data.

Table 23.—Distribution of zinc oxide shipments, by industry

(Short tons)

Industry	1967	1968	1969	1970	1971
Zinc oxide:					
Rubber	94,388	111,797	115,988	111,421	124,472
Paints	24,547	25,864	25,170	21,894	24,990
Ceramics	9,850	10,226	9,469	9,011	8,125
Chemicals	17,509	22,769	22,775	19,435	18,901
Agriculture	5,048	5,044	4,007	2,246	1,615
Photocopying	14,039	21,564	27,566	31,850	34,504
Other	16,105	16,562	14,748	17,426	14,896
Total	181,486	213,826	219,723	213,283	227,503

Table 24.—Distribution of zinc sulfate shipments, by industry

(Short tons)

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1967	W	W	17,156	14,803	31,644	24,742	48,800	39,545
1968	W	W	20,472	17,631	39,175	30,265	59,647	47,896
1969	W	W	19,029	16,424	45,563	33,861	64,592	50,285
1970	W	W	17,213	14,803	36,856	26,572	54,069	41,375
1971	W	W	16,268	13,812	33,035	28,690	49,303	42,502

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

Table 25.—Stocks of zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1967	1968	1969	1970	1971
At primary reduction plants	81,307	64,695	64,903	97,576	40,878
At secondary distilling plants	609	684	885	738	407
Total	81,916	65,379	65,788	98,314	41,285

Table 26.—Consumers stocks of slab zinc at plants, Dec. 31, by grade

(Short tons)

Date	Special high	High	Intermediate	Brass special	Prime western	Remelt	Total
Dec. 31, 1970 r	38,718	6,867	931	8,012	37,997	149	92,674
Dec. 31, 1971	50,793	4,864	614	10,674	37,204	143	104,292

r Revised.

Table 27.—Average monthly quoted prices of common zinc (prompt delivery or spot), East St. Louis, London, and the United States [1]

Month	1970			1971		
	Metallic zinc (cents per pound)			Metallic zinc (cents per pound)		
	East St. Louis	London	Foreign zinc	United States	LME	Foreign zinc
January	15.50	13.72	13.93	15.00	12.91	13.96
February	15.50	13.51	13.96	15.00	12.45	14.03
March	15.50	13.44	13.96	15.07	12.99	14.04
April	15.50	13.31	13.96	15.50	12.98	14.03
May	15.50	13.24	13.95	15.77	13.18	14.04
June	15.50	13.29	13.92	16.00	14.13	15.25
July	15.50	13.39	13.87	16.19	14.54	16.46
August	15.33	13.45	13.86	17.00	14.57	16.56
September	15.00	13.49	13.84	17.00	14.05	16.80
October	15.00	13.33	13.86	17.00	15.25	16.95
November	15.00	13.14	13.87	17.00	15.61	16.96
December	15.00	13.00	13.87	17.00	16.27	17.19
Average for year	15.32	r 13.36	13.90	16.13	14.08	15.52

r Revised.

[1] East St. Louis: Metal Statistics, 1970. Foreign Zinc, London, London Metal Exchange (LME), and United States: Metals Week.

Table 28.—U.S. exports of slab and sheet zinc, by country

(Short tons and thousand dollars)

Destination	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Slabs, pigs, blocks:						
Australia	20	$6	--	--	--	--
Canada	670	191	69	$34	233	$63
Chile	69	22	29	10	8	3
Colombia	2	1	--	--	--	--
Germany, West	17	8	22	4	4	2
Honduras	13	4	20	8	5	2
India	8,409	2,337	--	--	--	--
Liberia	3	1	21	9	6	2
Netherlands	2	1	21	4	--	--
Philippines	5	3	--	--	--	--
Spain	--	--	41	7	41	7
Turkey	--	--	--	--	3,024	738
United Kingdom	--	--	15	16	10,005	1,501
Venezuela	26	9	33	12	--	--
Other	62	29	17	10	20	19
Total	9,298	2,612	288	114	13,346	2,337
Sheets, plates, strips, or other forms, n.e.c.:						
Argentina	22	20	41	35	51	34
Australia	1	2	3	4	85	75
Brazil	7	6	4	6	(1)	(1)
Canada	1,188	909	1,006	825	1,065	946
Chile	27	21	5	5	2	2
Colombia	18	15	17	18	4	4
Costa Rica	9	8	10	9	14	13
Dominican Republic	3	3	8	3	51	20
El Salvador	5	4	10	10	14	13
Germany, West	27	20	--	--	1	(1)
India	361	164	--	--	1	1
Ireland	3	3	--	--	16	17
Israel	5	4	1	1	28	19
Mexico	14	13	13	11	43	36
New Zealand	7	5	12	11	2	1
Pakistan	779	346	23	20	--	--
South Africa, Republic of	1	1	14	11	101	90
Taiwan	33	22	54	25	--	--
United Kingdom	1	(1)	6	3	119	124
Venezuela	87	81	87	79	34	32
Other	116	99	98	97	55	59
Total	2,714	1,746	1,412	1,173	1,686	1,486

1 Less than ½ unit.

Table 29.—U.S. exports of zinc, by class

(Short tons and thousand dollars)

Year	Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n.e.c.		Zinc scrap and dross (zinc content)		Semifabricated forms, n.e.c.	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1969	9,298	$2,612	2,714	$1,746	1,989	$716	28,810	$6,321
1970	288	114	1,412	1,173	3,112	1,049	25,528	5,635
1971	13,346	2,337	1,686	1,486	2,000	504	6,042	2,709

Table 30.—U.S. exports of zinc pigments

Kind	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	6,326	$2,343	6,684	$2,439
Lithopone	1,541	523	545	425
Total	7,867	2,866	7,229	2,864

Table 31.—U.S. imports for consumption of zinc, by country

(Short tons and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
ORES [1]						
Australia	4,387	$700	1,893	$366	3,188	$720
Bolivia	9,407	1,489	4,098	595	4,738	696
Canada	326,929	48,552	263,287	40,230	257,555	38,588
Chile	1,025	213	1,331	267	--	--
Germany, West	3,701	658	10,438	1,638	3,517	528
Honduras	11,517	1,614	10,001	1,342	22,486	2,934
Ireland	99	20	537	38	1,965	310
Mexico	141,720	16,036	101,871	13,430	121,016	14,925
Morocco	8,848	873	--	--	8,531	868
Peru	54,925	8,591	51,269	8,330	44,256	3,088
South Africa, Republic of	1,959	421	5,040	764	100	19
Other	717	75	1,005	164	16	2
Total	565,234	79,242	450,770	67,164	467,368	62,678
BLOCKS, PIGS, OR SLABS						
Australia	34,237	8,896	30,335	9,359	37,096	11,634
Belgium-Luxembourg	13,296	3,416	14,371	3,876	9,365	2,701
Canada	148,851	39,578	120,611	34,329	149,700	42,698
Finland	--	--	1,313	368	32,417	9,270
France	1,435	354	512	150	2,211	752
Germany, West	--	--	442	122	6,138	1,772
Japan	52,502	13,239	32,525	8,764	8,705	2,308
Mexico	12,092	2,642	7,358	1,746	10,130	2,442
Mozambique	1,256	301	661	170	--	--
Netherlands	--	--	200	56	18,745	5,849
Norway	4,481	1,206	1,343	395	2,205	329
Peru	30,204	8,201	31,923	9,143	24,412	7,283
Poland	9,495	2,498	7,729	2,284	2,508	729
South Africa, Republic of	56	14	--	--	4,740	1,422
Spain	--	--	--	--	5,071	1,475
United Kingdom	1,041	259	1,054	294	745	196
Yugoslavia	385	93	114	32	138	39
Zaire	10,621	2,742	6,300	1,695	8,898	2,444
Zambia	3,799	949	1,773	493	315	91
Other	1,007	229	1,568	419	1,212	332
Total	324,758	84,617	260,132	73,695	324,751	93,766

[1] Does not include zinc ores and concentrates imported for refining and export; 1969: Canada, 16,235 short tons ($2,440,467); Mexico, 16 short tons ($5,498); Morocco, 243 short tons ($22,045). 1970: Canada, 18,932 short tons ($2,748,599); Mexico, 565 short tons ($102,213); Morocco, 145 short tons ($10,918). 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).

Table 32.—U.S. general imports of zinc, by country

(Short tons and thousand dollars)

Country	1969 Quantity	1969 Value	1970 Quantity	1970 Value	1971 Quantity	1971 Value
ORES						
Australia	2,940	$628	2,324	$518	2,857	$201
Bolivia	2,069	347	2,904	439	--	--
Canada	367,529	54,213	317,992	47,153	209,084	30,027
Chile	421	76	1,056	201	--	--
Guatemala	525	79	4	1	138	13
Honduras	15,272	2,138	19,267	2,845	21,512	3,230
Ireland	--	--	--	--	3,975	657
Mexico	143,747	17,001	128,949	16,921	89,845	11,099
Morocco	5,988	614	--	--	--	--
Peru	57,087	8,597	48,037	7,644	15,025	2,375
South Africa, Republic of	6,525	866	5,096	772	61	11
Other	17	1	130	18	24	3
Total	602,120	84,560	525,759	76,512	342,521	47,616
BLOCKS, PIGS, OR SLABS						
Australia	34,237	8,896	30,335	9,359	38,552	12,056
Belgium-Luxembourg	13,296	3,416	14,371	3,876	9,365	2,701
Canada	148,851	39,578	120,611	34,329	150,868	43,050
Finland	--	--	1,313	368	31,702	9,348
France	1,435	354	512	150	2,211	752
Germany, West	--	--	3,198	886	3,661	1,085
Japan	52,502	13,239	32,525	8,764	8,705	2,308
Mexico	12,092	2,642	7,358	1,746	10,130	2,442
Mozambique	1,256	301	661	170	--	--
Netherlands	--	--	7,725	2,143	13,283	4,220
Norway	4,481	1,206	1,343	395	2,205	329
Peru	30,204	8,201	31,923	9,143	23,873	7,132
Poland	9,495	2,498	7,729	2,284	2,618	764
Romania	--	--	--	--	1,221	354
South Africa, Republic of	56	14	--	--	4,740	1,422
Spain	--	--	--	--	5,071	1,475
United Kingdom	1,041	259	1,054	294	800	210
Yugoslavia	385	93	114	32	138	39
Zaire	10,621	2,742	6,300	1,695	8,898	2,444
Zambia	3,817	953	1,773	493	315	91
Other	1,007	229	1,568	419	1,212	332
Total	324,776	84,621	270,413	76,546	319,568	92,554

Table 33.—U.S. imports for consumption of zinc, by class

Year	Ore (zinc content) Short tons	Ore (zinc content) Value (thousands)	Blocks, pigs, slabs Short tons	Blocks, pigs, slabs Value (thousands)	Sheets, plates, strips, other forms Short tons	Sheets, plates, strips, other forms Value (thousands)
1969	565,234	$79,242	324,758	$84,617	840	$380
1970	450,770	67,164	260,132	73,695	692	419
1971	467,368	62,678	324,751	93,766	509	237

Year	Old and worn out Short tons	Old and worn out Value (thousands)	Dross and skimmings Short tons	Dross and skimmings Value (thousands)	Zinc dust Short tons	Zinc dust Value (thousands)	Total value [1] (thousands)
1969	1,770	$255	r 717	$67	8,251	$2,652	$167,213
1970	1,497	192	418	92	9,359	3,161	144,723
1971	1,114	147	853	140	8,184	2,949	159,917

r Revised.

[1] In addition, manufactures of zinc were imported as follows: 1969–$489,430; 1970–$1,276,276; 1971–$1,346,752.

Table 34.—U.S. imports for consumption of zinc pigments and compounds

Kind	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc arsenate	--	--	7	$1
Zinc oxide	12,073	$2,764	13,113	2,945
Zinc sulfide	349	109	428	142
Lithopone	77	19	81	13
Zinc chloride	1,151	228	1,319	266
Zinc sulfate	6,298	651	5,438	567
Zinc cyanide	143	96	162	116
Zinc compounds, n.s.p.f	675	239	372	137
Total	20,766	4,106	20,920	4,187

Table 35.—World mine production (content of ore), by country

(Short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada [2]	[r] 1,323,520	1,365,938	1,397,246
Guatemala (exports)	1,026	--	558
Honduras	17,644	22,090	25,236
Mexico	279,298	293,655	292,081
United States	553,124	534,136	502,543
South America:			
Argentina	34,927	42,974	44,000
Bolivia [3]	28,875	51,239	50,477
Brazil	5,952	13,900	[e] 14,000
Chile	1,629	1,694	2,086
Colombia	[r] 181	172	123
Ecuador	229	140	[e] 140
Peru	331,027	329,741	368,200
Europe:			
Austria	15,690	17,314	23,229
Bulgaria	[r] 85,000	84,200	[e] 77,200
Czechoslovakia	11,530	11,299	[e] 13,000
Finland	78,044	69,015	56,093
France	22,156	20,481	16,645
Germany, East [e]	11,000	11,000	11,000
Germany, West	122,069	125,423	143,937
Greece	10,128	10,325	15,063
Hungary [e]	5,300	5,300	5,300
Ireland	107,453	106,366	96,500
Italy	[r] 145,800	122,000	114,800
Norway	[r] 12,365	11,680	12,335
Poland	188,275	205,900	[e] 209,000
Portugal	1,203	1,770	2,228
Romania (recoverable) [e]	33,000	43,900	43,900
Spain	92,978	108,098	94,632
Sweden	[r] 99,697	103,000	105,500
U.S.S.R.[e]	672,000	672,000	717,000
Yugoslavia	106,624	111,493	110,451
Africa:			
Algeria	[r] 23,024	18,710	21,600
Congo (Brazzaville) [e]	630	100	55
Morocco	37,343	19,923	13,760
South Africa, Republic of	--	8	174
South-West Africa, Territory of [4]	[r] 30,971	51,462	48,168
Tunisia	10,313	13,170	13,265
Zaire	104,232	115,833	132,000
Zambia (smelter)	55,297	58,925	62,904
Asia:			
Burma	5,393	4,483	4,682
China, People's Republic of [e]	110,000	110,000	110,000
India	8,165	9,090	8,825
Iran [5] [e]	58,600	63,600	64,000
Japan	296,979	308,293	324,541
Korea, North [e]	138,000	143,000	149,000
Korea, Republic of	22,688	26,433	31,042
Philippines	3,622	3,517	4,271
Thailand (in lead-zinc ore) [e]	800	600	1,000
Turkey	[r] 20,700	26,100	[e] 28,000
Oceania:			
Australia	[r] 562,070	537,052	494,020
New Zealand	1,727	1,608	2,171
Total	[r] 5,888,298	6,008,150	6,077,981

[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] Zinc content of concentrates.

[3] 1969 and 1970 data are sum of production by COMIBOL and exports by medium and small miners; 1971 figure is total national exports.

[4] Data for year ending June 30 of that stated.

[5] Year beginning March 21 of year stated.

