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Minerals Yearbook 1970

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

The 1970 edition of the Minerals Yearbook marks the 89th 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 the year of review, and contains sufficient background information to interpret the year's developments. Although the same format has been followed as in previous editions, we direct the reader's attention to the change in numbering of the individual volumes. The former Volume I–II, Metals, Minerals, and Fuels, has been renumbered Volume I; Volume III, Area Reports: Domestic, has been changed to Volume II; and Volume IV, Area Reports: International, has been renumbered Volume III. The general content of the individual volumes is as follows:

Volume I, Metals, Minerals, and Fuels, contains chapters on virtually all metal, nonmetal, 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 II, Area Reports: Domestic, contains chapters covering the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, the Commonwealth of Puerto Rico, and the Canal Zone. This volume also has a statistical summary 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 enhance the value of the Yearbook for its readers can be aided by comments and suggestions. Toward that end, the constructive comments of readers will be welcomed.

ELBURT F. OSBORN, *Director*

Acknowledgments

This volume, Metals, Minerals, and Fuels, 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 Office of Accident Analysis of the Health and Safety Activity.

The collection and compilation of statistical data on the domestic minerals and mineral fuels industries appearing in this volume were preformed 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 mineral 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

Contents

Review of the Mineral Industries

By Bernadette S. Schumaker [1] and Jeannette I. Baker [2]

The year 1970 was highlighted by a continuation of rising prices although at a slower rate, a slackening in industrial production, and a rapid rise in the level of unemployment. Business investment in plant and equipment weakened, but a strong rise in residential construction surfaced late in the year. Both monetary and fiscal policies were applied to stimulate noninflationary growth, but with mixed results. Although inflation slowed down during 1970, real economic growth was at a standstill as the tradeoff between inflation and employment resulted in a slowdown in the former at the expense of the latter. Total gross national product (GNP) for the year was $976.5 billion (in current dollars), up about 5 percent from the 1969 figure. However, real GNP (in 1958 constant dollars) was down from $727 billion to $724 billion. Output, as measured by the Federal Reserve Board Index of Industrial Production, was down for the year. The mining sector, however, showed an increase. Manufacturing, especially durables, slumped and this fact was reflected in a substantial rise in personal savings.

Prices climbed almost 6 percent, slightly less than the 1969 increase. Data for the second half of 1970, however, showed prices increasing at a slower rate than during the first 6 months. Rising more rapidly than average was the price of services. Wholesale prices also advanced, but at a slower rate than in 1969. Among mineral commodities, the price index for coal climbed steeply while other minerals in general advanced moderately.

For the first time in 13 years, the Index of Industrial Production declined. The index for total manufacturing registered a 4-percent drop, reflecting primarily a 6-percent decline in durable manufacturing. Primary metals manufacturing declined from 114.1 to 106.9 index points, a 6.3-percent decrease. Both iron and steel and nonferrous metals and products trended downward following substantial increases in 1969. Although the total Federal Reserve Board Index of Industrial Production (1967 = 100) declined, the mining sector rose from 107.2 to 109.7 index points, a 2.3-percent advance. The production index for utilities also increased during 1970.

A shift in monetary policy also characterized 1970. The tight monetary policy of 1969 which slowed down the economy by reducing demand for credit was exchanged for an easier policy in 1970. This change provided an increased supply of credit and resulted in lower interest rates. From February to July, the supply of money grew at an annual rate of 7.3 percent. For all of 1970, the average increase was 5.5 percent compared with 3.1 percent the previous year. The movement of interest rates was especially significant during the year. Early in 1970, interest rates had reached historical highs as a result of heavy credit demands and a tight monetary policy. However, rates on long-term bonds, especially high-grade corporate bonds and municipal bonds, had begun a significant decline during the first quarter of 1970. During the same period, an even sharper reduction characterized short-term interest rates, a tendency consistent with the historical cyclical behavior of interest rates.

Private housing starts were at an annual rate of 1.3 million units for the first half of the year, but managed to advance to an 1.8-million annual rate in the fourth quarter.

During 1970, total employment increased moderately to 78.6 million compared with 77.9 million in 1969. Unemployment, however, rose substantially in 1970 from 3.9 percent in January to 6.2 percent in De-

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[2] Commodity research specialist, Office of Technical Data Services.

cember. The lackluster growth of employment resulted from a generally depressed demand for goods and services complicated by a major strike in the automobile industry. Employment in the goods-producing industries was severely affected while the service industries fared somewhat better. Among the goods-producing industries, defense and aerospace employment was sharply reduced. Unemployment among white collar workers rose sharply during the year. Mining employment also followed the generally declining trend in goods-producing industries. Other economic highlights of the year included a slowdown in the growth of federal spending. Much of the cutback was in defense-related spending. Expenditures by state and local governments rose 9 percent, slightly less than last year's growth.

Significant Congressional activities affecting the mineral industries included implementation of the National Environmental Policy Act of 1969. A Council on Environmental Quality was set up as required by the act. The Clean Air Amendments of 1970 established air quality standards for motor vehicle emissions. The law provides also for the regulation of fuels when they impair the performance of emission-control devices. The Mining and Minerals Policy Act (Public Law 91–631) became law late in the year. An annual report to Congress on the state of the mineral industries is required by this legislation.

A substantial decrease in disposal of material from mineral stockpile inventories developed in 1970. The total market value of inventories showed little change from the 1969 level. The Office of Mineral Exploration continued its financial assistance programs to encourage exploration for new domestic sources of essential materials.

The U.S. trade balance (excluding military grant exports) showed a surplus of $2.7 billion in 1970 following 2 years of rather small surpluses of $0.8 billion in 1968 and $1.3 billion in 1969. Among mineral resources exported, coal and steel exports showed substantial gains. Total selected mineral exports increased to $5.9 billion in 1970 while selected mineral imports climbed to $8.7 billion. Direct investments abroad in all industries in 1969 was $70.8 billion. Of this figure, $20 billion was accounted for by petroleum investments. Investments abroad in mining and smelting totaled $5.6 billion for 1969.

SOURCES AND USES OF MINERALS

Production.—In 1970, domestic production of primary minerals and mineral fuels was valued at $29.8 billion. In 1967 constant dollars, the value of mineral production was $27.0 billion. The value of mineral fuels and metals each increased more than 10 percent, while nonmetals advanced only slightly.

Reflecting the nation's general economic slowdown, the Bureau of Mines index of physical volume of mineral production (1967 = 100) showed little change in 1970; the total index gained less than one point for the year. While the overall average for metals increased from 127.9 to 135.8 index points, there was little change in the nonmetals and fuels components of the index. In 1970 the volume of ferrous metals production declined for the first time since 1967. Nonferrous metals again registered the sharpest advance among minerals produced during the year. Among nonferrous metals, the production index jumped 11.8 percent for base metals, 7.3 percent for monetary metals, and 7.7 percent for other nonferrous metals. Little change was recorded for nonmetals production. Coal gained over 7 points and climbed to 108, while crude oil and natural gas production was off slightly for the year.

During 1970, the Federal Reserve Board Index of Industrial Production (1967 = 100) declined from 110.7 to 106.7. However, all segments of mining except stone and earth minerals advanced. Coal mining, for example, climbed to 105.7 index points, a 4.5-percent increase. The index for crude oil production increased by over 4 percent while for natural gas, the gain was 2.6 percent. Continuing its trend upward, metal mining registered a 5.2-percent increase, less than half of the 1969 gain. For the second consecutive year, stone and earth mining declined.

Industrial production of metals and nonmetals posted a lackluster performance in 1970. For the first time since 1967, primary metals, iron and steel, nonferrous metals and products, and clay, glass, and stone

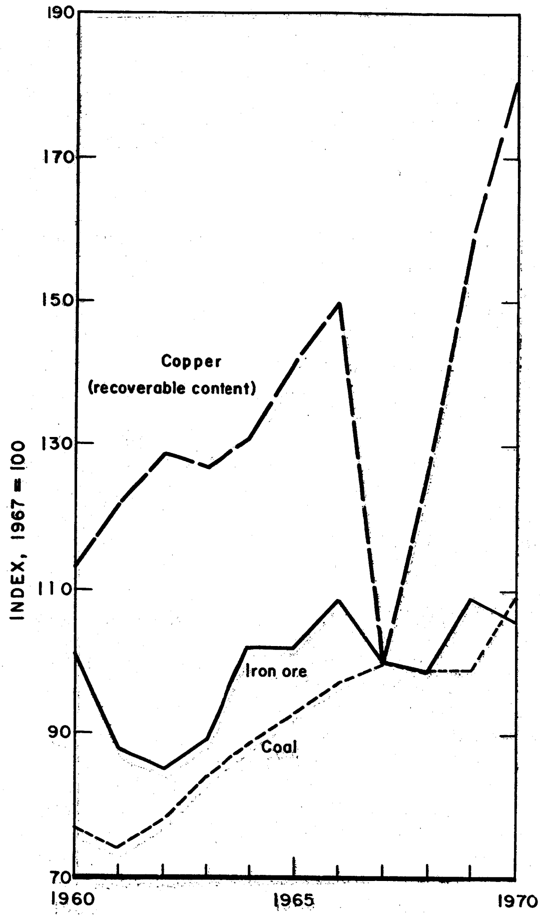

Figure 1.—Index of physical volume of mineral production for selected items in the United States.

products fell by at least 5 percent. The Federal Reserve Board monthly indexes of mining production (1967 = 100) showed a decline in mining activity during the first half of 1970 but a substantial increase in the last half of the year. Most major components of mining followed this trend with two exceptions. Stone and earth minerals production declined through the entire year of 1970. By contrast, coal mining production climbed sharply early in the year followed by a slowdown in midyear and additional gains late in 1970.

Figure 1 indicates the historical trends for important mineral commodities. In 1970, copper production continued to advance as output reached 180 index points (1967 = 100). Iron ore dipped slightly to 105. Following several years of either declining or stable production, coal increased to 108 index points.

A total of 59,146 trillion British thermal units (Btu) were produced by the fossil fuels group compared with 55,947 trillion Btu in 1969. Heat value of primary electricity produced at hydropower and nuclear powerplants, when added to that of fosssil fuels, brought the total to 61,994 trillion Btu, a 5.6-percent advance.