Table 36.—World smelter production, by country

(Short tons)

Country [1]	1969	1970	1971 [p]
North America:			
Canada	[r] 466,350	460,663	410,030
Mexico	88,477	88,915	85,828
United States	1,040,597	877,811	766,433
South America:			
Argentina	27,115	35,274	36,000
Brazil	[r] 5,398	11,600	[e] 11,600
Peru	68,649	75,715	63,048
Europe:			
Austria [2]	17,121	17,657	17,603
Belgium [2]	287,254	265,918	227,932
Bulgaria [2]	[r] 83,600	83,900	[e] 83,800
Finland	1,195	61,531	70,219
France	279,480	246,554	241,027
Germany, East [e] [2]	[r] 17,000	17,000	17,000
Germany, West	162,195	165,593	139,372
Italy	143,654	156,618	153,147
Netherlands	51,397	50,952	45,400
Norway	64,788	67,704	68,762
Poland [2]	228,700	230,400	242,500
Romania [e]	33,000	43,900	43,900
Spain	[r] 89,590	98,328	98,446
U.S.S.R. [e]	672,000	672,000	717,000
United Kingdom	166,441	161,596	128,400
Yugoslavia [2]	89,352	71,676	58,543
Africa:			
South Africa, Republic of	13,057	18,174	22,584
Zaire	70,252	70,272	70,100
Zambia	55,297	58,925	62,904
Asia:			
China, People's Republic of [e]	[r] 110,000	110,000	110,000
India	25,409	25,805	23,443
Japan	785,051	745,437	662,595
Korea, North [e]	66,000	99,000	110,000
Korea, Republic of	2,546	2,535	9,925
Oceania: Australia	[r] 271,524	287,252	285,164
Total	[r] 5,482,489	5,378,705	5,082,705

[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 about 10 percent more in 1971 than in 1970. Zircon imports increased slightly while zircon exports were more than double those shown for 1970. Exports of zirconium oxide, zirconium metal, and zirconium alloys, rose in 1971. Production of zirconium-bearing compounds for chemicals and refractories also increased.

Legislation and Government Programs.—The Statistical Supplement to the Stockpile Report to Congress, Dec. 31, 1971, showed no objectives for zirconium and hafnium materials. Stocks of 16,114 tons of Brazilian baddeleyite, 1,720 tons of zircon, and 1 ton of zirconium metal powder are in excess. The U.S. Atomic Energy Commission (AEC) had an inventory as of June 30, 1971, of approximately 74 tons of zirconium scrap, 1,064 tons of zirconium sponge, 83 tons of Zircaloy, 2 tons of hafnium scrap, 47 tons of hafnium oxide, ½ ton of hafnium sponge and shapes, and 39 tons of hafnium crystal bar.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

Product	1967	1968	1969	1970	1971
Zircon:					
Production	W	W	W	W	W
Exports	2,729	2,026	5,395	4,335	9,429
Imports	59,303	59,900	95,414	94,759	96,387
Consumption [e]	134,000	[1] 143,000	[1] 160,000	[1] 145,000	[1] 166,000
Stocks, yearend, dealers and consumers [2]	48,000	46,000	53,000	52,000	42,500
Zirconium oxide:					
Production [3]	3,865	3,864	5,702	4,957	10,770
Producers' stocks, yearend [3]	1,267	1,077	1,005	1,050	680

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Includes baddeleyite: 1968—200 tons; 1969—383 tons; 1970—355 tons; 1971—871 tons.
[2] Excludes foundries.
[3] Excludes oxide produced by zirconium metal producers.

DOMESTIC PRODUCTION

E. I. du Pont de Nemours & Co., Inc., was the only major producer of zircon mineral concentrates in the United States. Zircon was recovered from mineral sands at the dredging and milling facilities owned by du Pont, at Starke, Fla., and by the Humphreys Mining Co. for du Pont, near Folkston, Ga. Production data are withheld from publication to avoid disclosing individual company confidential data. The combined zircon capacity of these two plants is about 100,000 net tons per year.[2]

Statistical data on the production of zirconium sponge, ingot, and scrap and on hafnium sponge and oxide are also withheld to avoid disclosure of company confidential data. Zirconium powder and alloy and also zirconium sponge metal production increased 20 percent over that reported for 1970.

Twelve firms, an increase of eight, produced 47,500 tons of milled (ground) zircon, an increase of 3.7 percent over the 1970 producton. Six companies, an increase of two, excluding those that produce metal, produced 10,770 tons of zirconium oxide. Oxide production in 1971 was more than double that reported for 1970. Production of zirconium-bearing refractories totaled 31,500 tons, containing from 33 to 90 percent zirconium oxide.

Hafnium crystal bar, produced by several firms, amounted to 32 tons, compared with 35 tons in 1970.

[1] Physical scientist, Division of Nonmetallic Minerals.
[2] Lipton, J. M. Florida Deposit Insures Zircon Supply Through the Year 2000. Am. Metal Market, Zircon and Zirconium Rept., Aug. 6, 1971, pp. 3A and 6A.

CONSUMPTION AND USES

Zircon consumption in the United States in 1971 was estimated at 166,000 tons. Consumption of zircon concentrate and milled zircon was 116,000 tons for foundries, 23,000 tons for refractories, and 27,000 tons for all other uses. Foundries consumed 53 percent of the domestic zircon production. The remaining 47 percent was consumed by refractory, 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 minerals blends, including kyanite, sillimanite and staurolite, for foundry core and sandblasting applications.

Eighty-five percent of the imported South African baddeleyite ore in 1971 was used in the manufacture of abrasives. The remaining 15 percent was used in ceramic colors, refractories, chemicals, and other uses.

Preliminary Bureau of Census figures for 1971 showed that shipments of zircon and zirconia brick and shapes, composed mostly of these materials, totaled 2.0 million brick, expressed in terms of equivalent 9-inch brick, valued at $7.0 million. In 1970,

Table 2.—Producers of zirconium and hafnium materials, 1971

Company	Location	Materials
	ZIRCONIUM MATERIALS	
AMAX Specialty Metals, Inc	Akron, N.Y	Ingot.
Do	Parkersburg, W. Va	Sponge metal.
Barker Foundry Supply Co	Los Angeles, Calif	Milled zircon.
The Carborundum Co	Falconer, N.Y	Refractories.
Corhart Refractories Co	Buckhannon, W. Va	Do.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
E. I. duPont de Nemours and Co., Inc	Wilmington, Del	Zircon, foundry mixes.
Foote Mineral Co	Cambridge, Ohio	Alloys.
Do	Exton, Pa	Metal powder.
A. P. Green Refractories Co., Remmey Division.	Philadelphia, Pa	Refractories.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Harvey Aluminum, Inc	Torrance, Calif	Ingot.
Lava Crucible Refractories	Zelienople, Pa	Milled zircon.
M & T Chemicals, Inc	Andrews, S. C	Do.
Magnesium Electron, Inc	Secaucus, N.J	Alloys.
NL Industries, Inc Titanium Alloy Manufacturing Div. (TAM)	Niagara Falls, N.Y	Milled zircon, sponge, scrap, powder, alloys, refractories.
Norton Co	Huntsville, Ala	Oxide.
Ohio Ferro-Alloys Corp	Brillant, Ohio	Alloys.
Ronson Metals Corp	Newark, N.J	Baddeleyite (oxide).
Frank Samuel & Co., Inc	New Castle, Del	Milled zircon.
Do	Camden, N.J	Do.
Sherwood Refractories Co	Cleveland, Ohio	Milled zircon, ceramics.
Tizon Chemical Corp	Flemington, N.J	Oxide, other compounds.
The Charles Taylor Sons Co	Cincinnati, Ohio	Refractories.
Do	South Shore, Ky	Do.
Transelco, Inc	Dresden, N.Y	Various compounds, ceramics, alloys.
T. R. W., Inc	Cleveland, Ohio	Milled zircon, refractories.
Do	Danville, Pa	Do.
Do	Harrisburg, Pa	Do.
Union Carbide Corp	Alloy, W. Va., & Niagara Falls, N.Y.	Alloys.
Ventron Corp	Beverly, Mass	Do.
Wah Chang Albany Corp	Albany, Oreg	Oxide, chloride, sponge metal, ingot, powder.
C. E. Refractories, Div. of Combustion Engineering, Inc.	St. Louis, Mo	Refractories.
Zirconium Corp. of America	Cleveland, Ohio	Milled zircon.
Continental Mineral Processing Corp	Sharonville, Ohio	Do.
	HAFNIUM MATERIALS	
AMAX Specialty Metals, Inc	Akron, N.Y	Sponge metal, crystal bar.
Do	Parkersburg, W. Va	Oxide.
Nuclear Materials & Equipment Corp	Leechburg, Pa	Crystal bar.
Wah Chang Albany Corp	Albany, Oreg	Oxide, sponge metal, crystal bar, ingot.
R. M. T. Co	Ashtabula, Ohio	Sponge, crystal.

Table 3.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	Yearend 1970	Yearend 1971
Zircon concentrate held by dealers and consumers, excluding foundries	46,000	36,000
Milled zircon held by dealers and consumers, excluding foundries	6,400	6,400
Zirconium:		
Oxide	1,788	1,055
Sponge	625	426
Ingot	442	W
Scrap	351	741
Powder	W	W
Alloys	274	356
Refractories	7,495	8,098
Hafnium:		
Oxide	W	W
Sponge	30	42
Crystal bar	11	10

r Revised. W Withheld to avoid disclosing individual company confidential data.

final figures for shipments were 1.8 million brick valued at $7 million.[3]

Dealers and other firms indicated shipments of milled zircon and concentrate in 1971 to the following markets: Foundry use, 66,200 tons; refractories and chemicals, 59,800 tons; and chemical, metal, alloys, compounds, and other uses, 3,800 tons.

Zirconium metal was used in nuclear reactors, in chemical plants for corrosion resistant material, and in photography for flash bulbs. Zirconium compounds, natural and manufactured, were also used in refractories, glazes, enamels, welding rods, ferroalloys, and sandblasting.

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 flash cubes.

PRICES

Published prices of zircon, zirconium oxides and chemicals, zirconium hydride, zirconium metal powder and sponge, and hafnium metal products, except for zircon, were unchanged from 1970. Domestic and foreign zircon prices decreased approximately $2 per short ton. The baddeleyite price was furnished by the Ronson Metals Corp.

[3] U.S. Department of Commerce, Bureau of the Census. Refractories. First Quarter 1971, Series MQ–32C(71)–1, June 3, 1971; Second Quarter 1971, Series MQ–32C(71)–2, Aug. 17, 1971; Third Quarter 1971, Series MQ–32C(71)–3, November 1971; Fourth Quarter 1971, Series MQ–32C(71)–4, March 1972. Each report 4 pp.

Table 4.—Published prices of zirconium and hafnium materials, 1971

Specification of material	Price
Zircon:	
Domestic, f.o.b. Starke, Fla. (Folkston, Ga.), bags, per short ton [1]	$54.00–55.00
Imported sand, containing 65 percent ZrO_2, c.i.f. Atlantic ports, in bags, per long ton [2]	68.00
Domestic, granular, 1- to 5-ton lots, from works, in bags, per pound [3]	.04875
Domestic, milled, 1- to 5-ton lots, from works, in bags, per pound [3]	.055
Baddeleyite imported concentrate: [4]	
98–98 percent ZrO_2, c.i.f. Atlantic ports, minus 100-mesh, per pound	.15
99 + percent, minus 325-mesh, c.i.f. Atlantic ports, ton lots, per pound	.45– .60
Zirconium oxide: [3]	
Powder, commercial-reactor grade, drums, from work, per pound	6.50– 8.00
Chemically pure white ground, barrels or bags, works, per pound	1.50
Milled, bags, 5-ton lots, from works, per pound	.645
Glass polishing grade, 100-pound bags, 94–97 percent ZrO_2, works, per pound	.71
Opacifier grade, 100-pound bags, 85–90 percent ZrO_2, per pound	.42
Stabilized oxide, 100-pound bags, 91 percent ZrO_2, milled per pound	.80– 1.10
Zirconium oxychloride: [3]	
Crystal, cartons, 5-ton lots from works, per pound	.515
Zirconium acetate solution: [3]	
13 percent ZrO_2, drums, carload lots, from works, per pound	.22
22 percent ZrO_2, same basis	.38
Zirconium hydride: [3]	
Electronic grade, powder, drums, from works, per pound	14.50–16.00
Zirconium: [5]	
Powder, per pound	12.00–13.00
Sponge, per pound	5.50– 7.00
Sheets, strip, bars, per pound	12.00–16.00
Hafnium: [5]	
Sponge, per pound	75.00
Bar and plate, rolled, per pound	120.00
Nitrided	34.25

[1] Du Pont Price List, July 1, 1971.
[2] Metals Week. V. 42, No. 27, July 8, 1971, p. 22.
[3] Chemical Marketing Reporter. V. 200, No. 1, July 5, 1971, p. 36.
[4] Ronson Metals Corp., Baddelyite Price List, Jan. 1, 1971.
[5] American Metal Market. V. 77, No. 190, Oct. 1, 1971, p. 24.

FOREIGN TRADE

Exports.—Exports of zirconium ore and concentrates, zirconium oxide, and zirconium by classes rose in 1971 compared to 1970.

Zirconium ore and concentrate, exported to 13 countries in 1971, increased from 8,760,175 pounds valued at $590,983 in 1970 to 18,857,871 pounds valued at $801,833. The major recipients were the Netherlands, 59 percent; Canada, 25 percent; and the United Kingdom, 6 percent.

Exports of zirconium oxide increased from 717,136 pounds valued at $599,954 in 1970 to 1,122,741 pounds valued at $839,025 in 1971. These shipments were made to 24 countries. The five major recipients in 1970 were West Germany, 21 percent; Canada, 18 percent; Spain, 12 percent; Italy, 11 percent; and France, 9 percent.

The exports of total zirconium by classes increased in 1971, from 600,035 pounds valued at $6,284,004 in 1970, to 1,125,242 pounds valued at $13,053,378. The zirconium and zirconium alloy foil and leaf category, of the three listed, decreased in both value and quantity in 1971 compared to 1970.

Imports.—Imports for consumption of zirconium ores in 1971 established a record high of 96,387 short tons. The previous high was 95,414 short tons of zirconium ores imported in 1969. The South African zirconium ore imports 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 was $35.36 per short ton, compared with $37.81 in 1970. The South African baddeleyite value in 1971 of $320.32 per short ton decreased from the 1970 value of $377.46 per short ton.