Table 6 indicates the upward trend in energy production during 1966–70. All components of mineral and electrical energy recorded increased output during this time period except anthracite coal. Anthracite output in 1970 was only 75 percent of the 1966 production level. Production of bituminous coal and lignite reached 15,000 trillion Btu in 1970. Natural gas and crude petroleum production again recorded increases. A substantial increase in nuclear power output, from 146 to 231 trillion Btu, was registered during the year.

The net supply of principal minerals had a mixed pattern in 1970. In the metals category, the net supply of iron ore increased slightly while pig iron and steel ingot decreased 4 percent and 8 percent, respectively, below 1969. Chromite and nickel recorded increases of over 25 percent and molybdenum increased 17 percent. While the net supply of aluminum declined, copper supplies increased by 3 percent. Among nonmetals, sulfur supplies were stable and phosphate rock and potash posted increases.

Stocks and Government Stockpile.—The Bureau of Mines index of stocks of crude minerals (1967 = 100) increased substantially in 1970. Metal stocks, following a 16-point decline in 1969, climbed 9 index points to 113. Increased stocks of iron ore and other ferrous metals were recorded, while nonferrous metal stocks dipped slightly. Nonmetallic stocks were especially high at 154 index points. The index of stocks at mineral manufacturers, consumers, and dealers increased 15 points in 1970 (1967 = 100). Significant increases in all classes of metal stocks were registered. Nonmetallic stocks also increased during the year.

Producers' stocks of most mineral energy resources and related products grew during 1970. Stocks of bituminous coal were up 15 percent and anthracite stocks increased 32 percent. All categories of petroleum and related products increased except gasoline, special naphthas, petroleum asphalt, and residual fuel oil. Significant stock increases were recorded for carbon black, liquefied gases, and natural gasoline, plant condensate, and isopentane. Natural gas stocks were up 12 percent at yearend.

The seasonally adjusted book value of product inventories for selected mineral processing industries registered increases in all categories in 1970. For petroleum and coal products, the increase was 11.7 percent, raising the value of inventories to $2,539 million. A 6.6-percent increase in inventories was posted by stone, clay, and glass products which was about half the rate of increase in this category during the period 1967–69. Total inventories of stone, clay, and glass products reached $2,648 million in December 1970. The seasonally adjusted book value of primary metals inventories totaled $8,862 million, a 10.1-percent gain. The primary metals inventories were about equally divided between blast furnace and steel mills ($4,717 million) and other primary metals processing plants ($4,145 million). For selected mineral processing industries, the total seasonally adjusted book value of inventories advanced 9.7 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, industrial diamond stones, lead, metallurgical manganese, tin, tungsten, and zinc were all important stockpile commodities during 1970.

Exports.—The total value of selected minerals and mineral products exported advanced 26 percent in 1970, slightly more than the 24-percent gain of 1969. Accounting for the increase was a surge in coal exports, a substantial gain in iron and steel scrap exports, as well as increases in several manufactured metal exports. Coal exports were valued at more than 1 billion dollars in 1969, a 64-percent gain. Among manufactured metals, iron or steel ingots, copper and copper alloys, and aluminum and aluminum alloys advanced considerably. Gains were registered in all mineral categories, although in varying degrees. Crude nonmetallic exports were up slightly; chemicals and manufactured nonmetallics increased moderately. Mineral energy resources and related products posted the largest percentage increase followed by crude and scrap metals and manufactured metals.

Imports.—In 1970, selected mineral imports advanced 11 percent to $8.7 billion as increases were recorded in all major mineral categories except crude nonmetallics. Crude and scrap metals imported gained 19 percent led by increased imports of iron ore and concentrates, and ores and concentrates of nonferrous base metals. Imports of mineral energy resources climbed 10 percent led by an 18 percent gain in petroleum products imported. Chemical imports were up substantially in 1970 for an overall increase of 21 percent. In the manufactured metals category imports rose to $3.7 billion for the year.

Consumption.—The consumption pattern for major mineral products was generally mixed during the year. Iron ore consumption, after advancing 6.4 percent in 1969, dropped 4 percent to 135 million long tons in 1970. Raw steel consumption similarly trended downward. Overall consumption of chromite ores and molybdenum was down, while tungsten and manganese ore recorded gains. Among nonferrous metals, copper consumption fell by almost 5 percent compared with a 14-percent increase in 1969. Lead and silver consumption declined; the demand for mercury posted a substantial drop of 20 percent during the year.

In the nonmetals category, sulfur consumption dipped from 9.2 to 9.1 million long tons and depressed prices and a glutted market characterized the sulfur industry. Both phosphate rock and potash consumption were up. For all categories of mineral energy resources except anthracite, demand increased during 1970. Bituminous coal consumption edged up slightly as did petroleum consumption. A gain of almost 5 percent was recorded for natural gas. In general, consumption of major mineral products in 1970 was varied. Fuels were mostly up; nonmetals were mixed; and metals trended downward.

In 1970, the demand for electricity jumped to 1,638 billion kilowatt-hours, a 5.5-percent advance. Utilities scored a 6.1-percent gain as increases were recorded in both nuclear power and conventional fuel-burning plants. The demand for hydropower, however, declined from 251 to 249 billion kilowatt-hours. A remarkable 57-percent gain in nuclear power demand was registered during the year.

An examination of gross consumption of energy resources by major sources and consuming sectors revealed moderate increases in most categories. The household and commercial sector, for example, consumed 13,988 trillion Btu's of energy in 1970, up 2.8 percent. Natural gas continued to be the leading supplier to this sector followed by petroleum. Coal furnished only a very small part of energy consumed by the household and commercial sector.

Industrial consumption of energy resources was up less than 2 percent in 1970. Natural gas supplied over half of this sector's gross energy inputs. Petroleum, followed closely by bituminous coal and lignite, accounted for almost all of the remaining energy input.

In 1970, the transportation sector accounted for 16,468 trillion Btu's of gross energy consumption. Over 95 percent of this figure was supplied by petroleum. Natural gas and bituminous coal and lignite contributed much smaller amounts of energy demands.

The electric utility sector increased its consumption of energy resources by 8 percent in 1970. Bituminous coal and natural gas were the leaders in supplying energy to this sector. Total gross energy inputs for the year showed a 3.8 percent advance to 67,431 trillion Btu's, somewhat smaller than the 5.2 percent increase in 1969. Petroleum continued to be the overall leading energy source followed by natural gas and bituminous coal.

In 1970, the domestic supply of anthracite coal declined but bituminous coal advanced. Exports of the former fell to 1,467 thousand short tons while bituminous coal trade increased from 56 to 71 million short tons, a substantial gain of 26 percent. Imports of bituminous coal, at 36,000 short tons were quite low for the year. The total domestic supply of bituminous coal reached 517.5 million short tons; the supply of anthracite continued its downward trend and stood at 8.2 million short tons for the year.

The petroleum supply picture included an increase in crude oil production to 3,517 million barrels compared with 3,372 million barrels in 1969. Exports were up significantly from 1 to 5 million barrels, but imports decreased from 514 to 483 million barrels. The total crude oil supply climbed to 3,968 million barrels.

Production of domestic natural gas increased to 21,921 billion cubic feet, up almost 6 percent. Exports amounted to 70 million cubic feet and the much larger category of imports grew almost 13 percent, to 821 million cubic feet. Total supply of natural gas reached 21,367 billion cubic feet for the year.

Consumption of fuels in 1970 was, of course, influenced by the growing national concern for our environment. Low-sulfur fuels were in great demand during the year, and this trend is expected to continue well into the future.

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment in selected minerals mining and manufacturing sectors trended downward in 1970. As a result of a strong world demand for energy, bituminous coal employment posted the largest gain among selected mineral industries. Total mining employment, while declining only 1 percent to 622,000, was at its lowest level since 1967. In addition, nonmetal mining and quarrying declined to its lowest level in over 10 years. In the metals sector, iron ore mining gained 3.1 percent while copper mining declined slightly. Overall, total metal mining employment rose 2.8 percent to 94,800. Among fuels, all selected mineral fuel industries declined except bituminous coal employment, which advanced almost 7 percent for the year. Employment in oilfield and gasfield services fell by nearly 10 percent and a 1.8-percent decline was posted in crude petroleum and natural gasfields employment.

In 1970, minerals manufacturing employment slackened to 902,400. Although fuels advanced for the year, the much larger selected metals and nonmetals categories trended downward.

Hours and Earnings.—For the total mining sector, hourly earnings advanced 6.7 percent, to $3.66 compared with a 7.9-percent increase in 1969. Weekly earnings also increased at a decreasing rate, while weekly hours worked rose slightly from 44.7 to 44.8. In the metal mining group, average hourly earnings climbed to $3.88; 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 43.3 to 42.7 hours; average weekly hours for iron ore advanced to 41.9 while for copper ore the comparable figure was a decline to 44.7. The mineral fuels industries recorded hourly earnings of $3.97, a 7.3-percent increase. Once again the highest average hourly and weekly earnings were posted by bituminous coal mining. Average hourly and weekly earnings for crude petroleum and natural gas were up while average weekly hours fell slightly.

Average hourly earnings for manufacturing industries rose by only 4.3 percent in 1970, but most mineral manufacturing industries exceeded this average rate. For the cement industry, hourly earnings gained over 13 percent. Hourly earnings in the fertilizer industry, which are historically low compared with other mineral commodities, increased 7 percent to $2.91 an hour. A slight downward shift in weekly hours characterized the fertilizer industry in 1970. Accompanied by a moderate 3.2-percent increase in average hourly earnings and a decrease in weekly hours, weekly earnings for blast furnaces, steel and rolling mills fell slightly. While hourly earnings advanced 5.6 percent for nonferrous smelting and refining, a decrease in weekly hours slackened the growth of weekly earnings to 3.8 percent. Hourly and weekly earnings for petroleum and related industries climbed more than 6 percent, to $4.27 and $182.33, 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 1970. While there was no change in the metal mining accession rate, the rate for iron ore fell and the rate for copper advanced. Hires and rehires per thousand employees declined for nonferrous smelting and refining, blast furnaces, steel and rolling mills, hydraulic cement, and total manufacturing. Accession rates for the fuel industries were mixed, with petroleum refining and petroleum refining and related industries posting declines and coal mining advancing slightly. Most selected mineral industries experienced increased separation rates in 1970. The exceptions were manufacturing, nonferrous smelting and refining, petroleum refining and related industries, and coal mining. The manufacturing layoff rate for 1970 advanced from 12 to 18 per thousand employees. Excluding coal and copper mining, the rate climbed for all other selected mineral industries.