Table 5.—U.S. exports of zirconium ores and concentrates

Destination	1970		1971	
	Pounds	Value	Pounds	Value
Argentina	247,816	$31,669	193,680	$8,627
Austria	15,700	2,593	--	--
Brazil	76,000	4,875	--	--
Canada	6,890,860	236,698	4,804,760	252,013
Chile	30,800	3,288	166,000	6,247
Colombia	250	620	12,000	1,364
Ecuador	33,000	4,950	--	--
France	39,909	4,586	22,449	1,273
Germany, West	--	--	2,250	1,271
Hong Kong	--	--	210,640	17,500
Israel	6,800	1,840	1,420	891
Italy	254,912	33,743	5,200	2,185
Japan	1,131,541	263,127	447,507	179,611
Mexico	--	--	629,867	28,241
Netherlands	--	--	11,160,098	272,274
United Kingdom	32,587	2,994	1,202,000	30,336
Total	8,760,175	590,983	18,857,871	801,833

Table 6.—U.S. exports of zirconium by class and country

Country	1970		1971	
	Pounds	Value	Pounds	Value
Zirconium and zirconium alloys, wrought:				
Argentina	--	--	1,218	$22,892
Australia	573	$8,338	21	576
Belgium-Luxembourg	r 115	r 3,800	18,761	762,025
Brazil	72	523	2,078	5,818
Canada	r 215,550	r 2,580,239	378,047	3,970,358
Denmark	232	8,612	--	--
Dominican Republic	4,400	47,899	--	--
France	r 4,653	r 49,229	781	10,067
Germany, West	r 41,038	r 604,599	163,266	1,623,603
India	4,089	81,351	3,206	110,596
Indonesia	--	--	33	1,152
Iran	--	--	45	1,550
Israel	137	1,000	--	--
Italy	5,601	108,961	1,533	27,199
Japan	r 35,006	r 547,674	115,864	2,697,994
Netherlands	2,971	19,223	4,010	22,736
Norway	r 1,950	r 19,106	8,248	79,449
Pakistan	47	525	--	--
Peru	--	--	17	744
Portugal	--	--	574	6,298
Sweden	16,075	250,207	14,317	144,926
Switzerland	561	2,860	--	--
Thailand	--	--	365	596
United Kingdom	r 8,925	r 177,978	46,417	740,952
Zaire	68	1,170	--	--
Total	r 342,063	r 4,513,294	758,801	10,229,531
Zirconium and zirconium alloys unwrought and waste and scrap:				
Belgium-Luxembourg	291	4,755	250	3,793
Brazil	4,990	21,134	939	4,206
Canada	1,505	21,636	2,832	12,685
Colombia	--	--	424	1,900
France	20,671	145,546	2,561	11,474
Germany, West	21,773	146,828	123,922	776,822
Guatemala	94	937	200	2,270
India	660	4,620	3,081	18,500
Italy	2,200	12,647	949	5,475
Japan	31,944	177,821	70,180	694,152
Mexico	--	--	247	2,938
Netherlands	1,261	5,647	349	2,911
Norway	393	4,255	16,643	165,475
Portugal	--	--	30	1,520
Spain	98	441	--	--
Sweden	20,586	194,703	14,491	137,337
Switzerland	5,905	26,453	--	--
Turkey	974	3,926	--	--
United Kingdom	104,846	553,508	107,635	573,230
Total	218,191	1,324,857	344,733	2,414,688
Zirconium and zirconium alloy foil and leaf:				
Belgium-Luxembourg	199	3,956	2,814	51,207
Canada	12,889	212,010	13,041	272,656
France	163	1,935	--	--
Germany, West	8,453	60,587	909	13,804
Italy	--	--	3,035	53,992
Japan	11,499	31,853	1,809	15,558
Norway	270	2,632	--	--
United Kingdom	6,308	132,880	100	1,942
Total	39,781	445,853	21,708	409,159

r Revised.

Table 7.—U.S. exports of zirconium oxide, by country

Country	1970		1971	
	Pounds	Value	Pounds	Value
Argentina	43,153	$39,747	19,319	$14,807
Australia	17,414	23,626	1,600	1,366
Austria	--	--	22,000	16,324
Belgium-Luxembourg	4,179	2,800	15,765	11,204
Brazil	24,397	15,984	41,828	52,202
Canada	139,016	91,128	202,165	132,121
Dominican Republic	--	--	549	816
France	58,202	57,643	99,971	95,740
Germany, West	73,771	56,899	238,327	167,986
Greece	750	1,020	900	1,292
India	6,022	5,325	--	--
Israel	--	--	1,200	1,046
Italy	93,101	77,695	123,630	104,824
Japan	119,607	134,215	41,397	29,138
Kuwait	--	--	500	680
Mexico	84,263	58,297	85,620	59,130
Netherlands	26,000	15,400	54,330	33,083
Panama	--	--	610	620
Peru	336	484	--	--
Portugal	--	--	400	544
South Africa, Republic of	581	509	--	--
Spain	240	285	132,538	88,800
Sweden	6,087	4,078	12,073	8,089
Switzerland	2,300	1,209	3,400	2,029
United Kingdom	17,517	13,338	23,619	15,824
Uruguay	--	--	600	816
Venezuela	200	272	400	544
Total	717,136	599,954	1,122,741	839,025

Table 8.—U.S. imports for consumption of zirconium and hafnium, 1971

Country	Pounds	Value
Zirconium, wrought:		
Canada	1,014	$12,150
France	75,414	542,110
Japan	54	429
United Kingdom	2	535
Total	76,484	555,224
Zirconium waste, scrap and unwrought:		
Canada	4,798	4,546
Germany, West	36,692	54,572
Japan	164,124	549,800
Netherlands	12,867	11,659
Sweden	7,209	10,805
United Kingdom	240	1,457
Total	225,930	632,839
Zirconium alloys, unwrought:		
Canada	7,144	9,385
Germany, West	100	1,050
United Kingdom	257	350
Total	7,501	10,785
Zirconium oxide compound:		
Canada	593,360	80,794
France	103	540
Germany, West	1,117	2,288
Japan	32,500	11,505
Netherlands	40,000	5,000
Switzerland	13	1,201
United Kingdom	176,000	99,283
Total	843,093	200,611
Zirconium compounds, n.e.c.:		
Canada	3,837	2,494
France	26,000	10,602
Germany, West	7,611	30,301
Japan	37,920	5,000
Switzerland	140	1,280
United Kingdom	946,049	279,360
Total	1,021,557	329,037
Hafnium unwrought, and waste and scrap:		
Germany, West	115	6,244
Hafnium, wrought: France	55	1,107

Table 9.—U.S. imports for consumption of zirconium ores, by country

Country	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	87,743	$3,510	86,816	$3,265	93,402	$3,328
Canada [1]	3,818	93	3,104	98	2,114	49
French Pacific Islands	3,358	60	--	--	--	--
Malaysia	112	3	--	--	--	--
South Africa, Republic of	383	192	355	134	871	279
United Kingdom [1]	--	--	4,484	207	--	--
Total	95,414	3,858	94,759	3,704	96,387	3,656

[1] Believed to be country of shipment rather than country of origin.

WORLD REVIEW

Australia.—Planet Metals Ltd. announced encouraging findings of rutile and zircon mineral sands after completing their extensive offshore drilling programs off the North and Central Coasts of New South Wales. The company was considering an offshore dredging operation with a throughput capacity of 10,000 tons of sand per hour. Planet Metals Ltd. maintains that their planned 600-foot by 120-foot dredge will permit economic operation. Conventional onshore dry separation of the heavy mineral concentrate is planned.[4]

Naracoopa Rutile Ltd. continued developing their Lanherne Beach pit by commissioning a new 150-ton-per-hour wet concentrating plant.[5] The company also undertook further exploration on King Island and on the mainland. Known reserves will enable Naracoopa Rutile Ltd. to continue operating until 1976.[6] [7]

Brazil.—The Minegral-Companhia Brasileira de Minerações, Industria e Comercio recovered caldasite, an impure mixture of baddeleyite and zircon containing approximately 60 to 75 percent ZrO_2, from deposits in the Poços de Caldas area. The entire output was consumed domestically.[8]

Denmark.—The Danish chemical company Dansk Svovlsyre og Superphosphatfabrik, was attempting to improve a zirconium refining process originally developed by the Danish Atomic Energy Commission. The company will determine in about a year whether the process can be applied commercially to the vast Greenland kakortokite igneous zirconium deposits. Zirconium refining was reported to be complicated by the low metal content and the presence of sodium compounds in the eudialyte (a complex zirconium-bearing silicate) concentrate.[9]

Egypt, Arab Republic of.—Interest was renewed in further developing the Nile River black sand as a source of an ilmenite feedstock for U.S.S.R. pigment production. Byproduct zircon production is anticipated.[10]

Germany, West.—Rapid progress was reported in the exploration of alluvial heavy mineral deposits in the North Sea off the Lower Saxony Coast, West Germany. Preliminary tests carried out by the small prospecting ship Benno for the Federal Institute for Soil Research, Hannover, indicated the presence of relatively small amounts of rutile, ilmenite, and zircon. The deposits are commercially attractive because of their reported large reserves.[11]

Japan.—Nippon Mining Co. and Sumitomo Metal Mining Co. have agreed to form a jointly-owned company for zirconium production. The proposed firm will smelt and produce zirconium sponge and billets for use in the domestic manufacture of sheathing tubes for nuclear fuel elements.[12]

South Africa, Republic of.—The Phosphate Development Corp. Ltd. (FOSKOR) reported that their baddeleyite (ZrO_2) con-

[4] Oceanology International. V. 6, No. 4, April 1971, p. 31.
[5] Industrial Minerals. No. 44, January 1971, p. 31.
[6] Industrial Minerals. No. 45, June 1971, p. 46.
[7] Industrial Minerals. No. 42, February 1971, p. 51.
[8] Mineral Trade Notes. V. 68, No. 8, August 1971, p. 41.
[9] Metal Bulletin. No. 5543, Oct. 23, 1970, p. 21.
[10] Industrial Minerals. No. 50, November 1971, p. 25.
[11] Mining Magazine. V. 125, No. 6, December 1971, p. 575.
[12] Mining Journal (London). V. 277, No. 7091, July 16, 1971, p. 57.

centrate, produced as a byproduct from their unique Phalaborwa igneous deposit, was acceptable to the ceramics industry. Initial problems with production and quality reportedly associated with their zirconia concentrate have been resolved. FOSKOR maintained that industrial acceptance of their baddeleyite, as a substitute for chemically prepared zirconia, has prompted both increased production and expansion expenditures.[13]

Table 10.—Zirconium concentrates: Non-Communist world, production by country

(Short tons)

Country	1969	1970	1971 p
Australia	r 413,612	424,902	447,378
Brazil	3,874	4,483	4,956
Ceylon	75	123	1 111
India 2	5,467	7,649	e 7,700
Malagasy Republic	--	3	3
Malaysia	3 1,562	3 948	4 2,987
South Africa, Republic of 5	453	432	1,092
Thailand	276	953	1,682
United States	W	W	W
Total	r425,319	439,493	465,909

e Estimate. p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
1 Imports of zircon and/or zirconium-bearing sand by Japan from Ceylon.
2 Output of Indian Rare Earths Ltd. for years beginning April 1 of that stated.
3 Exports.
4 Imports of zircon and/or zirconium-bearing sand by Japan from Malaysia.
5 Official South African production figures are not available. Data are the total of zirconium concentrate imports by the United States and Japan and may be only a part of total output.

TECHNOLOGY

A Bureau of Mines report, based on beneficiating tests conducted on selected sand and gravel operations in the Southeastern United States, indicates that significant quantities of heavy minerals sand, containing mainly ilmenite, zircon, rutile, and kyanite, are lost annually.[14]

A 2 year, $2.4 million contract has been signed between the Office of Coal Research (OCR) and Avco Corp., covering the development of a system to generate electrical energy from coal through magnetohydrodynamics (MHD). Research and development work, to be done at Avco's Everett, Mass., facility will involve problems relating to materials of construction because of the high temperatures and corrosive MHD duct conditions, and to controlling the sulfur and nitrogen oxides resulting from the burning of coal. The Avco system uses calcia-stabilized zirconia electrode and insulator materials.[15] OCR has also finalized plans for supporting research to develop more efficient ceramic electrodes and insulators for coal-fired MHD systems.

The manufacture of thermally shock resistant, niobia-stabilized zirconia refractories with exceptionally high strengths at high temperatures[16] and a unique partially stabilized calcia-zirconia refractory[17] were reported.

A partially stabilized magnesia-zirconia nozzle has been developed and used in a new continuous copper casting and rolling process. The new nozzle, thermal shock resistant and chemically inert, contributed to both reduced processing costs and higher quality copper rods.[18] A cored yttria-stabilized zirconia brick shape has been developed for use in a regenerative ceramic wind tunnel storage heater for testing

[13] Phosphorous and Potassium. No. 53, May–June 1971, p. 44.
[14] Davis, E. G., and G. V. Sullivan. Recovery of Heavy Minerals From Sand and Gravel Operations in the Southeastern United States. BuMines Rept. of Inv. 7517, 1971, 22 pp.
[15] Chemical Engineering. Chementator. V. 78, No. 7, Mar. 22, 1971, pp. 37–38.
[16] Valdsaar, H. Stabilized Zirconia Containing Niobia and Calcium Oxide. U. S. Pat. 3,522,064, July 28, 1970.
[17] Garvie, R. C. Partially Stabilized Zirconia Refractory. U. S. Pat. 3,620,781, Nov. 16, 1971.
[18] Jaeger, R. E., and R. E. Nickell. Thermal Shock Resistant Zirconia Nozzles for Continuous Copper Casting. Proc. 6th Univ. Conf. on Ceram. Sci., North Carolina State University, Raleigh, N.C. Dec. 7–9, 1970, Plenum Press, N. Y., 1971, pp. 35–47.

reentry parameters. A tunnel has been constructed and simulated tests begun.[19]

The preparation of a zirconium diboride that is oxidation resistant up to 1,500° C was reported. The zirconium diboride was rendered more stable by adding small amounts of silicon carbide. During service at elevated temperatures, a surficial SiO_2-base glass is formed. This surface reportedly imparts additional protection to the refractory.[20]

Superior thermal shock resistance yttria-stabilized hafnia-based graphite and tungsten composites have been developed for use as rocket-nozzle throat inserts in solid propellant rocket engines.[21]

The plasma treatment of zircon to produce zirconia and sodium silicate is reportedly feasible on a pilot-commercial scale. The plasma temperature fusion of zircon produces an intimate mixture of amorphous silica and zirconia. The silica is separated as byproduct sodium silicate during a two-stage caustic soda leach. The plant's rated capacity is 200,000 pounds per year of 70-percent-pure zirconia (the balance being chiefly amorphous silica); a 99-percent-pure product is possible, but at a reduced production rate of 120,000 pounds per year.[22] The purification of South African baddeleyite ore by a multiple stage hydrochloric acid treatment process was reported. The method involves increasing acid strengths and variable leaching temperatures to remove the principal metallic contaminants, namely phosphorous, copper, and iron.[23]

The geology of the Florida heavy mineral sand deposits, including the du Pont Trail Ridge deposit was described in a report. The mining and processing flowsheet for the Trail Ridge plant was also presented in detail. The unique consistency of the Florida zircon grain, namely its freedom from impurities and its rounded frosted surface, was reported to be an extremely valuable product for the foundry industry.[24]

A comprehensive thesis on zirconia, its formation, its preparations, and its physical and chemical properties, was published.[25] A new abrasive grain consisting of alumina and zirconia with superior properties[26] and a welding technique applicable to zirconia-based ceramics was reported during the year.[27]

Union Carbide Corp. introduced Zircar, a novel yttria-stabilized fibrous zirconia material for thermal insulation applicable at temperatures up to 4,500° F. The fibrous zirconia is available in cloth, board and bulk fiber. An alkali resistant glass fiber for reinforcing cements was reported by the National Research Development Corp.[28]

AMAX Specialty Metals Inc. announced a new process for making hafnium foil less than 0.001 inch thick. The new hafnium foil was reported to be superior to zirconium in photographic flashcube application. Strengthening of the high melting molybdenum and tungsten superalloys with hafnium carbide was also announced.[29]

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[19] Fehrenbacher, L. L. Optimum Properties of Zirconia Ceramics for High Performance Storage Heaters. Proc. 6th Univ. Conf., North Carolina State Univ., Raleigh, N. C., Ceram. Sci., Plenum Press, N. Y., 1971, pp. 105–122.

[20] Graham, H. C., H. H. Davis, and I. A. Kvernes. Microstructural Features of Oxide Scales Formed on Zirconium Diboride Materials. Proc. 6th Univ. Conf. Ceram. Sci., North Carolina State Univ., Raleigh, N. C., Plenum Press, N. Y., 1971, pp. 35–47.

[21] Lineback, L. D. and C. R. Manning. Factors Affecting the Thermal Shock Behavior of Yttria Stabilized Hafnia-Based Graphite and Tungsten Composites. Proc. 6th Univ. Conf. Ceram. Sci., North Carolina State Univ., Raleigh, N. C., Plenum Press, N. Y., 1971, pp. 163–184.

[22] Thorpe, M. L., Jr., and P. H. Weeks. Chemical Engineering, v. 78, No. 26, Nov. 15, 1971, pp. 117–119.

[23] Greinacher, E. and W. Brugger. Process of Refining Baddeleyite. U. S. Pat. 3,552,914, Jan. 5, 1971.

[24] Garnar, T. E., Jr. Heavy Minerals Mining and Processing in North Central Florida. Geol. Rev. Some North Florida Mineral Resources. Southeast Geol. Soc. P.O. Box 1634, Tallahassee, Fla., October 1971, pp. 26–32.

[25] Rijorten, H. T. Zirconia. Ph. D. Thesis, Technische Hogeschool Delft., Drukkerij Gebr. Janssen N. V., Nijmegen, Netherlands, 1971, 146 pp. (in English).

[26] Ueltz, H. F. G. New developments in Abrasive Grain. Pres. Meeting Soc. Manufacturing Eng. April 1971, Phila., Pa., Tech. Paper MR 71–109, pp. 1–18.

[27] Rice, R. W. Welding Ceramic Parts. Mat. Eng., v. 74, No. 7, December 1971, pp. 30–33.

[28] Gadsden, P. Zirconium and Hafnium. Min. Ann. Rev., June 1971, pp. 92–93.

[29] Klopp, W. D., R. L. Raffo, and W. R. Witzke. Strengthening of Molybdenum and Tungsten Alloys with HFC. J. Metals, v. 23, No. 6, June 1971, pp. 27–38.

Minor Metals

By Staff, Division of Nonferrous Metals

CONTENTS

ARSENIC [1]

Domestic Production.—Arsenic trioxide was produced in the United States as a byproduct of base-metal ores, primarily copper ore, at the Tacoma, Wash., plant of The American Smelting and Refining Company. Production figures cannot be published. Production in 1971, however, was curtailed by the strike at copper facilities beginning on July 1 and ending in late August. Shipments were less than production and yearend stocks rose to the highest level since compilation of these data was begun in 1939.

Consumption and Uses.—Apparent consumption of arsenic, essentially all as white arsenic (As_2O_3), decreased approximately 10 percent from that of 1970. Calcium and lead arsenate chemicals were the major end products; minor quantities of arsenic were used in sodium arsenate and other chemical compounds.

Arsenic is primarily used for its toxic qualities in the agricultural industry for insecticides, selective plant killers, defoliants, and for parasitic control in chicken feed. Arsenic compounds continued to be used as wood preservatives. However, consumption of Wolman Salts, the principal arsenic preservative, declined from 2,330 tons in 1966 to 806 tons in 1970. In 1971, arsenic was utilized in the fever tick eradication program which included two related programs. One was the precautionary treatment of all cattle presented for importation from Mexico. This program involved the dipping of more than 500,000 cattle from tick-infested areas in a 0.22-percent arsenic oxide solution prior to entry. The other program involved apprehension of fever-tick-infested livestock which illegally enter the United States and eradication of infestations in the U.S. The animals are dipped at 2-week intervals until the infestations are eradicated and are dipped before leaving the quarantine zone to preclude carrying any fever ticks with them. Of 138,420 cattle and horses dipped in 1971, more than 115,000 were dipped in an arsenical solution.

About 3 percent of the arsenic consumed is used as metal for alloying with lead and copper. Small quantitites of high-purity arsenic are used in the electronics industry.

Prices.—The price of refined white arsenic, 99.5 percent, at New York docks, in barrels, small lots, has been unchanged at 6¼ to 6¾ cents per pound since July 6, 1968. 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.

Arsenic metal was quoted in London at £600 nominal per long ton (64.3 cents per pound) throughout 1971.

Lead arsenate in 50-pound bags was quoted at 26 to 29 cents per pound throughout 1971. The price of sodium arsenate, 60 percent arsenic pentoxide, in 200-pound drums was unchanged at 30 cents per pound; and sodium arsenite, 94-

[1] Prepared by Gertrude N. Greenspoon, mineral specialist.

percent-soluble pink powder, 75 percent arsenous acid, in 100-pound drums, was quoted at 23 cents per pound through September 20, 1971, when quotations were terminated.

Foreign Trade.—No exports of arsenic metal or white arsenic have been reported since 1945.

Imports of white arsenic declined 13 percent in 1971. Mexico displaced Sweden as the principal supplier with 51 percent of the total, Sweden furnished 39 percent and France 9 percent.

Receipts of arsenic metal rose 18 percent to 536 tons. Sweden supplied 516 tons, West Germany 10 tons, and Canada 9 tons. Small quantities were received from Japan, Belgium-Luxembourg, the Netherlands, and the United Kingdom.

Tariff.—Under the General Agreement on Tariffs and Trade (GATT), the duty on arsenic metal was reduced from 1.7 cents to 1.5 cents per pound, effective January 1, 1971. Arsenic oxide (white arsenic) enters duty free.

Table 1.—U.S. imports for consumption of arsenicals class by country

(Thousand pounds and thousand dollars)

Class	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
White arsenic (As_2O_3)	36,341	$2,064	37,525	$2,089	32,812	$2,187
Metallic arsenic	692	568	912	1,876	1,072	1,260
Sulfide	19	5	17	5	--	--
Sheepdip	44	9	--	--	--	--
Sodium arsenate	110	11	186	23	248	35
Lead arsenate	45	6	--	--	4	1
Arsenic compounds, n.e.c	10	43	42	50	1	26

Table 2.—U.S. imports for consumption of white arsenic (As_2O_3) content, by country

Country	1969		1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	17	$4	--	--	25	$9
France	4,336	420	2,650	$274	1,425	180
Germany, West	--	--	--	--	(1)	(1)
Mexico	7,361	875	7,750	867	8,316	980
Peru	255	19	110	65	68	27
South Africa, Republic of	121	13	111	13	196	23
Sweden	6,071	732	8,142	870	6,376	968
Western Africa, n.e.c	10	1	--	--	--	--
Total	18,171	2,064	18,763	2,089	16,406	2,187

[1] Less than ½ unit.

World Review.—*Japan.*—To meet the growing demand in Japan for ultra-high-purity arsenic metal, Furukawa Mining Co. began production of arsenic metal of 99.999 percent purity. The arsenic metal is produced from the white arsenic recovered as a byproduct of copper smelting at the Ashio plant. Crude white arsenic from reverberatory furnaces is further purified by being resublimed at about 500°C to obtain metal of over 99 percent purity. The ultra-high-purity metal is consumed in semiconductor compounds, principally gallium-arsenide, and is available also for export.

Table 3.—White arsenic (arsenic trioxide) [1]: World production, by country

(Short tons)

Country [2]	1969	1970	1971 [p]
Brazil	331	328	163
Canada	170	71	--
France [e]	15,000	15,000	15,000
Germany, West	648	408	[e] 33
Japan	[r] 639	974	1,054
Mexico	8,800	10,075	12,688
Peru	530	851	746
Portugal	272	209	[e] 210
South-West Africa, Territory of [3]	2,444	4,478	4,080
Spain	[r] 101	19	--
Sweden	18,188	18,078	[e] 17,600
U.S.S.R.[e]	[r] 7,830	7,880	7,880
United States	W	W	W
Total	[r] 54,953	58,371	59,454

[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 production has continued, and if so, at what levels.

[3] Output of Tsumeb Corp. Ltd. for year ending June 30 of that stated; data given are white arsenic equivalent of reported black arsenic oxide production.

CESIUM AND RUBIDIUM [2]

Domestic Production.—Imported pollucite and ALKARB, a residue from past lithium compound production, were the raw material sources for all of the cesium and rubidium compounds produced in the United States in 1971. No cesium or rubidium metal was produced in 1971, but the total production of compounds of the two metals increased. The compounds were produced by American Potash & Chemical Corp., Trona, Calif.; Cooper Chemical Co., Long Valley, N.J.; Kawecki Berylco Industries, Inc. (KBI), Revere, Pa.; and Rocky Mountain Research, Inc., Denver, Colo. Shipments of cesium and rubidium metal were made from stocks by KBI and MSA Research Corp., Callery, Pa.

No cesium or rubidium ores were produced in the United States during 1971. A supply of 47 tons of domestic pollucite, mined in 1962, was reported at the Tin Mountain mine near Custer, S. Dak. W. R. Grace & Co. reported shipments of imported pollucite from its warehouse at Erie, Mich.

Consumption and Uses.—Statistical data on the consumption and uses of cesium and rubidium metal and compounds were not available. The largest use was probably in research and development in a variety of technical fields. Commercial applications for cesium and rubidium included their use in pharmaceuticals, scintillation counters, photomultiplier tubes, infrared lamps, photoelectric cells, vacuum tubes, ultracentrifuges, and in chemical processes as a catalyst. Cesium and rubidium and their compounds can be substituted for each other in some applications.

The greatest potential for large usage of cesium and rubidium appeared to be in new power generation systems. Research on magnetohydrodynamics (MHD) was being expanded through Government assistance programs. Although cesium carbonate has been one of the materials used as an ionizing agent in MHD, it was uncertain whether cesium or potassium carbonate or some other material would be used should MHD be proven successful on a commercial basis. Research was also continued on the development of thermionic convertors, which may also utilize cesium or rubidium.

Prices.—Domestic prices of cesium and rubidium ores were not published. Metal Bulletin quoted a nominal price for pollucite concentrates, minimum 24 percent Cs_2O, f.o.b. source, at $11.45 (using 1£ = $2.40) per metric ton unit (22.046 pounds) of Cs_2O. The American Metal Market quotation on cesium metal, 99+ percent, was unchanged at $100 to $375 per pound. The quotation on rubidium metal, 99.5+ percent, was also unchanged at $300 per pound.

[2] Prepared by Horace F. Kurtz, industry economist.

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.—Data on imports of cesium and rubidium ores were not available, but probably none was imported during 1971. Imports of cesium compounds declined 17 percent from the 1970 level. Receipts of rubidium metal and compounds were only 13 pounds. No export data were available.

World Review.—*Canada.*—Tantalum Mining Corporation of Canada, Ltd. produced 250 tons of pollucite from its mine at Bernic Lake, Manitoba, for shipment to the U.S.S.R. In recent years, shipments had been made from stocks of pollucite mined about 1961.

Mozambique.—Pollucite was produced in conjunction with other minerals by the Sociedade Mineira do Marropino, Lda. Output in 1971 was reported to be about the same as the 100 tons produced in 1970. Fifty tons were exported to the Netherlands.

U.S.S.R.—The Soviet Government announced that it had put into operation an MHD/steam electric power generator in which cesium was used as an ionizing agent. The MHD part of the system was designed to produce 25 megawatts and is the first industrial-size plant of this kind. Construction of a much larger MHD plant was also planned. The development of a 5-kilowatt thermionic convertor for the conversion of heat to electricity was also announced.

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	1,748	$62,948	2,075	$75,094
Netherlands	--	--	154	2,474
United Kingdom	251	5,202	22	480
Total	1,999	68,150	2,251	78,048

GALLIUM [3]

Domestic Production.—Production of gallium metal and compounds in 1971 increased substantially over that of 1970. The rise in production was attributed mainly to increased uses of gallium by the electronics industry. Gallium metal was produced as a byproduct of alumina production by the Aluminum Co. of America at its Bauxite, Ark., plant. Gallium metal, oxide, and trichloride were produced by Eagle-Picher Industries, Inc., at its Quapaw, Okla., plant. Production data are company confidential.

Consumption and Uses.—The largest use of gallium is in electronic applications, principally in the form of gallium arsenide and phosphide, gallium-aluminum-arsenide, gallium-arsenic-phosphide, and indium-gallium-arsenide. Gallium semiconductor compounds are used in light-emitting diodes, Gunn effect diodes (microwave applica-

[3] Prepared by E. Chin, chemist.

tions), switching and tunnel diodes, and lasers. Gallium compounds also are used in transistors and in photoelectric materials. Gallium alloys are used for superconductive materials, in dental alloys, and for glass windows in vacuum systems. Other uses for gallium are as a sealant for glass joints, as a constituent of solders, as a backing for mirrors, as a low-temperature lubricant, and in research. Consumption of gallium in 1971, as measured by shipments of the two domestic producers, increased nearly threefold over that of 1970.

Prices.—Market prices, per gram, of gallium from bauxite sources in 1971 were as follows:

Quantity	99.99 percent	99.999 percent	99.9999 percent
Up to 999 grams	$1.00	$1.10	$1.20
1,000 to 4,999 grams	.80	.85	.95
5,000 to 24,999 grams	.70	.75	.85

Foreign Trade.—Imports of gallium (unwrought, and waste and scrap) were as follows:

Country of origin	Pounds	Value
Canada	587	$129,844
Germany, West	403	70,712
Japan	1	364
Netherlands	133	32,693
Switzerland	4,319	854,662
United Kingdom	25,958	99,656
Total	31,401	1,187,931

World Review.—Following a series of feasibility studies and pilot plant trials, Sumitomo Chemical Co. announced plans to recover gallium metal as a byproduct of alumina production at its facility in Kikumoto, Japan.