Wages and Salaries.—An upward trend continued for wages and salaries in all industries during 1970. Although failing to match the nearly 10-percent gain of 1969, wages and salaries in 1970 climbed 6.2 percent to $541.4 billion. In the mining sector, wages and salaries again increased faster than in the manufacturing industries. Total mining wages and salaries advanced 8.1 percent to $5.8 billion. A very slight increase in manufacturing was posted as wages and salaries rose less than

1 percent to $158.3 billion. Average earnings per full-time employee advanced moderately during the year. For all industries, the average increase was 6.6 percent or equal to the 1969 advance. Average earnings in mining climbed 7.5 percent, down slightly from an 8.2-percent increase in 1969. Average earnings per full-time employee in mining reached $9,262 while for manufacturing, average earnings were $8,150.

Productivity.—The most recent data on labor productivity in the mineral industries generally showed gains in output per employee, output per production worker, and output per production worker manhour. Among the selected mineral industries, moderate increases were posted for copper, iron, and petroleum, while bituminous coal and lignite registered only a slight gain in productivity. Copper ore mined per production worker man-hour increased 6 percent during 1969, to 144 index points (1957–59 = 100); recoverable metal mined per production worker manhour advanced 3.7 percent to 117.8, the largest percentage advance in the last 5 years. Productivity increases in both crude and usable iron ore were below the 1968 advance. Petroleum refined per production worker man-hour increased 11.1 percent to 216 in 1969, a gain from the 1968 increase. Productivity indexes for bituminous coal and lignite showed only a slight gain of less than one index point.

PRICES AND COSTS

Index of Average Unit Mine Value.—The index of average unit mine value (1967 = 100) increased at a decreasing rate in 1970. The total index climbed to 109.3. Posting the largest gain was the metals group followed by fuels and nonmetallics. A moderate 5.3-point advance in ferrous metals was recorded for the year in contrast to a 21.7-point gain in nonferrous base metals. For the second consecutive year, the average unit mine value of monetary metals fell. Other nonferrous metals advanced substantially from 95.4 to 129.2 index points. All nonmetallic groups declined with the exception of construction nonmetallics. The average unit mine value of coal rose spectacularly from 108 to 134.2 index points. Crude oil and natural gas declined slightly.

Index of Implicit Unit Value.—In 1970 the index of implicit unit value (1967 = 100) increased 4.3 percent to 110.5, about the same percentage increase as in 1969. The index for ferrous metals was up moderately, while for nonferrous base and other metals, the index climbed sharply. Monetary metals were down 8.5 points for 1970. Nonmetals showed little change in advancing from 102.3 to 103.0. In the fuels category, crude oil and natural gas declined slightly but coal advanced. Overall, the fuel sector increased from 106 to 109.8 index points.

Prices.—During 1970, the increase in the wholesale price index for most metal commodities ranged from a 2-percent rise in iron ore to a 25-percent climb in the index for iron and steel scrap. Most increases in metals were, however, between 5 and 8 percent. Among selected metals, only one decline was posted—a 2-percent reduction in the price index for nonferrous scrap. The overall average increase in the metal index was 7.6 percent compared with a 5.8-percent gain in 1969. The price indexes of most nonmetallics advanced during the year. While building materials generally posted gains, fertilizers were lower following substantial declines in 1969. Overall, nonmetallic mineral products advanced 5.2 percent. The price index for fuels and related products and power increased by 5 percent in 1970. A steep rise in both anthracite (12.2 percent) and bituminous (34.9 percent) coal was posted. The price index for coke climbed 17 percent to 127.4 in 1970. Crude petroleum and petroleum products were up only slightly. All commodities posted a moderate 3.7-percent gain for the year.

Unit prices for mineral energy resource commodities were up during 1970. A 14-percent increase was posted in the price of bituminous coal while the average price of anthracite was up almost 14 percent. Prices of petroleum and petroleum products also increased. Crude petroleum, for example, climbed to $3.18 a barrel, a 2.9-percent gain. Gasoline prices advanced 3.3 percent. The price of residual fuel oil climbed sharply while distillate fuel oil posted more moderate gains. The average price of natural gas at the wellhead increased to 17.1 cents per thousand cubic feet.

During 1969 (latest data available), the average cost of electrical energy for the United States remained at 1.5 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 posted no change from 1968 in the average cost of electrical energy. Most areas reported no change in the total cost of electrical energy with the exception of a slight decline in the Middle Atlantic region and a slight rise in the East South-Central region. Alaska and Hawaii remained the highest cost areas for electrical energy while the East South-Central region remained the lowest cost area.

Index of Principal Metal Mining Expenses.—Principal metal mining expenses trended upward during 1970. Overall, the index climbed 5 points compared with a 4-point advance in 1969. The labor component of the index increased 6 points, about twice the 1969 gain. The 4-percent increase in the price index for supplies was also above the 1969 advance. Fuels were up almost 5 percent compared with a 3-percent increase during the previous year. Of the principal metal mining expenses, the index for electrical energy again increased at the slowest rate (2.9 percent).

Costs.—A general price rise characterized the indexes of relative labor costs and productivity for selected minerals. The index of labor costs per unit of output for iron ore recorded a 7-point increase, while for copper, the comparable gain was 5 index points. Although the index of value of product per man-period was up only 1 index point for iron ore, the index for copper climbed sharply. A decline was recorded for the third consecutive year in the index of labor costs per dollar of product for copper. However, the index for iron ore advanced 5 index points.

The price indexes for mining construction and material handling machinery and equipment increased moderately. The smallest increase recorded was a 2.1-percent gain in the index for portable air compressors. Except for a 4.6-percent advance in the price of scrapers and graders and a 6.5-percent increase in special construction machinery, 1970 increases did not exceed 5.1 percent.

INCOME AND INVESTMENT

National Income Generated.—While national income originating from all industries advanced only 4.2 percent in 1970, a gain of 9.8 percent was recorded in national income originating in mining. Income generated by both metal mining and coal mining showed substantial gains of 14.4 and 28.5 percent, respectively. Crude petroleum and natural gas, which account for a large part of mining income, gained only 3.1 percent and reached $3.1 billion. National income originating from nonmetallics mining and quarrying was up less than 1 percent to $1.3 billion. The manufacturing sector registered a disappointing 1.9-percent decline to $218 billion. Petroleum refining and related industries, stone, clay, and glass products, and primary metal industries all recorded slight declines in national income while chemicals and allied products edged up 0.6 percent to $16.1 billion. Total national income for all industries reached $796 billion in 1970.

Profits and Dividends.—In 1970, the average annual profit rate on shareholders' equity for manufacturing was at its lowest level since 1960. The profit rate of 9.3 percent was also a 2.2-percent decline from 1969. All selected mineral manufacturing corporations posted declines, although of varying degrees. Petroleum refining and related industries, for example, experienced only a slight decline of 0.7 percent while primary iron and steel fell 3.3 percent. Stone, clay, and glass products also declined slightly from a 9.2- to a 6.9-percent profit rate. Chemicals and allied products continued to have the highest annual profit rate among selected mineral industries despite a 1.3-percent decline for the year. Total dividends for all manufacturing amounted to $15.1 billion, a slight increase over 1969. Petroleum refining and related industries was the leader in total dividends among selected mineral industries with a 3.1-percent advance to $3.2 billion. Most other selected mineral industries showed slight increases in dividends, with the exception of primary iron and steel, and stone, clay, and glass products, which declined about 3 percent each.

The total number of industrial and commercial failures in 1970 increased to almost 11,000, and current liabilities rose to $1.9 billion. In the mining sector 54 failures were reported with current liabilities of $59 million compared with 34 failures in 1969 and $15 million in current liabilities. Manufacturing failures and liabilities were also up considerably in 1970.

New Plant and Equipment.—In 1970, new plant and equipment expenditures by mining firms increased by only $30 million to $1.89 billion compared with a $230-million increase in 1969. The manufacturing industries also experienced only a slight gain in new plant and equipment expenditures, increasing from $31.68 billion in 1969 to $31.95 billion in 1970. Among selected mineral manufacturing industries in 1970, increases in expenditures were registered by primary nonferrous metals and chemicals and allied products. On the other hand, primary iron and steel, stone, clay, and glass products and petroleum and coal products all posted declines in new plant and equipment expenditures.

Plant and equipment expenditures of foreign affiliates of U.S. companies in mining and smelting gained $220 million or 19 percent during 1970. Mining and smelting expenditures declined for Latin America and remained the same for Europe. An $89 million gain for Canada and a $138 million advance in other areas were also posted. Total petroleum expenditures reached $3,994 million, and all reporting areas showed gains. Manufacturing expenditures rose to $7,042 million, a 42-percent gain for the year. Europe and Canada accounted for 73 percent of total manufacturing plant and equipment expenditures.

Issues of Mining Securities.—In 1970, estimated gross proceeds of new securities offered by the extractive industries totaled $2,082 million, compared with $1,721 million in 1969. Common stock accounted for 85 percent of the proceeds in extractive industry offerings, while bonds contributed about 14 percent and preferred stock comprised less than 1 percent.

Sources and Uses of Fund.—Funds from all sources for direct foreign investment by mining and smelting industries increased by $0.5 billion to $1.9 billion in 1968 (latest data available). Once again, Canada and Latin America were the leaders in generating funds. Both areas relied chiefly on net income originating from the industries, although funds from the United States and abroad rose substantially.

In 1968 (latest data available), funds used for direct foreign investment by U.S. mining and smelting industries for property, plant, and equipment climbed to $911 million, a 27-percent advance. In general total funds were expended as follows: plant, property and equipment, 47 percent; income paid out, 30 percent; other assets 18 percent; inventories and receivables, about 2 percent each.