Technology.—Studies on the radiographic scanning of intravenously injected gallium-67 citrate indicate that this technique is about 95 percent accurate in diagnosing lesions deep within the body resulting from Hodgkin's disease.[4] The radioactive gallium compound, injected three days before the scan, concentrates in affected lymph nodes or in the spleen.

A process for fabricating electronic display panels from tiny light-emitting semiconductor diodes has been developed by the research and development center of General Electric Co. in Schenectady, N.Y.[5] As many as 2,000 diodes and their interconnections can be placed on a coin-sized wafer of gallium phosphide by etching grooves into the wafer and growing into the grooves gallium phosphide containing an n-type dopant. Applications for this type of electronic display panel include two-way communications systems, computers, and perhaps low-cost home display terminals.

GERMANIUM [6]

The decline in germanium demand which began in mid-1970 continued through 1971, reversing the short supply situation that prevailed from 1967 until the middle of 1970. Estimated production of germanium from primary and secondary sources declined in 1971 compared with 1970 figures. It was expected that germanium consumption in the optical industry would more than recover the loss that was suffered from substituting silicon for germanium in semiconductors. However, in 1971 about equal amounts of germanium were consumed by the electronics and optical industries.

Domestic Production.—Primary germanium output was obtained by treating smelter residues resulting from retorting roasted zinc concentrates from the Kansas-Missouri-Oklahoma region and zinc concentrates from fluorspar-zinc-lead ores from Kentucky and Illinois. Supplementing domestic primary production was the recycling of waste or new scrap generated in the manufacture of diodes and transistors. Cutting the semifabricated shapes for end-use items returned as much as 70 percent of the metal as scrap. Eagle-Picher Industries Inc. of Miami, Okla., was the only producer of primary germanium from domestic sources. This company also produced germanium from scrap. Other producers of secondary germanium were: GTE Sylvania, Towanda, Pa.; Kawecki Berylco Industries, Inc., Revere, Pa.; and Atomergic Chemetals Co., Long Island, N.Y.

Consumption and Uses.—Germanium was used chiefly by the electronics and optical industries. A sharp decline in the use of germanium diodes and transistors accounted for the lower germanium demand; the use of germanium semiconductors dropped 48 percent from 1970 while demand for silicon units was off only 9

[4] Chemical Engineering News. Hodgkin's Disease. V. 49, No. 27, July 5, 1971, p. 36.
[5] Chemical Engineering News. V. 49, No. 9, Mar. 1, 1971, p. 22.
[6] Prepared by Herbert R. Babitzke, chemist.

percent. While much of the drop in germanium use was caused by the substitution of silicon for germanium semiconductors, a market for germanium will continue to exist in those applications where it is more reliable than silicon, specifically in some high-frequency and high-power requirements. Germanium is inherently better than silicon since it has mobility values for electrons and holes greater by a factor of 2 than those for silicon.[7] The major consumers of germanium were: Motorola Semiconductor Products, Inc.; Texas Instruments, Inc.; Delco Radio, Division of General Motors Corp.; and Western Electric Co. These four companies accounted for approximately 85 percent of the semiconductors manufactured in the United States.

There were numerous miscellaneous uses for germanium. In Japan and Europe, a germanium dioxide catalyst was utilized as a whitener in the manufacture of fabrics. In the United States germanium was used in nuclear radiation detectors, in solder and brazing alloys, in resistors, thermistors, photoconductors, and superconductors. Germanium has a high refractive index and is transparent to infrared light, but opaque to visible or ultraviolet light. To take advantage of this unique property, germanium windows, prisms, or lenses were employed in various optical systems for specialized applications. Such systems were used in microscopes, lasers, military surveillance devices, and clear air turbulence detection devices for aircraft, in aerial photography for agricultural and pollution surveillance, and in medical devices for detecting tumors. Germanium is one of a number of semiconducting materials which exhibit thermal runaway. Such materials have appreciable transmittance at the infrared wavelength and little absorption, but absorption rises rapidly with increasing temperature. When the material is used and some of the energy is absorbed the temperature is increased, thus giving a corresponding increase in the optical absorption, which in turn leads to a further temperature increase and still higher absorption. This sequence of events will continue with a rapid rise in temperature until the transmittance becomes zero. Upon cooling, the reaction is reversible, whereupon the material returns to its original state.

Prices.—No price change took place on domestic germanium and germanium dioxide. The last increase was on June 8, 1970, which established a price of $293 and $167.50 per kilogram for zone-refined (intrinsic) germanium and germanium dioxide, respectively. On January 1, 1971, the price for imported germanium and germanium dioxide was decreased to $207 and $108.50, respectively (a reduction of $2 and $1, respectively).

Foreign Trade.—U.S. imports of germanium metal (unwrought, and waste and scrap) totaled 6,625 pounds valued at $1,033,302, a decrease of 66 percent in quantity and 51 percent in value. Japan, the leading supplier, furnished 47 percent of the total germanium imported. Imports of germanium were subject to the 10-percent ad valorem surcharge imposed August 16, 1971, and removed December 20, 1971.

World Review.—World production of primary germanium was estimated at 150,000 pounds for 1971, which was lower than 1970 production because output was discontinued by Tsumeb Corp., Ltd. in South-West Africa and by Mitsui Mining and Smelting Co., Ltd. in Japan. Because of the decreasing mining activity for zinc in the U.S., most of the future germanium-carrying retort residues will be derived from foreign ores and concentrates. Foreign areas of major germanium occurrence are Austria, Zaire (formerly Congo-Kinshasa), Territory of South-West Africa, Peru, and the Ural mountain region of the U.S.S.R.

[7] Gleim, Paul S. Germanium. Ch. in McGraw-Hill Encyclopedia of Science and Technology. McGraw-Hill Book Co. Inc., New York, v. 6, 1971, pp. 186–194.

Table 6.—U.S. imports for consumption of germanium, by country

Country	Pounds	Value
	Unwrought, and waste and scrap	
Belgium-Luxembourg	682	$535,706
Canada	25	1,121
Czechoslovakia	1,890	158,593
Denmark	25	5,200
France	11	1,300
Italy	90	7,871
Japan	3,102	233,078
Switzerland	3	612
U.S.S.R	764	86,235
United Kingdom	33	3,586
Total	6,625	1,033,302
	Wrought	
Belgium-Luxembourg	42	8,893
France	1	321
Japan	30	2,123
Total	73	11,337

INDIUM [8]

Domestic Production.—The only domestic production during the year was by the American Smelting and Refining Company. Recovery of indium was recorded at the company's plants in Perth Amboy, N.J., and Denver, Colo. Indium was recovered from flue dusts and residues in which recoverable quantitites of the metal were concentrated during the processing of zinc ores and concentrates.

Uses.—Consumption of indium was chiefly in electronic devices. It was used as a component of solder for connecting lead wires to germanium in transistors, and as a property-modifying agent in intermetallic germanium semiconductors. Compounds of indium (arsenides, antimonides, and phosphides) were employed in various electronic applications. Special indium-containing alloys were used in glass-sealing and in dental requirements. It was reported that indium halides were used in mercury vapor lamps as a color correctant.

Stocks.—It was estimated that stocks remained steady, or increased slightly, during the year.

Prices.—Prices at yearend were unchanged at $2.50 per troy ounce for sticks under 100 ounces; ingots of 100 ounces were priced at $2.05 and at $1.75 in lots of 10,000 ounces. Trade sources intimated that imported material was priced in the range of $1.00 per ounce.

Foreign Trade.—Exports of indium are not separately listed in the trade statistics, but it is believed that none was exported. Quantity of total imports declined by 3 percent compared with imports for the preceding year. The chief sources of imports were Canada, 45 percent; the Netherlands, 16 percent; U.S.S.R., 15 percent; and others, 24 percent.

Under the General Agreement on Tariffs and Trade, import duties on unwrought, waste and scrap metal in 1971 were 6 percent ad valorem for the most-favored-nation rate and 25 percent for imports from Communist-bloc countries, except Yugoslavia. Duties on wrought metal were 10.5 percent ad valorem for the most-favored-nation rate, and 45 percent ad valorem for imports from Communist-bloc countries, excepting Yugoslavia.

Table 7.—U.S. imports for consumption of indium, by country

Country	Troy ounces	Value
	Unwrought, waste and scrap	
Canada	174,570	$221,144
Germany, West	22,787	36,500
Japan	38,223	55,599
Netherlands	61,455	90,035
Peru	27,031	47,302
U.S.S.R.	57,468	53,239
United Kingdom	5,836	83,831
Total	387,370	587,650
	Wrought	
Germany, West	73	503
Netherlands	52	762
United Kingdom	1	619
Total	126	1,884

RADIUM [9]

Radium was used extensively, although in small quantities, during the year, primarily in therapeutic treatment of cancer; substitution of cheaper and less hazardous radioisotopes continued.

Legislation and Government Programs.—The four Government agencies which have regulations directly controlling non-Federal use of radium are the Department of Labor, the Department of Transportation, the Food and Drug Administration, and the National Institutes of Health. Three agencies which have furthered radium control in the non-Federal sector, although not having direct regulatory authority, are the Atomic Energy Commission (AEC), the Bureau of Radiological Health, and the National Bureau of Standards. The Bureau of Radiological Health of the U.S. Department of Health, Education, and Welfare published a study of State and Federal controls during the year. The study includes a review of health hazards, the extent and magnitude of radium usage through 1968, and an evaluation of present State and Federal control measures.[10]

[8] Prepared by Burton E. Ashley, physical scientist.

[9] Prepared by James S. Kennedy, industry economist.

[10] Pettigrew, G. L., E. W. Robinson, and G. D. Schmidt. State and Federal Control of Health Hazards from Radioactive Materials Other Than Materials Regulated Under the Atomic Energy Act of 1954. U.S. Bureau of Radiological Health, June 1971, 101 pp.

Domestic Production.—Radium has not been produced in the United States since 1956. The small domestic requirements were met by imports and excess dealer stocks. The principal dealer is Radium Chemical Co., Inc., New York, which imported its supplies of radium salts from a Belgium company, Union Minière, S. A. Radium Chemical also provided a reincapsulation service for radium. Two other domestic firms having an interest in radium sales and shipments were Canadian Radium and Uranium Division, Canrad Precision Industries, Inc., New York, and Nuclear Radiation Development Corp., Grand Island, N.Y.

Uses.—The penetrative power of radium's gamma radiation is used in the therapeutic treatment of cancer. Experiments have shown the radioisotope californium-252 to be more effective in the treatment of some types of cancer than radium, offering the possiblity of its eventual substitution for radium in this application. In addition, the price of californium-252 was substantially reduced during the year as a result of increased availability and efforts of the AEC to develop new uses and applications for this radioisotope. Other uses of radium, largely replaced by safer and cheaper substitute radioisotopes, include luminous compounds, static eliminators, and neutron sources.

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. Because of efforts to license and limit the use of radium, some former users have reportedly offered radium salts at low asking prices or free of charge in order to dispose of the material.

Foreign Trade.—Radium is included in a trade classification which prevents disclosure of pertinent data. Imports of radium are exempt from tariff duty.

Technology.—The minor quantities of radium found in uranium ores are not recovered with the uranium but are discarded in tailings of uranium milling plants, becoming a potential health hazard. National attention was focused on this problem when such tailings were used as backfill and, to some extent, in construction materials for homes and other buildings in Grand Junction, Colo. The Bureau of Mines investigated techniques to recover radium from uranium ores prior to its ejection from uranium mills and the reprocessing of old tailings for radium removal. Research indicates that in the absence of soluble sulfates, up to 95 percent of the radium can be extracted by hydrochloric acid (HCl). If soluble sulfates are present, essentially all of the sulfates must be removed by prior treatment to prevent reprecipitation of radium sulfate during HCl leaching.

SCANDIUM [11]

Scandium, obtained as a byproduct of uranium processing, was produced in limited but increasing quantities for use primarily in high-intensity lamps and in research and development. The small domestic requirements for raw materials were met by producers' stocks and imports from Australia and Canada.

Domestic Production.—Research Chemicals, a division of Nucor Corp., Phoenix, Ariz., and Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N.Y., continued as the only domestic producers of scandium. Alfa Inorganics, Inc., Beverly, Mass., sold scandium foil and ingots during the year.

The supplies of scandium available from domestic uranium ore are potentially large but unavailable from current processing methods. The extraction of scandium from domestic phosphate rock and tungsten concentrate was not considered profitable due to limited scandium demand.

Uses.—Scandium has only two established commercial uses. High-purity scandium metal was used in increasing amounts in the manufacture of high-intensity mercury vapor lamps. Although more costly and having only one-third the life of a straight mercury vapor lamp, the high illuminating efficiency and a color range approaching natural sunlight make these lamps particularly useful at night sporting events televised in color. The radioisotope scandium-46 was used in milligram quanti-

[11] Prepared by James S. Kennedy.

tites as a tracer of flow in oil wells. Scandium was also used during the year in research and development, largely Government-sponsored.

Prices.—The price of scandium oxide, 99.9 percent, as quoted by Research Chemicals, remained unchanged during the year at $2.80 per gram in lots of 100 to 453 grams; that of scandium metal in ingots and distilled forms decreased to $8 and $15, respectively, while that of powder and chips remained unchanged at $10.35, same basis; prices for scandium sheet and foil were $17.85 to $85 per square inch for 51 to 100 square inch lots, ranging from .001 to .100 inches thick. Prices for sheet and foil are based on a theoretical weight of 0.0499 grams of scandium per square inch for every .001 inch of thickness. Larger quantities were available for most items at lower prices.

World Review.—Kolon Trading Co., Inc., New York, U.S. sales agent for rare-earth metals exported by Techsnabexport, Moscow, U.S.S.R., offered scandium oxide, in purities up to 99.9999 percent, and metal during the year.

Technology.—The separation of scandium, hafnium plus zirconium, nickel, and thorium from complex mixtures was demonstrated using ion-exchange paper chromatography.[12] The magnetic susceptibility of scandium alloys with 0.02 to 2 atomic percent cerium was measured over the temperature range of 4° to 300° Kelvin (K). No evidence for a spin-compensated state such as that induced by cerium in yttrium and lanthanum was found. The addition of gadolinium and dysprosium was found to polarize the scandium matrix. The influence of the nonmagnetic alloying elements titanium and thorium on scandium was also investigated.[13] The standard heats and free energies of formation, entropies, and enthalpies at 298.15° K and heats of formation at 0° K for compounds of scandium were published by the National Bureau of Standards.[14]

SELENIUM [15]

Production and shipments of selenium decreased substantially from those of 1970; imports also declined. Despite the decrease in demand, producers stocks remained at a low level because of the curtailment in production caused by the copper industry labor strike during July and August.

Public Law 92–110, effective August 11, 1971, authorizes disposal of 475,000 pounds of selenium from the Government stockpile. The General Services Administration (GSA) announced on November 12, 1971, that selenium would be offered on an unrestricted bid basis, except that total awards at each of the bid openings in December, February, and May will not exceed approximately 45,000 pounds. On December 13, 1971, GSA announced that no acceptable bids were received at the December 9 bid opening.