Foreign Investment.—The value of U.S. direct investments abroad for all industries amounted to $70.8 billion in 1969. Twenty-eight percent of this figure, or $20.0 billion was attributed to investments in petroleum affiliates. Because of smaller capital outflows and negative reinvested earnings of $59 million, the increase in petroleum investment was significantly smaller than the 1968 increase. Forty-eight percent or $525 million of last year's $1.1 billion advance in the book value of foreign petroleum investments was accounted for by the developed countries. The less developed countries rose by $334 million. In 1969, the book value of Canadian petroleum affiliates gained $0.3 billion, close to the 1968 advance. For Europe, the value of petroleum investments increased by less than $0.2 billion. Investments in the less developed countries increased but at a slower rate in 1969. Both Latin America and Africa experienced a small gain in book value of petroleum investments while Middle East investments fell slightly.

During 1969, U.S. direct investments in foreign mining increased by over $0.3 billion, significantly less than the 1968 increase. Contributing to the lackluster gain in investment was the completion of some major investment projects in Australia and the involuntary sale of controlling ownership in two Chilean mining ventures. While reinvested earnings showed little movement, capital outflows declined from $0.4 billion to less than $0.1 billion. Of the total book value at yearend of $5.6 billion in total direct private investment in foreign mining and smelting industries, the developed countries accounted for $3.3 billion and the less developed countries accounted for $2.3 billion.

Foreign direct investments in the U.S. totaled $11.8 billion in 1969. The book value at yearend of foreign petroleum investments totaled $2.5 billion, a 10-percent gain or about 50 percent of the 1968 advance. In 1968 a foreign international petroleum company purchased more than $200 million of stock in its U.S. subsidiary, and new petroleum investment rose considerably. In 1969, there was no similar transaction. Of the total foreign petroleum investment in the U.S. of $2.5 billion, Europe accounted for $2.3 billion or 92 percent. By far the largest foreign investors in the U.S. petroleum industry were the Netherlands ($1.3 billion) and the United Kingdom ($0.8 billion).

TRANSPORTATION

The quantity of selected minerals and mineral energy products transported by rail and water gained moderately in 1969 (latest data available). For total mineral products, rail transportation advanced 3.3 percent and water transportation increased by 5.1 percent. Once again, the majority of selected metals and nonmetals was transported by rail, while 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 increased by 4.2 percent, to 449.6 million short tons. The quantity transported by water gained 10.2 percent, to 247.4 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 climbed moderately in 1969 except for a 29-percent advance in other nonferrous ores and concentrates, a 15-percent increase in the amount of lime transported, and a 15-percent decline in the quantity of gypsum and plaster rock transported.

Significant changes in commodities other than mineral energy resources transported by water included a 211-percent increase in the amount of other nonferrous metals and alloys transported, and a 42-percent increase in the amount of lime transported. Both of these commodities, however, form a very small percentage of total quantity of selected minerals transported by water. Among nonmetals transported by water, most showed gains for 1969 excluding liquid sulfur, clays, ceramic and refractory materials, limestone flux, and calcareous stone.

In 1969, 418 million short tons of mineral energy resources and related products were transported by rail and 533 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. The amount of coke transported by rail climbed significantly from 262,000 short tons in 1968 to 1.8 million short tons in 1969.

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 1969. The total volume of selected mineral energy resources and related products transported by water was 927.4 million short tons, a 4.4-percent gain for the year.

A total of 892,000 miles of gas pipeline was recorded for 1969 (latest data available), a 3-percent advance. Once again, natural gaslines accounted for the overwhelming majority of total pipeline mileage with small amounts distributed among manufactured, mixed, and liquefied petroleum gas. Total petroleum pipeline mileage in 1968 (latest data available) dipped to 209,000 miles, the first reduction in the last four decades. Of the total petroleum pipeline mileage reported, 35 percent was in crude gathering systems in field operations, 34 percent in larger size crude trunklines and 31 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 1968 (latest data available) totaled $17.4 billion. Of this amount, $8.9 billion originated from company expenditures and $8.6 billion from government funding. Research and development expenditures in petroleum refining and extraction totaled $538 million, an 18-percent increase from 1967. Over 86 percent of petroleum research and development activities was financed by private expenditures while government funds supplied the remaining 14 percent. In the chemical and allied products industries, a total of $1.6 billion was channeled to research and development activities, a moderate 4.5-percent gain for the year. Company expenditures in this field were $1.4 billion and government expenditures were about $0.2 billion.

Bureau of Mines.—During 1970, the programs of the Bureau of Mines emphasized the effective utilization of our natural minerals and fuel resources. Insuring adequate mineral supplies without objectionable environmental, social, and occupational effects, continued to be the mission of the Bureau. Coal research projects were directed mainly to advancing coal technology to meet energy requirements and solve related environmental problems. Oil shale projects emphasized the development of scientific and engineering information necessary to utilize this resource. Among the mining research projects emphasized during the year was the use of infrared techniques for detecting hazardous mine conditions. Solid waste research was again stressed by the Bureau; and in the area of health and safety research, the emphasis was placed on developing technology to minimize mining hazards. Petroleum research included continuation of Project Rulison, experiments using natural gas or propane to control engine emissions, and a preliminary analysis of the cost of subsurface waste disposal compared with the cost of surface treatment. Economic studies continued to focus on the mineral industries, environmental problems, and supply and demand studies.

During fiscal year 1970, Bureau of Mines funding obligations for mining and mineral research and development reached $58.0 million, a 25-percent gain from the previous year. Funds allocated to applied research increased to $31.6 million or 54 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 $20 million or 34 percent of the total. Funds for development have increased almost fourfold between 1969 and 1971. Total research funds of $38.1 million were obligated by the Bureau and were divided as follows: Engineering science, $27.4 million; physical sciences, $7.4 million; mathematical sciences, $0.8 million; and environmental sciences, $2.5 million. Among the sciences, funds for environmental sciences showed the largest percentage gain for the year.

Highlights of the accomplishments of Bureau research programs, including work in progress, are described in the following paragraphs.

Mining Research.—Infrared techniques were tested for the detection of hazardous conditions in and around underground mines. Results indicated that temperature differences of from 0.2 to 0.5° C exist between loose and solid rock in most mines and that these differences can be used to detect loose, hazardous rock. Laboratory studies of rock fabric at the microscale suggested it may be a useful tool for predicting the most probable directions of fracture. Laboratory measurements suggested that orientation of microfractures in granite coincides with known rift and grain fracture orientations in the quarry. It is hoped that this technique can be utilized in virgin rock to predict directions of easy fracture and that economical mining methods may take advantage of these natural fracture tendencies.

Study of a new concept for secondary breakage of rock by thermal energy demonstrated the feasibility of using thermal shock from rapid heating and cooling to fragment hard rocks. The technique should be applicable to both spallable and nonspallable rocks. Studies were completed on the cuttability of geologic materials by high-pressure water jet action. These studies yielded basic information on the relationship of cutting rates and energy requirements to jet parameters and physical properties of the material. This information should enable industry and hydraulic research institutions to formulate programs for the extraction of material by high-pressure water jets.

Efforts to improve ground support in coal mines through chemical stabilization were continued in three categories: coatings, impregnation (filling fractures, joints, and pores), and pumpable rock bolts. Of the many polymeric materials tested as coatings for shale to prevent deterioration by moisture exchange with the mine atmosphere, epoxy resins showed the greatest promise at a reasonable cost. To achieve greater penetration of rock, novel impregnation methods such as prefracturing and gang-drilling were studied. Pumpable rock bolts, using quick-set polymers, bonded strongly to shale and provided good structural support. They should compete favorably on an economic basis. Anchorage from these bolts in areas stabilized by fracture impregnation and/or seal coatings may ultimately furnish a total ground-support system for coal mines. Also under intensive study were the problems of methane origin, release, and control. Gas pressure gradients and rates of emission were measured, the effects of geologic structures and discontinuities were investigated, methods of draining methane from gob and working areas were tested, and improved methane detection and recording equipment was developed.

A method for measuring and analyzing the initial deformation that occurs in the mine opening as it is created has recently been developed and tested. The instrumentation developed proved to have the sensitivity and resolution necessary to measure rock deformation around a full-scale raise bore during excavation. Tests showed the relationship of rock deformation to the progress of the raise boring and to time. A new technique for filling inundated mine voids to provide surface support was successfully demonstrated at Rock Springs, Wyo. A total of 19,500 cubic yards of sand was transferred from the surface to the mine voids through a single injection borehole system and concentrated in a mined area of about 2.6 acres. The success achieved provides a strong basis for assuming the process would be equally effective in filling both dry and water-filled voids, not only with sand, but also with waste material such as crushed mine refuse. An experiment to verify this assumption is being planned for the anthracite region of Pennsylvania.

Metallurgy Research.—Two processes were developed for recovering the fluorine in the waste fluosilicic acid solution generated by phosphatic fertilizer manufacture. Besides overcoming a pollution problem, a material in short supply is reclaimed by these techniques. One process involved converting fluosilicic acid to acid-grade calcium fluoride (CaF_2) by treating it first with ammonia to remove silica and then with calcium hydroxide to precipitate the fluoride. More than 95 percent of the fluorine in the fluosilicic acid was recovered as CaF_2. A second process involved reacting fluosilicic acid with calcium hydroxide and silica, then volatilizing hydrofluoric acid (HF). After precipitation and heat treatments, 80 percent of the fluorine in the feed reported as anhydrous HF.

A technique was developed to treat the low-grade, high-clay potash ores of New Mexico's Permian Basin, a large reserve not recoverable by present commercial methods. The essential feature of the bench-scale procedure was the development of a scrubbing-desliming step to remove the clay completely without degrading the salt particles. Concentrate grades achieved were a marketable 58 to 61 percent K_2O at 71- to 84-percent recovery. Research in separating natural potash salts from clay with heavy liquids has been concluded. Concentrate grades were comparable to those obtained with a flotation procedure; recoveries ranged from 68 to 78 percent.

Grindability test data for a Minnesota nonmagnetic taconite, reduction-roasted and water-quenched, showed optimum size reduction and work index when roasted at 650° C. Subsequent tests indicated that the optimum conditions for concentration coincided with those for grinding. A 12-minute rod-mill grind was sufficient for subsequent production of a concentrate containing 67 percent iron and 4.9 percent silica at 95-percent iron recovery. Promising Bureau research showed that iron may be reduced from ilmenite in the electric arc furnace. A titanium-enriched slag resulted, to which phosphorus pentoxide was added to complex the oxide impurities into a slag matrix. The temperature was increased to the 1,350° C range to promote crystal growth of rutile. The slag was cooled and comminuted, and the rutile crystals, 96 to 99 percent TiO_2 and up to 160 microns in size, were recovered by mineral dressing methods. Recovery of titania exceeded 90 percent.

A simple countercurrent ion exchange system for recovering uranium was demonstrated in the laboratory and tested in the field at several uranium mines and mills. The process involves recovering uranium from natural mine waters and from clear solutions or slime pulps resulting from leaching uranium ores with sulfuric acid or sodium carbonate solutions. Results of these tests and concurrent engineering evaluations showed that use of these ion exchange contactors would reduce by 70 percent the capital cost for recovering uranium from mine waters compared with present ion exchange practice. It is estimated that use of these contactors in a resin-in-pulp-type flow sheet would reduce the capital and operating costs for a 2,000-ton-per day uranium mill by at least 30 percent.

Solid Waste Research.—Air classification techniques have been used successfully to separate components of automobile scrap. Two pilot-scale air elutriating devices have been designed and constructed for separating the nonferrous metallics from the nonmetallic material present in the nonmagnetic reject scrap from automobile shredders. Both units allowed upgrading the reject from a range of 35–40-percent metal to about 74-percent metal content, with recoveries of 90 to 96 percent of the metal. Final upgrading of the material of 74-percent grade to 99-percent metal was readily obtained in a specially designed water column.

The Bureau's smokeless automobile incinerator has been operating on a production-line basis for more than 1 year. Except for normal maintenance, the operation has been trouble free. Capacity was increased from a range of 48–52 to 88–96 car bodies per 8-hour work shift by burning bodies crushed to slabs of 10- to 14-inch thickness. This reduced burning costs to less than $2.00 per car and will lower transportation costs, presently the single largest deterrent to recycling obsolete automobiles.

A new use for waste silicofluorides, a byproduct of superphosphate fertilizer manufacture, was in the manufacture of portland cement. Very minor amounts of silicofluorides, when added to the clay-limestone mixes from which portland cement is made, reduced temperatures now required in manufacture by several hundred degrees centigrade, thus lowering fuel costs.

Simple procedures have been developed for reclaiming tungsten carbide and cobalt from drilling bits; the methods are already being used commercially. Other studies have shown that variations in density of major polymer species can be the basis for separating and recycling waste plastics found in urban and municipal refuse.

Coal Research.—The Bureau's coal gasification process, designated the "SYNTHANE" process, was further developed and tested in a pilot plant during 1970. The economic and operational feasibility of the gasification process to convert coal to pipeline-quality gas was judged attractive by an outside engineering firm. Design of a prototype plant is underway. Pilot plant tests demonstrated that strongly caking coal can be gasified in a fixed-bed unit if mechanical stirring is employed to break up agglomeration in the fuel bed. The tendency of coals to agglomerate when heated has hampered the gasification of coals from the Eastern United States, potentially a large market for synthetic gas. Although the Bureau's fixed-bed operation required screened coal, it is attractive for larger-scale application, offering high throughput and an economical operation.

The Bureau demonstrated that slurries of coal in high-temperature tar can be hydrogenated to an oil over fixed-beds of pelleted cobalt molybdate catalyst. Hydrogenation of a 30-weight-percent coal slurry at 425° C and 4,000 psi resulted in 91 percent of the moisture and ash-free coal being converted to liquids and gases, with the yield of liquid products amounting to 96 percent of the paste feed. Sulfur content of the oil was as low as 0.2 percent. These results confirmed the technical feasibility of converting coal to low-sulfur utility fuels compatible with air pollution regulations.

Two-stage combustion was applied to the Bureau's magnetohydrodynamic (MHD) power generation system to reduce the inherent high production of nitrogen oxide (NO_x). In this technique, initial combustion was accomplished with 80 to 95 percent of the quantity of air necessary for complete burning of the fuel. Additional air, sufficient to complete the combustion of the fuel, was injected at a point where the first stage combustion gases had cooled to 2200° to 2800° F. In one MHD test, NO_x production was one-third less than the average output from a conventional pulverized-coal-fired furnace. The Bureau's two-stage combustion technique is believed amenable to conventional furnace usage, which in turn could result in an important decrease in NO_x output from tomorrow's fossil fuel combustion. In a study being coordinated by the Bureau and involving nearly a dozen private and government laboratories, a round-robin series of coal analyses is underway to determine the mercury content of coals fueling the Nation's powerplants. Ten coals, sampled from current production going to operating powerplants across the Nation and representing a wide geographical area, are being examined. Besides producing a reliable method for the determination of mercury in coal, the cooperative program is expected to provide information on the environmental impact of mercury from coal-burning powerplants.

Petroleum and Natural Gas Research.— A preliminary analysis of the cost of subsurface waste disposal systems versus the cost of surface treatment of many liquid industrial wastes indicated that the former is more economical. Capital costs of the subsurface disposal systems were about one-half the cost of biological units for treatment of many organic wastes. Annual operating cost of subsurface injection was also generally less than the cost of surface treating systems. Subsurface waste disposal systems used for disposal of industrial and municipal wastes from several widely separated areas were reviewed. During 1970 the Project Rulison preshot exploratory well was cleaned out and redrilled as a directional hole to the top of the chimney created by the nuclear detonation. The well was completed initially August 1, 1970, and recompleted October 4, 1970, following remedial work required after first attempts to produce gas resulted in plugged tubing and production equipment. Cumulative gas produced, including nonhydrocarbon constituents, to April 20, 1971, is 453 million cubic feet.

Excluding exhaust conversion systems, experiments with laboratory engines showed that using either natural gas or propane resulted in lower engine exhaust emissions than are possible with gasoline and conventional gasoline carburetors. However, the advantage of low emissions with the light hydrocarbons was accompanied by a power loss in moving from the traditional fuel-rich, "best-power" fuel/air mixture to the fuel-lean, "lowest-emission" fuel/air mixture. In studying the chemistry of the asphalt-aggregate interaction as it related to performance in road pavements, significant differences were found in the interfacial reactivity of a number of different asphalt-aggregate systems. These differences were measured by immersing aggregate in asphalt in a sensitive microcalorimeter. This microcalorimeter is capable of measuring temperature changes in millionths of a degree and energy changes in microcalories. In cooperation with the Federal Highway Administration (FHWA) studies are being made on selected asphalt and aggregate samples with varying performance characteristics.

In studies of the thermal conditioning of oil and gas reservoirs, tensile strength, toughness, and a relative brittleness index were determined on specimens subjected to cryogenic, ambient, and elevated temperatures. Changes in tensile strength were considered indications of changes in energy needed to induce a hydraulic fracture; changes in toughness were indications of energy required to initiate an explosive fracture. Increases in rock strength and a decrease in brittleness at cryogenic temperature indicated that neither hydraulic nor explosive fracturing would be encouraged as a result of conditioning the formation to an extremely low temperature. Rock specimens subjected to an elevated temperature of 700° F produced little or no change in observable properties of sandstone. At successive cycles of 1,000° F, change in temperature caused impact toughness to decrease by about 15 percent, suggesting further investigation of such treatment as a means of improving explosive fracturing. Comparison of oil-production records of wells representing the East Canton, Ohio, oilfield indicated production was closely correlated to the amount of net sand having greater than 80 percent quartz. Correlation of production data with the net thickness of the 80 percent or more clean sand was made on more than 100 wells scattered throughout the field.

Oil Shale Research.—Research by the Bureau on environmental problems related to oil-shale development resulted in a process that appears from laboratory tests to be suitable for treatment of waste waters produced by both above ground and in situ retorting operations. The process involved treatment with lime, activated carbon, and two types of ion exchange resins. A nonpolluted water suitable for reuse or safe release to the environment was produced. Interest in mercury as a potential pollutant led to an examination of retort waters for this trace element using activation analysis and low-level atomic absorption. No significant quantities were found, the largest concentration being 20 parts per billion. Vegetation studies were concentrated on burned shales as there is greater difficulty in getting satisfactory plant growth on these shales than on retorted but unburned shale. Successful germination of grasses such as annual rye was obtained when the shale was conditioned with 5 to 10 percent Leonardite, and further improvement resulted from adding peat moss. Tests are underway on the effects of various combinations of fertilizer components on growth improvement.

The Bureau continued its investigation of in situ processing of oil shale by multiple coring of the shale bed at the site of the first successful demonstration of this environmentally attractive technique. A second, larger scale field experiment at greater depth was initiated. Related research with a 150-ton retort to simulate in situ processing resulted in completion of the first half of a statistically designed series of runs to develop data on optimum combinations of retorting variables. Specifically developed for thermal analysis of oil shales, a unique Bureau device permitted simultaneous determination of heat changes, weight changes, and analysis of gases evolving from a single sample during heating. This technique provided information on both organic and mineral constituents of the shale. Other developments involving minerals associated with oil shale included analyses of the dawsonite and nahcolite contents of Piceance Creek Basin oil-shale sections. A newly developed technique that may produce a valid estimate of the nahcolite in the entire basin was used. As part of an integrated oil-shale processing operation, material progress was made in development of methods for recovering products derived from these two potentially valuable minerals.

Economic Analysis.—The Bureau's program of economic analysis focused on the economic forces at work within the mineral industry, and on the relationships between the industry and the national economy. The purpose of the activity is 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 one of the alternatives. The economic analysis program seeks to provide the general methodology needed for such analyses, as well as information relevant to problem-solving in the field of mineral economics.

A study estimated the potential for mineral-based construction materials as a result of the growing demand for better insulation against noise in private homes and apartments.[3] This potential was found to be substantial but fairly expensive in terms of cost per dwelling unit.

Input-output tables provide models that show the internal structure of mineral markets and that permit detailed estimates to be made of how changes in sales or purchases within one sector will affect other sectors. During the past fiscal year, several important components were completed, most of these designed for computer application. Special attention was devoted to the development of "multipliers" that permit estimation of how much a dollar of additional minerals consumption stimulates the entire economy. Work was slowed during the year by the need to adjust previously compiled minerals data to agree with the national tables for 1963. Supporting information for the input-output studies included detailed analyses of certain industries—notably coal and copper mining.[4] Studies on these industries were completed and placed on open file.