Domestic Production.—Selenium was produced at four plants operated by the following major electrolytic copper refiners: American Metal Climax, Inc., Carteret, N.J.; The American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; and Kennecott Copper Corp., Garfield, Utah. Crude selenium containing materials produced at other plants were transferred to these four plants for refining.

Consumption and Uses.—Selenium was used primarily in the glass industry. Small percentages were used to neutralize the green tint caused by iron, and larger percentages to tint glass used in construction and transportation industries to decrease heat transfer. In still larger percentages it was used with cadmium to produce orange and red glasses used in transportation signals and decorations. The demand for selenium in electronic components declined, partly because of conservation practices in the form of inventory controls instituted by some of the major consumers.

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[12] Sherma, J., and F. J. Van Lenten. Ion-Exchange Paper Chromatography of Metal Ions With Mixed Aqueous-Organic Solvents Containing Mineral Acid and a Selective Extractant. Separation Sci., v. 6, April 1971, pp. 199–206.

[13] Isaacs, L. L., D. J. Lam, and F. Y. Fradin. Magnetic Properties of Dilute Alloys of Scandium. J. Appl. Phys., v. 42, March 1971, pp. 1458–1459.

[14] Wagman, D. D., W. H. Evans, V. B. Parker, I. Halow, S. M. Bailey, R. H. Schumm, and K. L. Churney. Selected Values of Chemical Thermodynamic Properties. Tables for Elements 54 through 61 in the Standard Order of Arrangement. (NBS-TN-270-5), March 1971, 49 pp.

[15] Prepared by John W. Cole, physical scientist.

Table 8.—Salient selenium statistics
(Thousand pounds of contained selenium)

	1967	1968	1969	1970	1971
United States:					
Production	598	633	1,247	1,005	657
Shipments to consumers	659	941	1,429	1,056	663
Imports for consumption	301	583	546	454	395
Stocks, Dec. 31, producers	736	428	240	189	182
Price per pound, commercial- and high-purity grades	$4.50–$6	$4.50–$6	$7–$8.50	$9–$10.50	$9–$11.50
World: Production	2,051	1,946	r 2,834	r 2,849	2,283

r Revised.

Prices.—The producers price for commercial-grade selenium remained at $9 a pound throughout the year; the price of high-purity selenium was raised from $10.50 to $11.50 per pound January 1, 1971, and remained at that level the remainder of the year.

Foreign Trade.—Imports for consumption of selenium declined 13 percent and the value of imports decreased 5 percent. Canada continued to be the principal supplier as shown in the following table:

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	325	$3,251
Japan	18	151
Mexico	19	370
Netherlands	3	23
Peru	3	26
Sweden	(1)	(1)
U.S.S.R.	(1)	1
United Kingdom	5	42
Total	373	3,864
	Oxide (selenium content)	
Canada	15	143
Germany, West	1	13
Japan	1	19
United Kingdom	5	47
Total	22	222

1 Less than ½ unit.

World Review.—Canada led the world in selenium output, displacing the United States as the leading producer. The United States was second and Japan was third. These three countries accounted for 82 percent of world production (excluding the U.S.S.R.).

Technology.—Abstracts were published covering more than 3,000 published books and scientific papers that contain references to selenium and tellurium [16].

Although selenium is toxic in higher concentrations in animal foods, it is an essential trace element in the metabolism of the higher animals. The selenium content of a wide variety of foods representing a cross-section of the American diet was determined by fluorometry [17]. Most fruits and vegetables contained less than 0.01 part per million of selenium. Exceptions were garlic, mushrooms, and radishes containing 0.25, 0.13, and 0.04 part per million, respectively. Grain products varied widely in selenium content, with corn flakes containing as low as 0.025 part per million and barley cereal as high as 0.66 part per million. Whole wheat flour and brown sugar contained two to four times as much selenium than did white flour and white sugar. Dried skim milk powder samples ranged from 0.095 to 0.24 part per million. Meat samples ranged from about 0.1 part per million for chicken muscle to as high as 1.9 parts per million for pork kidney with most values between 0.2 and 0.5 part per million. The content of seafood was generally higher, ranging from 0.4 to 0.7 part per million.

In another study [18] it was determined that the daily human intake of selenium on a standard diet was 62 micrograms. The calculated human body burden of selenium was 14.6 milligrams. Wild animals contained 2 to 3 times the human levels. Kidneys contained the highest amounts. Selenium seems to be associated with normal growth, muscle function, liver integrity, and fertility. In mammals, excess selenium is teratogenic, hepatotoxic, and neurotoxic; it retards growth and causes muscular weakness. A deficiency of selenium is associated with hepatic necrosis, retarded growth, muscular degeneration, and infertility.

[16] Selenium and Tellurium Development Association, Inc. Selenium and Tellurium Abstracts, New York, v. 12, 1971, No.'s 1–12.

[17] Morris, V. C. and Orville A. Levander. Selenium Content of Foods. Selenium and Tellurium Abstracts, v. 12, March 1917, p. 1.

[18] Schroeder, Henry A., Douglas V. Frost, and Joseph J. Balassa. Essential Trace Elements in Man. Selenium and Tellurium Abstracts, v. 12, April 1971, p. 7.

Table 10.—Selenium: World refinery production, by country [1]

(Thousand pounds)

Country [2]	1969	1970	1971 [p]
Australia [e]	4	4	4
Belgium-Luxembourg [3]	46	68	120
Canada	[r] 820	852	[4] 690
Finland	14	15	14
Japan	435	467	524
Mexico [5]	[r] 65	278	115
Peru	15	15	16
Sweden	168	[e] 110	[e] 110
United States	1,247	1,005	657
Yugoslavia	20	35	[e] 33
Total	2,834	2,849	2,283

[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 (formerly Congo-Kinshasa) 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: 1969–599; 1970—663.

5 Elemental selenium only; excludes selenium content of sodium sellenate produced, as follows in thousand pounds: 1969—371; 1970 and 1971—none.

TELLURIUM [19]

Production, shipments, and imports of tellurium decreased because of a decrease in demand. Production was curtailed during July and August by the copper industry labor strike.

Domesic Production.—Production of tellurium was reported by the following companies: American Metal Climax, Inc., Carteret, N.J.; The American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; and United States Smelting Lead Refinery, Inc., East Chicago, Ind.

Consumption and Uses.—The metallurgical industry consumed over 80 percent of the tellurium used in the United States. It was used in steel and copper to facilitate machinability, in white cast iron as a carbide stabilizer, and in lead to improve corrosion resistance. Over 10 percent was used in rubber and miscellaneous plastic products. The remainder was used in chemical and allied products.

Prices.—The quoted price for commercial-grade tellurium remained steady at $6 per pound throughout the year.

Table 11.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1967	1968	1969	1970	1971
United States:					
Production, primary and secondary	135	121	234	158	164
Shipments to consumers	172	201	182	209	163
Stocks, Dec. 31, producers	186	157	177	128	110
Imports	91	71	112	64	30
Price per pound, commercial grade	$6	$6	$6	$6	$6
World: Production	270	258	395	365	318

Foreign Trade.—Quantity and value of imports for consumption decreased 53 and 50 percent, respectively, from 1970 totals.

Table 12.—U.S. imports for consumption of tellurium, by country

(Thousand pounds and thousand dollars)

Country	Quantity	Value
Canada	7	$51
Peru	22	122
United Kingdom	1	4
Total	30	177

19 Prepared by John W. Cole.

World Review.—The United States continued to lead the world in tellurium output. Japan was second and Peru displaced Canada for third place.

Table 13.—Tellurium: World refinery production, by country [1]

(Thousand pounds)

Country [2]	1969	1970	1971 p
Canada	72	67	[3] 22
Japan	51	78	79
Peru	38	62	53
United States	234	158	164
Total	395	365	318

p Preliminary.
[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 (formerly Congo-Kinshasa) 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. Corresponding figures for previous years in thousand pounds are: 1969—62; 1970—59.

THALLIUM [20]

Thallium and thallium compounds have limited applications. Although a number of alloys and compounds have interesting properties with potential usefulness, Federal restrictions regarding some applications and the toxicity of thallium discourages the use of this minor element.

Domestic Production.—The American Smelting and Refining Company, Denver, Colo., was the only domestic producer of thallium and thallium compounds. Although production increased over 1970, consumption and shipments were down.

Uses.—Distribution of thallium consumption for 1971 was about 50 percent for academic purposes and development research, 25 percent for electronics and low-melting alloys, and 25 percent for miscellaneous applications.

Use of thallium compounds as agricultural pesticides has been curtailed. A Senate bill (S. 2083) was introduced June 17, 1971, to prohibit poisoning of animals and birds on the public lands of the United States. Thallium was specifically mentioned as the poison responsible for the accidental killing of a large number of eagles in Wyoming in May 1971.

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 1971 were 602 pounds of unwrought, and waste and scrap thallium valued at $3,410. The amount was about half that imported in 1970. Imports of thallium compounds were 1,906 pounds valued at $5,723.

Technology.—Metallic iodide additions to mercury arc lamps have received interest in the past few years with good growth potential; however, quantities used in each lamp are small (this end use consumed less than 50 pounds during the year). By adding a small quantity of thallium iodide to a mercury lamp the spectral output is dominated by thallium lines even though it is only a minor constituent in the discharge in terms of atomic density.[21] The spectral lines which are intensified are in the green region with excellent color rendition and increased efficiency of the lamp. A similar behavior was observed with xenon discharge lamps with metallic halide additives.[22] The choice of metallic halide in the xenon lamp depends upon the desired emission wavelength and spectrum.

[20] Prepared by Herbert R. Babitzke, chemist.
[21] Gallo, C. F. Theoretical Analysis of the Behavior of Mercury Plus Thallium Iodide Arc Lamps With Variable Mercury Loadings. Appl. Optics, v. 9, No. 12, December 1970, p. 2711–2716.
[22] Gallo, C. F. Continuum Emission Spectra From Long Linear Xenon Discharge Lamps With Metallic Halide Additives. Appl. Optics, v. 10, No. 11, November 1971, p. 2517–2520.

Table 14.—U.S. imports for consumption of thallium, by country

Country	Compounds (gross weight)		Unwrought, and waste and scrap	
	Pounds	Value	Pounds	Value
Belgium-Luxembourg	25	$323	602	$3,410
France	500	1,125	--	--
Germany, West	1,381	4,275	--	--
Total	1,906	5,723	602	3,410

Minor Nonmetals

By Staff, Division of Nonmetallic Minerals

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GREENSAND [1]

Domestic production of greensand (glauconite) decreased about 5 percent in quantity and 1 percent in value compared with 1970. The average annual production for 1967–71 was 3,437 short tons valued at $233,000. Since only two firms produced greensand in 1971, Inversand Co., near Sewell, N.J., and Kaylorite Corp. near Dunkirk, Md., statistical data on production and sales are withheld to avoid disclosure of individual company confidential data.

Greensand was used as a soil conditioner and water softener.

IODINE [2]

Reported domestic consumption of crude iodine declined for the first time in 4 years, as demand became sluggish in late 1971. Domestic output, which represented a small part of the overall supply, was also a little lower in 1971 than in 1970, whereas imports increased sharply in quantity and even more in value.

Crude iodine production in the free world rose by possibly 2 million pounds or approximately 10 percent, almost all accounted for by Japan which gained ground as the world's leading producer. This increase in supply did not have the effect of holding down prices, which in fact made radical advances. The iodine price in the United States, which in December 1970 stood at $1.30 to $1.45 per pound, rose to $1.59 to $2.27 by December 1971. Japan was still holding to $1.59 on December 19, even though Chilean and U.S. producers had raised prices to $2.27 since February. On December 20, Japan increased its iodine price to $1.86 to compensate for the upward revaluation of the Yen.

Legislation and Government Programs.—On December 31, 1971, the Government strategic stockpile contained 2,955,692 pounds of crude iodine and the supplemental stockpile contained 5,056,122 pounds for a total of 8,011,814 pounds. The stockpile objective for iodine, established by the Office of Emergency Preparedness, is 8 million pounds. There were no deliveries to, or withdrawals of iodine from the Government stockpile in 1971.

Domestic Production.—The Dow Chemical Co., the only domestic producer, employing a process that has been in use since the start of operations in 1964, recovered crude iodine from well brines at Midland, Mich., as a coproduct with bromine, calcium and magnesium compounds, and potash. Compared with 1970 figures, both the quantity and value of output declined by approximately 10 percent.

[1] Prepared by Donald E. Eilertsen, physical scientist.
[2] Prepared by K. P. Wang, supervisory physical scientist.

Table 1.—Crude iodine consumed in the United States

Products	1970			1971		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	6	117	2	5	W	W
Potassium iodide	10	1,907	r 38	6	1,612	34
Sodium iodide	4	W	W	4	W	W
Other inorganic compounds	19	r 1,077	r 21	15	1,209	25
Organic compounds	21	r 1,960	39	21	1,980	41
Total	[1] 38	r[2] 5,062	100	[1] 34	[2] 4,802	100

r Revised.
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.
[2] Data may not add to total shown because of independent rounding.

Consumption and Uses.—Based upon returns from questionnaires, approximately 4.8 million pounds of crude iodine was consumed by 34 firms in 14 States. Leading iodine-consuming States in 1971, in descending order of magnitude, were Missouri, New York, New Jersey, and Pennsylvania, which together accounted for more than four-fifths of the total crude iodine consumption.

The above information is indicative of the use pattern, but is not necessarily comprehensive. Imports alone have been consistently higher than reported consumption, with net differences as follows, in thousands of pounds: 1969–803; 1970 r—981; and 1971—2,473. A more exact estimate of apparent consumption cannot be published, as U.S. production figures for crude iodine cannot be revealed.

Increases were reported in the amount of crude iodine consumed in producing resublimed iodine, sodium iodide, and organic iodine-containing compounds. Major uses of iodine included photographic chemicals, household and industrial disinfectants, pharmaceutical preparations, and animal and fowl feeds. Lesser amounts of iodine were consumed in making high-purity metals, motor fuels, iodized salt, smog inhibitors, swimming pool sanitizers, lubricants, and catalysts in chemical processes.

Prices.—In February 1971 prices for crude iodine, c.i.f. United States, were increased from $1.59 to $2.27 per pound by the Chilean Nitrate Sales Corp. for Chilean iodine and by The Dow Chemical Co. for domestic iodine. In April 1971 the Mitsubishi International Corp. raised the prices of Japanese iodine from $1.45 to $1.59; in late December prices were again raised to $1.86 per pound. Prices for resublimed iodine and iodine compounds went up accordingly. Late in the year, higher prices were imminent in view of the world iodine situation. Quoted prices for iodine and iodine compounds at yearend 1971 were as follows:

	Per pound
Crude iodine, drums	$1.59–$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, 300 to 999 pounds delivered	2.60– 2.95
Potassium iodide, U.S.P., crystals, drums, smaller lots, delivered	2.75– 2.95
Sodium iodide, U.S.P., crystal, 300-pound drums, freight equalized	3.50– 3.63

Source: Oil, Paint and Drug Reporter.

Foreign Trade.—Crude iodine imported into the United States in 1971 increased 21 percent in quantity and 69 percent in value over that imported in 1970. The average value of imported crude iodine rose from $1.15 per pound in 1970 to $1.82 per pound in 1971, reflecting increases in price by all suppliers. More than 7.27 million pounds of crude iodine was imported, of which three-fifths was from Japan and two-fifths from Chile. Imports of resublimed iodine were nominal as compared with imports of crude iodine.

Tariff rates were lowered from 6 to 5 cents per pound on resublimed iodine and from 15 to 12 cents per pound on potassium iodide. These reductions represented the final phases of a program to reduce tariffs on resublimed iodine and potassium iodide to 5 and 12 cents per pound, respectively, by January 1, 1972. Crude iodine enters the United States duty free.

World Review.—*Chile.*—Production of

Table 2.—U.S. imports for consumption of crude iodine, by country
(Thousand pounds and thousand dollars)

Country	1969		1970		1971	
	Quantity	Value	Quantity	Value	Quantity	Value
Chile	2,308	$2,215	r 1,723	r $2,076	2,950	$5,679
Japan	3,397	3,538	r 4,320	r 4,758	4,325	5,831
Total	5,705	5,753	r 6,043	r 6,834	7,275	11,510

r Revised.

crude iodine in 1971 as a byproduct of nitrates was 2,500 short tons (preliminary as compared with 2,480 short tons (revised) in 1970. Output in 1970 was much below capacity because of a long strike that was not settled until April 28, 1970, and a 25-day shutdown of the Victoria plant for repairs. With the completion of additional facilities at Victoria and resumption of normal operations in 1971, it was hoped that the 3,000-ton output level would be reached. This did not materialize, however, due to a major fire at one of the plants in early October 1971.

Chilean iodine made significant headway, nonetheless, with regard to pricing and value received. Despite the price hike from $1.59 to $2.27 per pound of crude iodine in February 1971, world demand remained strong. Comparing 1971 figures with those of 1970, U.S. imports of crude iodine from Chile nearly doubled in quantity and nearly tripled in value. Apparently the Chileans had built up some stocks from the previous year, and were also exporting more to the United States at the expense of Europe.

Japan.—Japan continued to be the world's foremost iodine producer during 1971. Its output of 7,423 short tons of crude iodine (6,497 tons in 1970) was approximately three times that of Chile, the only other major world producer. More than three-fourths of the Japanese production was exported, principally to the United States, which took about 2,163 short tons in 1971. Japan's other iodine markets included European Economic Community (EEC) countries, the United Kingdom, India, People's Republic of China, and Canada.

Japan's iodine was produced from brines by six firms operating 18 plants.[3] All of the plants are located on Chiba Peninsula east of Tokyo, except for one in the north, at Niigata. Three new plants came onstream in 1971. Two others completed in 1970 were brought into full-scale production. Several manufacturers have pipelines on Chiba to deliver brine to processing plants located elsewhere.

At yearend 1971 the cutoff grade for Japanese natural gas brines was 60 milligrams of iodine per liter or 60 parts per million (ppm), but most brines worked contained 80 ppm. The basic method employed in the extraction of iodine is the ion exchange process. Improved methods developed by several Japanese companies suggest that the cutoff grade can be lowered to 40 ppm. Teikoku Oil Co., Japan's largest natural gas producer, with facilities in Niigata, was considering entry into the business of extracting iodine from brines analyzing 40 to 60 ppm.

Japan's iodine producers continued to pay large dividends because of high prices. The Japan Iodine Export Corp. held down the export prices at $1.59 per pound, c.i.f. United States, through December 19, 1971 despite the fact that Chilean and U.S. producers had been selling crude iodine at a much higher price during most of 1971.

The outlook for the Japanese iodine industry continued to be bright. The reserve picture improved further under high price conditions and better technology. Japan had enough iodine in its natural gas wells to support a yearly production of 10,000 tons for several centuries. The country's output of iodine had already risen 28 percent in 1970 and another 14 percent in 1971. Subsidence and pollution control difficulties in some Chiba operations, apparently will not hold back overall Japanese iodine production in the next few years. No information is available on Japanese efforts to produce iodine from Indonesian brines.

Technology.—A new process that disinfects water quickly without affecting taste was developed by Lambert and Fina of

[3] U.S. Embassy, Tokyo, Japan. State Department Airgram A-938 (Iodine Developments in Japan), Nov. 8, 1971, pp. 2.

Kansas State University.[4] The process, involving formation of an insoluble combination of triiodide disinfectant with ion exchange resin beads, is said to be inexpensive and very effective against bacteria.

Cannon of Eli Lilly & Co. developed a promising new disinfectant—antimicrobial oxiodinium—which can take the place of iodonium compounds and is more stable.[5] Product is still high cost and has not been thoroughly tested.

Monsanto Chemical Co. built a commercial plant at Texas City to produce acetic acid by a new process based upon the reaction of methanol with carbon monoxide in the presence of an iodide-promoted rhodium catalyst.[6]

A "halogen recycle" route to dehydroadiponitrile, a precursor of Nylon 66, has been developed by Esso Research & Engineering Co.[7] The process involves reaction of butadiene with iodine and copper cyanide to produce a cuprous iodide complex. Hydrolysis of this complex yields dehydroadiponitrile while allowing regeneration of the iodine and cuprous cyanide.

LITHIUM [8]

Domestic output of lithium minerals, including lithium carbonate from brines, was unchanged from that of 1970, reflecting the general sluggishness of the economy. Imports for consumption of lithium ore were nearly three times greater than the quantity imported in 1970.

Legislation and Government Programs.—Ad valorem tariffs on lithium metal were 15 percent and on lithium compounds 6 percent during 1971; lithium mineral concentrates are imported duty free. From August 16 to December 20, 1971, a 10-percent ad valorem surcharge was imposed on all dutiable imports up to the statutory limit. At yearend 6,490 short tons of lithium hydroxide monohydrate were held by General Services Administration 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.; American Potash and Chemical Corp. recovered lithium carbonate from brines at Trona, Calif.

Processors of lithium raw materials to lithium primary products were Foote Mineral Co., Sunbright, Va., and Silver Peak, Nev.; American Potash and Chemical Corp., Trona, Calif.; and Lithium Corp. of America, at Bessemer 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 aluminum metal production, ceramics, greases, air conditioning, alloying, welding and brazing, swimming pool sanitation, and organic synthesis.

Although consumption of most lithium compounds either remained unchanged or declined during the year, sales of lithium carbonate to the aluminum industry showed a significant increase.

Lithium Corp. of America began offering lithium carbonate in pellet form for use in aluminum potlines. Added savings were claimed due to the elimination of dust generally created when adding the powdered carbonate.[9]

Prices.—The Oil, Paint and Drug Reporter quoted prices for lithium metal and compounds at yearend as follows:

	Per pound
Lithium metals, 1,000-pound lots or more, delivered	$8.18
Lithium carbonate, carlots, truck loads, delivered, in drums	.51
Lithium chloride, anhydrous, carlots, truck loads, delivered, in drums	.89
Lithium fluoride, carlots, truck loads, delivered, in drums	1.56
Lithium hydroxide, carlots, truck loads, delivered	8.05
Lithium hydroxide, monohydrate, carlots, truck loads, delivered, in drums	.61
Lithium nitrate, technical 100-pound lots, in drums	1.25–1.55
Lithium stearate, 50-pound cartons, carlots, works, freight allowed	.58
Lithium sulfate, 100-pound lots, in drums	1.20–1.30

[4] Chemical & Engineering News. Disinfection: Quick Process for Water. V. 49, No. 8, Feb. 22, 1971, p. 10.

[5] Science News. Promising New Disinfectant. V. 100, No. 11, Sept. 11, 1971, p. 176.

[6] Chemical & Engineering News. Catalyst Behind New Route to Acetic Acid. V. 49, No. 35, August 30, 1971, p. 19.

[7] Chemical & Engineering News. Nylon Precursor. V. 49, No. 14, Apr. 5, 1971, p. 31.

[8] Prepared by Donald C. Wininger, physical scientist.

[9] Metals Week. Lithium Pellets for Potlines. V. 42, No. 47, Nov. 22, 1971, p. 4.

Foreign Trade.—Exports of lithium hydroxide declined from 1,366,415 pounds valued at $614,180 in 1970 to 478,239 pounds valued at $244,834 in 1971. Quantitative data on exports of lithium minerals and lithium metal, alloys, and other compounds were not available. Domestic imports of lithium minerals were nearly three times greater than in 1970. Brazil supplied 83 percent of all the mineral imports. As a result of trade sanctions there have been no imports from Southern Rhodesia since 1968.

Imports of lithium metal were 53 pounds valued at $459, from Sweden. There were 34 pounds of organic lithium salts valued at $2,345 imported from West Germany. Imports of lithium compounds were 18,200 pounds valued $55,033, principally from France (96.9 percent), with small amounts from Japan, the United Kingdom, and West Germany.

World Review.—*Ireland.*—Northgate Exploration, Inc., on the basis of a limited drilling program, estimated that more than two million tons of good-grade lithium minerals occur in an extensive series of pegmatite dikes in County Carlow, Ireland.[10]

[10] American Metal Market. International Lithium Report, Dec. 8, 1971, p. 2A.

Table 3.—U.S. imports for consumption of lithium ore, by country of origin and U.S. customs district

Country and customs district	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Brazil: Baltimore	--	--	5,292	$442
Canada: Buffalo	467	$10	--	--
South Africa, Republic of: Baltimore	1,678	118	1,115	83
Total	2,145	128	6,407	525

Table 4.—Lithium minerals: World production by country

(Short tons)

Country [1]	Mineral produced	1969	1970	1971 [p]
Argentina	not specified	388	270	[e] 280
Australia	do	795	864	[e] 750
Brazil [2]	do	1,709	4,025	NA
Canada [3]	spodumene	200	467	NA
Mozambique	lepidolite [4]	[r] 432	41	NA
Portugal	lepidolite	NA	276	827
Rhodesia, Southern [5]	not specified	67,000	67,000	67,000
South Africa, Republic of	spodumene	39	10	1
South-West Africa, Territory of [6] [e]		4,372	7,616	[7] 7,654
United States	not specified	W	W	W

[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, others (notably the U.S.S.R.) may produce lithium minerals, but available information is inadequate to make reliable estimates of output levels.

[2] Exports.

[3] United States imports from Canada.

[4] Includes amblygonite as follows, in short tons: 1969—1; 1970—14; 1971—NA.

[5] 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 6). 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.

[6] Output has not been reported since 1966, but presumably has continued, inasmuch as a number of countries record imports from "South Africa" which in total considerably exceed reported output of the Republic of 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 5) 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.

[7] Imports by United States, West Germany and the Netherlands only (see also footnote 6).

Technology.—According to a number of articles in the Journal of the Electrochemical Society, research continued on the use of lithium in various ways in battery and fuel cell generation of electrical power. Several firms announced during the year that they have developed lithium batteries and plan to market them in the very near future.

Public interest was renewed during the year in the development of breeder reactors to power U.S. electric generating stations. The state-of-the-art and outlook for controlled nuclear fusion were reviewed in several articles.[11] Potentially this field could open up a large new use for lithium, which can be used directly as a fuel, as a breeding source of tritium in the deuterium-tritium reaction, or as a heat exchanger.

Primary producers began experimenting with the use of lithium carbonate in aluminum potlines on a major scale in 1968. A 7- to 10-percent boost in designed potline output and cost savings of ½ to 1 cent per pound of aluminum are claimed by producers who use lithium carbonate as an additive to their aluminum cells. An added benefit is a 25 to 50 percent reduction in fluorine emissions from the cells in which lithium is used. According to a lithium producer, the lithium carbonate additions to the cryolite electrolytic bath are converted to lithium fluoride and reduce the melting point of the bath. Ridging formations on the cathode are reduced allowing more current to flow and more aluminum to be produced.[12]

MEERSCHAUM [13]

Demand for meerschaum in the U.S. continued to be supplied by imports in 1971, but the quantity imported, 17,482 pounds, was 28 percent less than that imported in 1970. Total value of imported meerschaum decreased 13 percent from $29,760 in 1970 to $25,825. The Somali Republic supplied 94 percent of U.S. imports of crude meerschaum in 1971 compared with 98 percent in 1970; the remaining 6 percent came from Turkey.

Domestic use of meerschaum was primarily in pipes and cigarettes holders.

QUARTZ CRYSTAL [14]

ELECTRONIC-GRADE

Total raw quartz crystal consumption declined significantly from that of 1970. However, the quantity of manufactured quartz crystal consumed increased and surpassed the quantity of natural quartz consumed. The quantity of electronic-grade material imported declined greatly. Exports of natural quartz declined, but those of manufactured quartz increased over those of 1970. The production of finished crystal units rose to almost 21 million units.

Legislation and Government Programs.—The Government continued to maintain a stockpile objective of 320,000 pounds of electronic-grade quartz crystal, but also sold excess material through the General Services Administration at a maximum authorized rate of 200,000 pounds per year. At yearend the Defense Materials Inventory had declined slightly from the previous year to 4.57 million pounds of stockpile-grade material and 353,301 pounds of nonstockpile-grade material.

Domestic Production.—There were no reports of production of natural electronic-grade quartz crystal during 1971. At yearend, six companies reported production of manufactured quartz for use by the electronics 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; Thermodynamics Corp., Shawnee Mission, Kans.; and West-

[11] Davis, John C. Fusion. Reactors Shaping Up. Chem. Eng., v. 78, No. 8, Apr. 5, 1971, pp. 64–68.

Lubin, Moshe J., and Arthur P. Fraas. Fusion by Laser. Sci. Am., v. 224. No. 6, June 1971, pp. 21–33.

Rose, David J. Controlled Nuclear Fusion: Status and Outlook. Science, v. 172, No. 3985; May 21, 1971, pp. 797–808.

Solon, Leonard R. Lasers and Fusion. Ind. Res., v. 13, No. 12, November 1971, pp. 46–49.

[12] Metals Week. Lithium Use Catching On. V. 42, No. 38, Sept. 20, 1971, p. 2.

[13] Prepared by Arthur C. Meisinger, industry economist.

[14] Prepared by Benjamin Petkof, physical scientist.

ern Electric Co., Inc., North Andover, Mass. The firms producing manufactured quartz remained unchanged from the previous year. Manufactured quartz production declined 16 percent from the quantity reported in 1970 to 110,395 pounds in 1971. Sawyer Research Products Inc., and Thermodynamics Corp. were the major producers.