[3] Cooper, Franklin D. and Lucille M. Langlois. Economic Potential of Mineral-Based Insulating Materials in Combating the Noise Problem in Residences. BuMines Inf. Circ. 8466, 1970, 24 pp.

[4] Cooper, Franklin D. Changing Pattern in Expenditures for Supplies in the U.S. Bituminous Coal and Lignite Industry—1958 and 1963. Preparation and Cleaning. BuMines Open-File Rept. 5-70, 1970, 54 pp.

———. Changing Patterns of Expenditures for Supplies in the U.S. Copper Industry—1958 and 1963. BuMines Open-File Rept. 6–70, 1970, 90 pp.

A special staff analysis was prepared during the year, estimating the impact on regional coal production of a shift from high to low sulfur coal. The goal was both to analyze the expected impact in southeastern Ohio, an area that produces almost entirely high sulfur coal, and to develop a method with general applicability. The methodology adapted turned out to be useful and applicable, but suffered from the fact that the needed data have been collected for only about 7 years—barely enough for statistical significance.

Health and Safety Research.—Following the passage of the Federal Mine Health and Safety Act of 1969, the Bureau in 1970 enlarged by almost tenfold its support of research to develop the technology needed to minimize mining hazards and substantially reduce the absolute number of mining accidents. To reach the objective of considerably improving the safety of mines in the shortest possible time, research contracts were granted. Examples of the technology being sought include developing means for measuring and suppressing respirable dust, establishing methods for protecting miners from rockfalls, developing techniques for minimizing the probability of methane gas explosions in coal mines, and advancing the technology to provide life support to trapped miners following a mine explosion, inundation, or major ground collapse. Reduction of respirable dusts in underground mines continued to be a major inhouse health research objective. Steam and water sprays proved about equally effective in suppressing coal dust in laboratory experiments designed to simulate coal cutting at a face. Up to 75 percent airborne coal dust was collected by water spray in a dust tunnel, and a theoretical model for suppression by water spray was developed. Up to 90 percent respirable coal dust was suppressed in laboratory trials with an experimental water-based, high-expansion chemical foam. Agglomeration of electrically charged dust particles on a plastic surface also showed promise as a dust-suppression mechanism.

In the prevention of mine fires and explosions, new design criteria were prepared for explosion proof bulkheads based on extensive comparison of Bureau experimental data with British and German mine standards. Flame quenching experiments established the relative efficiency of several halogenated flame extinguishants, and various extinguishant dispersion devices were evaluated. A modified hot-wire velocity probe was developed for measuring concentrations of gaseous quenching agents, making possible measurements in tens of milliseconds as compared with tenths of seconds with the present analyzer. Mathematical models of aerodynamic disturbances in mine networks were developed and applied to studies of propagating and stationary mine fires, and to methane emission from gob areas induced by such disturbances.

Bureau research on potential hazards in the mine environment included studies of toxic halides generated by reaction of halogenated extinguishants (Halons) with methane flames, and toxic combustion products formed by smoldering and burning conveyor belts. Polarography proved an accurate, rapid method for determining oxides of nitrogen in metal and nonmetal mines. Some progress in the control of radon in uranium mining was made with the development of a device for measuring radon diffusion across barriers and by good preliminary results with a number of candidate wall sealants.

Explosives and Explosions Research.—A number of investigations involving explosives and explosion and combustion reactions were again conducted for other government agencies. For the Department of Transportation, hazard classification tests were developed for use in the safe transport of potentially explosive materials by land, air, and water. Experiments for the Department of the Army established that postcrash fires could be reduced significantly through the use of thickened (emulsified or gelled) fuels. In experiments for the Department of the Air Force, the ignition temperatures of combustible aircraft fluids determined under simulated flight conditions were found to be considerably higher than their minimum autoignition temperatures determined under static conditions. Large-scale research for the National Aeronautics and Space Administration on the behavior of commercial explosives in extraterrestrial (lunar) environments was made possible by the construction of a 1,225 ft^3 facility in which vacuums below 10^{-4} torr can be maintained.

In studies on the ignition of flammable atmospheres, evidence was obtained that there is a minimum size below which a single, irradiatively heated particle (coal, magnesium, carbon) no longer ignites a flammable environment. Computerized methods were used increasingly to attack fundamental problems relating to low-velocity detonation, shock waves in airways, and toxic fume formation by explosives.

Helium Conservation.—Helium is stored for conservation purposes to assure a future supply after depletion of more economical resources. Approximately 30 billion cubic feet of helium is in storage which otherwise would have been wasted. Bureau-produced helium in excess of current sales will continue to be stored for conservation. Research on helium properties and processes was phased out at the end of 1970.

LEGISLATION AND GOVERNMENT PROGRAMS

Of special interest to the minerals industries during the year were several pieces of legislation with direct environmental impact as well as a law establishing a national mining and minerals policy. Nineteen-seventy was the first year that the National Environmental Policy Act (Public Law 91–190) was in effect. A Council on Environmental Quality was appointed by the President to "formulate and recommend national policies to promote the improvement of the quality of the environment." An annual Environmental Quality Report to Congress is an integral part of the law. Also during the year, the Federal Water Pollution Control Act was amended, and the Resource Recovery Act (Public Law 91–512) was passed to amend the Solid Waste Disposal Act. In addition, a bill (Public Law 91–604) was passed late in 1970 to amend the Clean Air Act. One provision, probably the most well-known part of the act, requires a 90-percent reduction in carbon monoxide and hydrocarbons emissions from automobiles by January 1, 1975. Similar standards covering nitrogen oxides emissions must be met by January 1, 1976. Provision for civil suits against polluters was also incorporated into the law. In general, the act is considered to be a fairly strict environmental measure.

Late in 1970 Congress passed the Mining and Minerals Policy Act of 1970 (Public Law 91–631). Goals of this legislation include (1) the development of an economically sound domestic minerals industry; (2) the orderly development of mineral resources; (3) the use of mining, minerals, and metallurgical research (including the recycling of scrap) to promote the efficient use of resources; and (4) the study and development of methods for disposing, controlling, and reclaiming mineral waste products and the reclaiming of mined lands. The law further requires the Secretary of the Interior to include in his annual statement to Congress a report on the state of the domestic minerals industries.

An attempt was made during 1970 to enact a trade bill. The legislation as recommended by the President in 1969 included eliminating the use of the American selling price as a basis for setting certain import duties and the liberalizing of criteria for assisting employees and businesses adversely affected by imports. After much discussion, the subsequent bill included many other provision, the most controversial being a general increase in import restrictions. The trade bill, which would have been a sudden switch to protectionism by the United States, failed to pass Congress.

As of December 31, 1970, the acquisition cost of strategic materials in government inventories totaled $6.4 billion with a market value of $7.1 billion. Included in these government inventories were $2.7 billion of materials (market value) considered in excess of stockpile needs. As of June 30, 1970, over 76 percent of the market value of these excesses was accounted for by 13 commodities. These commodities included aluminum, metallurgical grade bauxite (Jamaica and Surinam), metallurgical grade chromite (upgraded forms and subspecification ores), cobalt, industrial diamond bort and stones, lead, metallurgical grade manganese, quartz crystals, rubber, tin, tungsten, and zinc. A total of $187 million of mineral commodities was disposed of in calendar year 1970, a 43-percent decline from the 1969 figure. Major mineral stockpile items sold during the year with a sales value of at least $5 million each included aluminum, chromite (chemical and metallurgical), cobalt, fluorspar (acid grade), magnesium, molybdenum, silver, tin, tungsten, vanadium, and zinc.

WORLD REVIEW

World Economy.—In 1970, persistent inflation characterized world economic conditions. In response to this situation, many foreign countries maintained high interest rates in an effort to control demand for goods and services. By yearend, however, many countries were loosening the credit reins substantially. Canada, for example, followed a fairly restrictive monetary policy early in 1970, but overall, the interest rate declined for the year. Most countries experienced moderate growth in the GNP. Preliminary estimates of GNP for Germany indicated a 12-percent advance. However, more than half the growth in GNP resulted from a rise in prices. Gross Community product for the European Economic Community (EEC) increased by 6 percent in real terms in 1970, at a slightly lower rate than that of 1969, or by 12.5 percent at current prices. GNP figures for Canada indicate a 10-percent advance at current prices. In South America, the economies of Argentina and Brazil were again hampered by inflation. The Japanese economy continued to expand with an estimated real growth of more than 11 percent for the year.

World Production.—World production of most major minerals continued to trend upward in 1970. The United Nations (UN) indexes of world mineral industry production (1963 = 100) for the extractive industries climbed 8 points to 143. In the metals category, production increases were moderate to substantial. Total output of coal edged up only 2 index points to 103 in 1970, but the United States, Canada, Australia, and New Zealand recorded more significant increases. European coal production declined from 77 to 74 index points. All major reporting areas showed increased production of crude oil and natural gas. Industrial output as measured by the UN overall production indexes rose 7 points to 157 for 1970, following a 10-point gain in 1969.

World Trade.—The value of world trade in all commodities climbed to $272.7 billion in 1969 (latest data available). This represented a 14-percent increase for the year compared with a 12-percent increase in 1968. Mineral commodities exported totaled $58.2 billion, a 12-percent gain. Once again metals accounted for the larger part of the mineral commodity trade. In 1969, $31 billion worth of metals were exported, a significant rise of 17 percent from 1968. In the metals group, ores, concentrates, scrap, and nonferrous metals increased 15 percent; iron and steel exports were up 20 percent. Nonmetals, however, advanced less than 4 percent in 1969 compared with an 8.5-percent gain in 1968. World trade in mineral fuels totaled $24.9 billion, an 8-percent increase compared with a 12-percent increase in this category in 1968. In general, increased trade was reported for metals, nonmetals, and fuels in 1969, although percentage increases for nonmetals and fuels did not match the 1968 advances.

World Prices.—The mineral commodity export price indexes (1963 = 100) registered moderate increases in fuels and crude mineral prices in 1970. Metallic ore prices, however, were up significantly. In 1970 the price index for metals climbed 8 index points to 122. The index was especially high in the first quarter of the year, but dropped 3 index points by the end of 1970. Fuel prices gradually rose from 103 index points in early 1970 to 108 at yearend. Crude mineral prices advanced to 109 for the year, a 5-point increase. Mineral prices in developed areas posted significant increases for total minerals and nonferrous base metals. For the less-developed areas, the total mineral export price indexes edged up 1 point while nonferrous base metals increased 4 points, compared with a 22-point advance in 1969.

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

(Millions)

Mineral group	1966 Production	1966 Exports [2]	1966 Imports [2]	1967 Production	1967 Exports [2]	1967 Imports [2]	1968 Production	1968 Exports [2]	1968 Imports [2]
Metals and nonmetals except fuels:									
Nonmetals	$5,176	$228	$412	r $5,200	$241	$414	$5,448	$246	$490
Metals	2,703	158	1,192	2,333	171	1,117	2,703	241	1,161
Total	7,879	386	1,604	r 7,533	412	1,531	8,151	487	1,651
Mineral fuels	15,088	490	1,311	16,195	601	1,289	16,820	539	1,309
Grand total [3]	22,968	876	2,915	r 23,729	1,013	2,820	24,971	1,026	2,960

Mineral group	1969 Production	1969 Exports r [2]	1969 Imports r [2]	1970 Production	1970 Exports [2]	1970 Imports [2]
Metals and nonmetals except fuels:						
Nonmetals	r $5,624	$222	$491	$5,711	$225	$558
Metals	r 3,332	246	1,094	3,926	322	1,252
Total [3]	r 8,956	467	1,586	9,637	547	1,810
Mineral fuels	17,965	632	1,428	20,153	1,011	1,460
Grand total	r 26,921	1,099	3,014	29,790	1,558	3,270

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	1966	1967	1968	1969	1970 p
Metals and nonmetals except fuels:					
Nonmetals	$5,320	$5,200	$5,373	$5,498	$5,555
Metals	2,801	2,333	2,574	2,964	3,051
Total	8,121	7,533	7,947	8,462	8,606
Mineral fuels	15,318	16,195	16,753	16,948	18,354
Grand total	23,439	r [2] 23,729	24,700	25,410	26,960

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 group and subgroup

(1967 = 100)

	1966	1967	1968	1969	1970 p
METALS					
Ferrous	109.2	100.0	102.4	110.9	109.3
Nonferrous:					
Base	138.4	100.0	120.4	149.6	167.3
Monetary	123.9	100.0	97.1	115.5	123.9
Other	90.4	100.0	113.9	111.0	119.5
Average	131.0	100.0	117.6	141.7	157.4
Average, all metals	121.2	100.0	110.8	127.9	135.8
NONMETALS					
Construction	103.2	100.0	104.6	106.6	106.3
Chemical	97.0	100.0	98.9	101.4	103.0
Other	105.2	100.0	106.5	107.3	109.1
Average	101.9	100.0	103.4	105.5	105.7
FUELS					
Coal	96.9	100.0	98.5	100.9	108.0
Crude oil and natural gas	94.3	100.0	104.2	110.5	108.6
Average	94.5	100.0	103.4	109.1	109.1
Average, all minerals	98.7	100.0	104.1	110.1	110.9

p Preliminary.

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

(1967 = 100)

	1966	1967	1968	1969	1970 p
Mining:					
Coal	97.2	100.0	98.2	101.1	105.7
Crude oil and natural gas:					
Crude oil	94.3	100.0	103.2	104.8	109.4
Gas and gas liquids:					
Average [1]	95.7	100.0	104.0	106.9	109.7
Average coal, oil, and gas	95.9	100.0	103.2	106.1	109.2
Metal	119.3	100.0	111.4	124.8	131.3
Stone and earth minerals	102.2	100.0	103.7	102.8	98.8
Average	109.1	100.0	106.8	111.7	112.0
Average mining	98.4	100.0	103.9	107.2	109.7
Industrial production:					
Primary metals	108.8	100.0	103.2	114.1	106.9
Iron and steel	107.5	100.0	103.6	113.0	105.3
Nonferrous metals and products	110.7	100.0	102.6	116.0	109.7
Clay, glass, and stone products	105.3	100.0	106.0	112.5	106.3
Average industrial production	98.0	100.0	105.8	110.7	106.7

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

Source: Federal Reserve System, Board of Governors. Federal Reserve Statistical Release, Aug. 16, 1971, and attached Supplement, Industrial Production and 18 Major Divisions, January 1954–March 1971, 1971 edition.

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

(1967=100)

Month	Total mining[1]		Coal, oil, and gas		Coal		Crude oil and natural gas				Metal, stone, and earth minerals		Metal mining		Stone and earth minerals	
							Total[2]		Crude oil							
	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
January	105.1	109.5	103.2	107.7	99.2	98.1	104.0	109.5	101.2	107.9	113.3	117.1	125.8	139.3	104.8	102.0
February	105.1	109.2	102.8	108.3	99.4	106.9	103.2	108.6	99.9	107.5	115.0	113.1	128.0	140.0	106.5	94.8
March	106.1	109.1	104.0	108.0	102.0	109.2	104.4	107.9	102.0	107.4	115.0	114.7	130.8	137.5	104.3	99.1
April	105.9	108.7	105.3	108.2	99.5	102.8	106.4	109.0	105.0	109.1	108.3	110.9	115.0	124.7	103.8	101.5
May	106.8	108.6	106.6	108.8	104.0	110.5	107.0	108.7	105.3	107.5	105.0	107.9	113.3	123.5	99.5	97.3
June	107.9	107.1	108.4	107.0	97.2	102.3	110.0	107.9	109.1	106.2	107.0	107.4	114.1	117.5	102.4	100.6
July	106.3	106.5	106.0	105.5	97.0	102.3	107.5	106.2	104.8	103.9	107.4	110.4	116.6	122.3	101.2	102.4
August	106.4	108.8	105.3	108.6	101.6	108.8	106.0	108.7	102.4	108.2	110.8	110.4	125.1	129.1	101.1	97.6
September	107.8	110.9	107.2	111.3	102.4	109.7	108.0	111.5	105.6	112.3	110.7	110.0	126.0	130.5	100.3	96.2
October	109.0	112.4	107.7	112.3	102.7	108.7	108.6	112.9	107.2	114.5	114.5	113.0	133.0	134.3	102.1	98.6
November	110.0	113.7	107.6	112.6	104.8	107.9	108.0	113.4	106.6	114.7	119.6	118.6	143.3	148.5	103.3	98.4
December	110.8	112.1	108.7	110.0	104.6	103.6	109.2	112.3	108.2	113.1	119.2	116.4	139.8	144.7	105.2	97.3
Average	107.2	109.7	106.1	109.2	101.1	105.7	106.9	109.7	104.8	109.4	111.7	112.0	124.8	131.3	102.8	98.8

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

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

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	
1966	329	r 13,507	r 18,984	16,925	r 2,029	r 57	r 51,831
1967	311	r 13,904	20,087	r 18,100	r 2,311	r 80	r 54,793
1968	291	r 13,664	21,548	18,593	r 2,319	r 130	r 56,545
1969	266	13,957	22,838	18,886	2,614	146	58,707
1970 p	247	15,001	24,154	19,744	2,617	231	61,994

p Preliminary. r Revised.

[1] Heat values employed for bituminous coal and lignite are 1966, 12,650 Btu per pound; 1967, 12,580 Btu; 1968, 12,530 Btu; 1969, 12,450 Btu; and 1970, 12,440 Btu.

[2] Heat values employed for crude petroleum are 1966, 5,257,440 Btu per barrel; 1967, 5,628,540 Btu; 1968, 5,585,016 Btu; 1969, 5,601,070 Btu; and 1970, 5,613,290 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 10,415 Btu per net kilowatt-hour in 1966; 10,432 Btu in 1967; 10,398 Btu in 1968; 10,447 Btu in 1969; and 10,583 Btu in 1970.

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				
1966	290	r 12,205	17,393	22,405	1,989	r 2,040	r 57	r 56,379
1967	274	r 11,982	18,250	23,191	2,144	r 2,308	r 80	r 58,229
1968	258	r 12,401	19,580	24,607	2,445	r 2,314	r 130	r 61,735
1969	224	12,509	21,020	26,029	2,392	2,625	146	64,945
1970 p	210	12,712	22,029	27,123	2,488	2,638	231	67,431
				PERCENT				
1966	0.5	21.6	30.9	39.7	3.5	3.7	0.1	100.0
1967	.5	20.6	31.3	39.8	3.7	4.0	.1	100.0
1968	.4	20.1	31.7	39.9	4.0	3.7	.2	100.0
1969	.3	19.3	32.4	40.1	3.7	4.0	.2	100.0
1970 p	.3	18.9	32.7	40.2	3.7	3.9	.3	100.0

p Preliminary. r Revised.

[1] Heat values employed are anthracite, 12,700 Btu per pound and bituminous coal and lignite, weighted average Btu provided by the Division of Fossil Fuels, Branch of Coal, 12,550 Btu per pound in 1966; 12,470 Btu per pound in 1967; 12,430 Btu per pound in 1968; 12,330 Btu per pound in 1969; and 12,290 Btu per pound in 1970. Weighted average Btu for petroleum products obtained by using 5,248,000 for gasoline and naphtha-type jet fuel; 5,670,000 for kerosine and kerosine-type jet fuel; 5,825,000 for distillate; 6,287,000 for residual; 6,064,800 for lubricants; 5,537,280 for wax; 6,636,000 for asphalt; and 5,796,000 for miscellaneous; natural gas dry, 103.2 Btu; natural gas liquids, weighted average Btu: natural gasoline and cycle products, 110,000 Btu per gallon; LP-gases, 95,000 per gallon; and ethane, 73,390 Btu per gallon. Hydropower (adjusted for net imports or net exports) and nuclear power are derived from net electricity generated, converted to theoretical energy resources inputs calculated from national average heat rates for fossil-fueled steam-electric plants provided by the Federal Power Commission, using 10,415 Btu per net kilowatt-hour in 1966; 10,432 Btu in 1967; 10,398 Btu in 1968; 10,447 Btu in 1969; and 10,583 Btu in 1970.