Consumption and Uses.—Total raw quartz crystal consumption declined 20 percent from the 164,941 pounds recorded in 1970 to 132,739 pounds in 1971. The consumption of natural quartz declined 37 percent to 61,784 pounds and manufactured quartz increased 6 percent to 70,955 pounds in 1971. For the first time the consumption of manufactured quartz exceeded that of natural quartz. Almost 21 million finished crystal units were manufactured from the quantity of natural and synthetic quartz consumed during the year. The 1971 consumption data reported in table 5 are based on reports received from 26 crystal cutters in 12 States. Finished piezoelectric units were produced by 22 of the cutters; the remainder produced only semifinished blanks. Of these cutters two consumed natural quartz only, 13 cut manufactured quartz only, and 11 cut both natural and manufactured quartz.

Twelve consumers in four States accounted for 85 percent of the raw quartz crystal consumption. Pennsylvania was the leading quartz-consuming State with 47 percent of the total, followed by Kansas, Illinois, and Missouri. Piezoelectric units were manufactured by 37 producers in 15 States. Fifteen of these producers worked from partially processed quartz crystal blanks and did not consume raw material. Fifteen plants in four States supplied nearly 76 percent of the total output of finished crystal units. Oscillator plates comprised 73 percent of production. The remainder included filter plates, telephone resinator plates, and other miscellaneous items.

Stocks.—At yearend, stocks of raw quartz crystals held by consumers totaled 120,964 pounds. Of this total, 90,444 pounds was natural material and the remainder was manufactured quartz.

Foreign Trade.—The imports of electronic-and optical-grade quartz crystal (valued at more than $0.50 per pound) declined in both quantity and value in 1971 to 35,059 pounds and $76,248, respectively. This was a decline of 63 percent in quantity and 24 percent in value from the previous year's totals. The average value of imports was $2.17 per pound. About 97 percent of the material imported was supplied by Brazil; the remainder was supplied by West Germany, Japan and the United Kingdom. The quartz crystal imported from Japan, West Germany, and the United Kingdom probably originated in Brazil.

A total of 716,942 pounds of lasca valued at $291,768 was imported in 1971, a decline of 19 percent in quantity and 9 percent in value from 1970 figures. Lasca was used to produce fused quartz and as a nutrient material for the manufacture of quartz crystal. Brazil provided all of the imports.

U.S. exports of natural quartz crystal declined 51 percent from 230,698 pounds in 1970 to 112,560 pounds in 1971. Exports of

Table 5.—Salient electronic- and optical-grade quartz crystal statistics

	1969	1970	1971
Production of manufactured quartz thousand pounds	125	131	110
Imports of electronic- and optical-grade quartz crystal			
Quantity do	237	94	35
Value thousands	$278	$100	$76
Exports of electronic- and optical-grade quartz crystal			
Quantity thousand pounds	NA	286	174
Value thousands	NA	$1,123	$1,626
Natural:			
Quantity thousand pounds	NA	231	113
Value thousands	NA	$396	$833
Manufactured:			
Quantity thousand pounds	NA	55	61
Value thousands	NA	$727	$793
Consumption of raw electronic-grade quartz crystal thousand pounds	188	165	133
Natural do	104	98	62
Manufactured do	84	67	71
Production, piezoelectric units, number thousands	19,562	18,971	20,924

NA Not available.

manufactured quartz increased 10 percent from 55,382 pounds in 1970 to 60,750 pounds in 1971. The average price of natural quartz exported was $7.40 per pound; that of manufactured quartz, was $13.06 per pound.

World Review.—*Brazil.*—Exports of raw quartz crystal suitable for electronic use totaled 388,088 pounds valued at $418,276 in 1970. In addition, 12.6 million pounds of lasca valued at $2.6 million was exported. Both varieties of quartz were shipped to France, West Germany, Japan, United States, Italy, and the United Kingdom.

STAUROLITE [15]

Staurolite is a complex aluminosilicate of iron, the precise composition of which is disputed and probably variable. The mineral occurs as reddish-brown to black crystals with a specific gravity of 3.65–3.77 and between quartz and topaz in hardness (7 to 8 on Moh's scale). Aside from a limited rock-shop trade in cruciform-twinned crystals from some deposits ("fairy crosses") sometimes credited with mystical powers as good-luck amulets, staurolite is produced commercially in the United States only in the form of a magnetic fraction of the heavy-mineral concentrate recovered by E. I. du Pont de Nemours & Co. from a deposit of Ice Age beach sand in Clay County, Fla. The staurolite fraction formerly was used only as an ingredient in some Portland cement formulations, but more recently this product, containing small admixtures of kyanite, quartz, rutile, spinel, tourmaline, and zircon and averaging 45 percent Al_2O_3 and 15 percent Fe_2O_3, is being marketed under two trade names either for use as a sandblast abrasive or to be mixed with bentonite and other substances to serve as a foundry sand in some specialized molding applications. Although production data were not made available for publication, the output of staurolite in 1971 was reported to be 8 percent more than in 1970, while sales amounted to 4 percent less in tonnage but 3 percent more in total value.

STRONTIUM [16]

Legislation and Government Programs.—Government stockpiles contained 12,062 tons of stockpile-grade and 13,787 tons of nonstockpile-grade celestite at yearend. No sales of celestite were made during the year.

Domestic Production.—Strontium minerals have not been produced commercially in the United States since 1959. However, firms that produced various strontium compounds from imported celestite included Chemical Products Corp., Cartersville, Ga.; E. I. du Pont de Nemours & Co. Inc., Grasselli, N.J.; FMC Corp., Modesto, Calif.; Foote Mineral Co., Exton, Pa.; Mallinckrodt Chemical Works, St. Louis, Mo.; and Sherwin-Williams Co., Ashtabula, Ohio.

Consumption and Uses.—Domestic consumption of celestite in the manufacture of various strontium chemicals continued to increase. Quantitative information concerning consumption is incomplete, however, the major producing companies reported strontium carbonate production totalling 19,350 short tons. Sales of strontium carbonate to manufacturers of glass for color television picture tubes were reported to be 15,533 short tons. Consumption of celestite in the manufacture of chemicals for pyrotechnics was not available.

Miscellaneous chemical applications for strontium compounds included greases, ceramics, plastics, medicines, paint, electronic components, and in making high-purity zinc. Three companies reported 179 pounds of strontium metal were sold or used during 1971. Strontium metal was used primarily by research companies. King Laboratories, Inc., Syracuse, N.Y., consumed a small quantity of metal to produce getter alloys used in the manufacture of vacuum tubes.

Prices.—Prices quoted at yearend in the Oil, Paint and Drug Reporter were as follows: Strontium carbonate—technical, bags, carlots, works, at 13 to 21 cents per pound; strontium nitrate—bags, carlots works, at

[15] Prepared by J. Robert Wells, physical scientist.

[16] Prepared by Donald C. Wininger, physical scientist.

Table 6.—U.S. imports for consumption of strontium minerals,[1] by country

Country	1970		1971	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Malagasy Republic	(2)	(2)	--	--
Mexico	29,228	$589	35,621	$812
Spain	3,360	69	4,464	97
United Kingdom	4,666	169	5,420	206
Total	37,254	827	45,505	1,115

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.
[2] Less than ½ unit.

$15 per 100 pounds. No price quotations were published for strontium sulfate. Final prices of strontium compounds are negotiated between buyer and seller. The average value of imported strontium minerals at foreign ports was about $25 per ton.

Foreign Trade.—Imports of strontium minerals totaled 45,505 tons, a 22 percent increase over the 1970 total. The material was imported from Mexico, Spain, and the United Kingdom. Other imports for consumption were as follows: Strontium carbonate, precipitated—8,000 pounds valued at $800 from Canada; strontium nitrate—69,302 pounds valued at $8,220 primarily from Canada, (98.4 percent) with a small quantity from West Germany; strontium sulfate—22,046 pounds valued at $505 from Spain; and other strontium compounds—97,521 pounds valued at $26,917 from West Germany (94.4 percent) and France. Quantitative data on U.S. exports of strontium compounds were not available.

World Review.—*Canada.*—The discovery of large deposits of high grade barite and celestite in the Dorchester area of Southeastern New Brunswick was reported early in the year. A diamond drilling program is planned to confirm the surface and geophysical indications.[17]

Kaiser Strontium Products Ltd., subsidiary of Kaiser Aluminum and Chemical Corp., began production of strontium chemicals at its new plant at Point Edward near Sydney in March and operated through the summer and fall months. Despite plant startup problems, shipments of strontium carbonate reportedly were made to glass plants for use in face plates for color television picture tubes.[18]

Iran.—Celestite was discovered about 95 miles east of Tehran in economic quantity 3 years ago. So far 300 tons have been exported. A few other celestite deposits situated in the south of Iran near the oil fields were in the prospecting stage. The deposits were believed to hold large reserves of bedded ore.[19]

Technology.—Experiments were reported on the solubility of strontium sulfates in brines (principally sodium chloride). The need for solubility data of the less soluble sulfates in waters, particularly those flow-

[17] Canadian Mining Journal. Dorbeck Syndicate Has Barite-Celestite Discovery. V. 92, No. 3, March, 1971, p. 8.
[18] Killin, A. F. Industrial Minerals. Can. Min. J., v. 93, No. 2, February 1972, pp. 146–147.
[19] Economic Committee Advisory Group on Minerals Development, Central Treaty Organization. Tehran, Dec. 5, 1971.

Table 7.—Strontium minerals: World production by country

(Short tons)

Country [1]	1969	1970	1971 p
Argentina	14	470	e 500
Canada e	13,000	18,000	60,000
Italy	1,020	931	920
Mexico	19,937	29,211	2 35,621
Pakistan	r 728	151	447
Spain	4,032	7,716	e 24,000
United Kingdom	13,128	13,000	13,000
Total	r 51,859	69,479	134,488

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] U.S. imports from Mexcio.

ing from or produced in petroleum formations, was the prime reason for the study.[20]

The alloying behavior of strontium with copper was examined by differential thermal analysis and X-ray diffraction.[21]

WOLLASTONITE [22]

Wollastonite is a naturally occuring fibrous calcium metasilicate that is useful as a ceramic raw material, as a filler for plastics and asphalt products, as a pigment and extender for paints, and in welding rod coatings. In ceramics, wollastonite is used in wall and floor tile bodies, in clayware, in electrical porcelain for fixtures and insulators, and in ceramic coloring preparations. Minor quantities have been used in the manufacture of mineral wool, and weathered wollastonite float, with a gnarled texture resembling that of driftwood, has been used on a small scale as an ornamental building stone.

Wollastonite is stable in its familiar crystal form only below 1,190° C and above that temperature is converted to a pseudohexagonal modification [23] in view of which fact conclusions of cosmological significance concerning crystallization temperatures of some extraterrestial materials possibly may be derived from the recent discoveries of crystals of wollastonite in a meteorite [24] and in a specimen brought back by Apollo 15 from the surface of the moon.[25]

Wollastonite was produced in the United States in 1971 from only one mine operated by INTERPACE. at Willsboro, Essex County, N.Y. Specific U.S. production figures were last made public in 1950, in which year the national output was 800 short tons valued at $16,000. Wollastonite production and consumption have expanded since that date by substantially more than one order of magnitude. Both tonnage and total value figures for 1971, although notably below the high marks reached in 1966, exceeded those for 1970 by 6 percent.

Wollastonite prices per short ton, works, were quoted in Chemical Marketing Reporter on December 27, 1971, as follows: Fine, paint-grade, bags, carlots, $43.80; 10,000-pound lots or more, $47.80; medium, paint-grade, bags, carlots, $33.00; 10,000-pound lots or more, $37.00. These quotations were, in each case, $1.00 more per ton than those of the previous year. Actual sales, for the most part, were arranged as usual at negotiated prices not on public record.

Production was reported in 1970 of 7,200 short tons of wollastonite in Mexico and 6,700 short tons in Finland, up from 5,000 tons and 5,200 tons, respectively, in 1969. India, with no recorded production in 1969, produced 620 short tons of wollastonite in 1970 and 2,600 short tons in 1971. Wollastonite, feldspar, kaolin, and fluorspar were the raw materials of local origin that, together with talc and ball clay imported from the United States, were mentioned as being used in an automated, large-scale ceramic tile plant in Mexico described in an industrial journal.[26] Products from this operation were marketed throughout Mexico and the United States.

A patent was issued for a process in which wollastonite is sintered to form a porous body of beta-wollastonite for use in the manufacture of high-temperature kiln furniture.[27]

A process was patented in which an aqueous dispersion of wollastonite and kaolin, with various specified additives, is used to coat glass fibers to be formed into nonabsorbent batts for the thermal insula-

[20] Davis, James W., and A. Gene Collins. Solubility of Barium and Strontium Sulfates in Strong Electrolyte Solutions. Environ. Sci. Tech., v. 5, No. 10, Oct. 8, 1971, pp. 1039–1043.

[21] Bruzzone, G. The Binary Systems Calcium-Copper, Strontium-Copper, and Barium-Copper. J. Less-Common Met., v. 25, No. 4, December 1971, pp. 361–366.

[22] Prepared by J. Robert Wells, physical scientist.

[23] Clarke, F. W. The Data of Geochemistry. U.S. Geol. Surv. Bull. 770, 1959, p. 381.

[24] Fuchs, Louis H. Occurrence of Wollastonite, Rhonite, and Andradite in the Allende Meteorite. Amer. Mineral., v. 56, Nos. 11–12, November–December 1971, pp. 2053–2068.

[25] Hargraves, R. B., and L. S. Hollister. Mineralogic and Petrologic Study of Lunar Anorthosite Slide 15415,18. Science, v. 175, No. 4020, Jan. 28, 1972, pp. 430–432.

[26] Vincent, George. Mexican Tile Production Matches World Efficiency. Ceram. Ind. Mag., v. 96, No. 3, March 1971, pp. 32–33.

[27] Rostoker, D. (assigned to Corning Glass Works, Corning, N.Y.). Sintered Wollastonite. U.S. Pat. 3,552,915, Jan. 5, 1971.

tion of dwellings.[28] Finely divided wollastonite, in an intimate mixture with rare-earth compounds, is the major component in a polishing preparation for which a patent was issued.[29] A foreign patent was granted for a process in which natural wollastonite is reacted with phosphoric acid and further treated to produce improved grades of fillers and pigments.[30] Also patented was a similar process involving reaction with aqueous sulfuric acid instead of with phosphoric acid to obtain the same result.[31]

[28] Deuseman, H. N. J. (assigned to Fiberglass Canada, Ltd., Toronto). Process for Coating Nonabsorbent Fibers. U.S. Pat. 3,573,886, Apr. 6, 1971.

[29] Goetzinger, N. J., and W. L. Silvernail (assigned to Kerr-McGee Chemical Corp.). Rare-Earth Oxide and Wollastonite Polishing Composition. U.S. Pat. 3,573,886, Apr. 6, 1971.

[30] Cohen, M. I., and R. D. Perdue (assigned to Elliot Edwin Rosenberg). (No title). British Pat. 1,247,990, Sept. 29, 1971.

[31] Rosenberg, E. E. (No title). British Pat. 1,254,949, Nov. 24, 1971.