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					
1966	143	r 534	5,945	5,766	-----	---	r 12,388	2,101	r 14,489
1967	128	r 457	6,223	6,206	-----	---	r 13,014	2,257	r 15,271
1968	r 121	r 408	6,451	r 6,128	-----	---	r 13,108	2,467	r 15,575
1969	107	340	6,890	6,268	-----	---	13,605	2,752	16,357
1970 p	103	324	7,108	6,453	-----	---	13,988	2,921	16,909
				INDUSTRIAL					
1966	88	r 5,384	8,203	4,352	-----	---	r 18,027	1,788	r 19,815
1967	90	r 5,110	8,599	4,298	-----	---	r 18,097	1,868	r 19,965
1968	r 80	r 5,044	9,274	4,820	-----	---	r 19,218	2,044	r 21,262
1969	70	4,981	9,885	5,047	-----	---	19,983	2,155	22,138
1970 p	59	4,945	10,162	5,138	-----	---	20,304	2,289	22,593
				TRANSPORTATION [7]					
1966	NA	r 16	553	12,777	-----	---	r 13,346	16	r 13,362
1967	NA	r 13	594	13,542	-----	---	r 14,149	17	r 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 p	NA	8	744	15,716	-----	---	16,468	16	16,484
				ELECTRICITY GENERATION, UTILITIES [3]					
1966	56	r 6,271	2,692	905	r 2,040	r 57	r 12,021	3,905	------
1967	55	r 6,402	2,834	1,013	r 2,308	r 80	r 12,692	4,142	------
1968	56	r 6,938	3,245	1,181	r 2,314	r 130	r 13,864	4,529	------
1969	47	7,180	3,594	1,628	2,625	146	15,220	4,924	------
1970 p	48	7,435	4,015	2,090	2,638	231	16,457	5,226	------
				MISCELLANEOUS AND UNACCOUNTED FOR					
1966	3	------	------	594	-----	---	597	-----	------
1967	1	------	------	276	-----	---	277	-----	------
1968	1	------	------	242	-----	---	243	-----	------
1969	---	------	------	229	-----	---	229	-----	------
1970 p	---	------	------	214	-----	---	214	-----	------
				TOTAL GROSS ENERGY INPUTS					
1966	290	r 12,205	17,393	24,394	r 2,040	r 57	r 56,379	-----	------
1967	274	r 11,982	18,250	25,335	r 2,308	r 80	r 58,229	-----	------
1968	r 258	r 12,401	19,580	27,052	r 2,314	r 130	r 61,735	-----	------
1969	224	12,509	21,020	28,421	2,625	146	64,945	-----	------
1970 p	210	12,712	22,029	29,611	2,638	231	67,431	-----	------

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 10,415 Btu per net kilowatt-hour in 1966; 10,432 Btu in 1967; 10,398 Btu in 1968; 10,447 in 1969; and 10,583 Btu in 1970. Excludes inputs for power generated by nonutility 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

	1969		1970 p	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
ANTHRACITE				
Supply:				
Production [1]	10,472.9	266.0	9,729.4	247.1
Exports [2]	−1,634.0	−41.5	−1,466.5	−37.2
Imports	NA	NA	NA	NA
Stock change; withdrawals (+), additions (−)	---------	---------	---------	---------
Losses, gains, and unaccounted for	−29.9	−.8	−14.9	−.4
Total	8,809.0	223.7	8,248.0	209.5
Demand by major consuming sectors: [3]				
Household and commercial [4]	4,209.0	106.9	4,042.0	102.7
Industrial [5]	2,751.0	69.9	2,309.0	58.6
Transportation [6]	(7)	(7)	(7)	(7)
Electric generation, utilities	1,849.0	46.9	1,897.0	48.2
Miscellaneous and unaccounted for	---------	---------	---------	-------
Total	8,809.0	223.7	8,248.0	209.5
BITUMINOUS COAL AND LIGNITE				
Supply:				
Production [1]	560,505.0	13,956.6	602,932.0	15,000.9
Exports	−56,234.0	−1,522.0	−70,908.0	−1,920.0
Imports	109.0	2.8	36.0	.9
Stock change; withdrawals (+), additions (−)	5,496.0	136.7	−11,777.0	−292.5
Losses, gains, and unaccounted for	−2,601.0	−64.7	−3,125.0	−77.6
Total	507,275.0	12,509.4	517,158.0	12,711.7
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial [4]	12,666.0	339.5	12,072.0	323.9
Industrial [5]	180,149.0	4,828.7	178,718.0	4,794.6
Coal carbonized for coke [8]	(92,901.0)	(2,490.1)	(96,009.0)	(2,575.7)
Transportation [6]	313.0	8.4	298.0	8.0
Electricity generation, utilities	308,461.0	7,180.4	320,460.0	7,434.7
Total	501,589.0	12,357.0	511,548.0	12,561.2
Raw material: Industrial [9]				
Crude light tar	1,284.7	34.4	1,220.0	32.7
Crude coal tar	4,401.3	118.0	4,390.0	117.8
Total	5,686.0	152.4	5,610.0	150.5
Grand total	507,275.0	12,509.4	517,158.0	12,711.7

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 British thermal unit of value of raw materials for coal chemicals.

Table 10.—Domestic supply and demand for natural gas

	1969		1970 p	
	Million cubic feet	Trillion Btu	Million cubic feet	Trillion Btu
Supply:				
Production [1]	20,698,240	22,838.1	21,920,642	24,153.5
Exports	−51,304	−52.9	−69,813	−72.0
Imports	726,951	749.5	820,780	846.2
Stock change; withdrawals (+), additions (−)	−119,500	−123.2	−398,160	−410.5
Transfers out, extraction loss [2]	−866,560	−2,391.7	−906,413	−2,487.8
Losses, gains, and unaccounted for	----------	--------	----------	--------
Total	20,387,827	21,019.8	21,367,036	22,029.4
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	6,682,804	6,890.0	6,894,007	7,107.7
Industrial [3]	8,895,419	9,171.2	9,190,960	9,475.9
Transportation	630,962	650.5	722,166	744.6
Electricity generation, utilities	3,486,391	3,594.4	3,894,019	4,014.7
Total	19,695,576	20,306.1	20,701,152	21,342.9
Raw material: Industrial [4]				
Carbon black	98,251	101.3	85,884	88.5
Other chemicals [5]	594,000	612.4	580,000	598.0
Total	692,251	713.7	665,884	686.5
Grand total	20,387,827	21,019.8	21,367,036	22,029.4

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. Btu 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 331,587 million cubic feet in 1969 and 227,650 million cubic feet in 1970.

[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]

	1969		1970 P	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu
Supply:				
Crude oil: [2]				
Production	3,371.8	18,885.7	3,517.4	19,744.2
Exports	−1.4	−7.8	−5.0	−28.1
Imports	[3] 514.1	2,879.5	[3] 483.3	2,712.9
Stock change; withdrawals (+), additions (−)	7.0	39.2	−11.1	−62.3
Losses and transfers for use as crude	−11.9	−66.7	−17.1	−95.0
Total	3,879.6	21,729.9	3,967.5	22,271.7
Petroleum input runs to stills:				
Crude oil [2]	3,879.6	21,729.9	3,967.5	22,271.7
Transfers in, natural gas liquids [4]	264.6	1,176.8	278.3	1,237.0
Other hydrocarbons	4.2	23.2	6.2	34.3
Total	4,148.4	22,929.9	4,252.0	23,543.0
Output:				
Refined products	4,148.4	22,929.9	4,252.0	23,543.0
Unfinished oils, net	34.3	215.6	38.1	239.5
Overage or loss	122.4	713.4	131.1	761.1
Total	4,305.1	23,858.9	4,421.2	24,543.6
Exports	−83.4	−473.5	−89.5	−519.1
Imports	641.4	3,924.6	764.1	4,663.8
Stock change, including natural gas liquids	12.5	68.8	−26.5	−146.3
Transfers in, natural gas liquids [4 5]	315.6	1,214.9	327.6	1,250.8
Losses, gains, and unaccounted for	−31.3	−172.4	−32.9	−181.6
Total	5,159.9	28,421.3	5,364.0	29,611.2
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	947.6	5,259.6	965.3	5,370.8
Industrial	541.9	3,220.2	546.5	3,251.6
Transportation [6]	2,815.8	15,124.6	2,902.1	15,588.1
Electricity generation, utilities	259.8	1,627.8	333.8	2,090.7
Other, not specified	24.5	137.7	23.8	132.2
Total	4,589.6	25,369.9	4,771.5	26,433.4
Raw materials: [7]				
Petrochemical feedstock offtake	291.0	1,307.6	303.9	1,371.5
Other nonfuel use	262.7	1,652.4	273.7	1,724.1
Total	553.7	2,960.0	577.6	3,095.6
Miscellaneous and unaccounted for	16.6	91.4	14.9	82.2
Total	5,159.9	28,421.3	5,364.0	29,611.2

P Preliminary.
[1] Supply and demand for crude oil and petroleum products. Petroleum products include products refined and processed from crude oil, including still gas and LRG; also natural gas liquids transferred from natural gas.
[2] Btu value for crude oil for each year shown is based on average Btu value of total output of petroleum products (including refinery fuel and losses) adjusted to exclude natural gas liquids inputs and their implicitly derived values. Value for 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 products and by major consuming sectors[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
1969												
Fuel and power:												
Liquefied gases	182.3	731.2	27.5	110.3	34.9	140.0	------	------	4.6	18.4	249.3	999.9
Jet fuels:												
Naphtha type	------	------	------	------	108.5	581.0	------	------	------	------	108.5	581.0
Kerosine type	------	------	------	------	253.2	1,435.6	------	------	------	------	253.2	1,435.6
Total	------	------	------	------	361.7	2,016.6	------	------	------	------	361.7	2,016.6
Gasoline	------	------	------	------	2,042.5	10,719.0	------	------	------	------	2,042.5	10,719.0
Kerosine	75.4	427.5	24.8	140.6	------	------	------	------	.2	1.2	100.4	569.3
Distillate fuel	511.8	2,981.2	105.8	616.3	258.1	1,503.4	12.2	71.1	12.4	72.2	900.3	5,244.2
Residual fuel	178.1	1,119.7	170.3	1,070.7	118.6	745.6	247.6	1,556.7	7.3	45.9	721.9	4,538.6
Still gas	------	------	160.4	962.4	------	------	------	------	------	------	160.4	962.4
Petroleum coke	------	------	53.1	319.9	------	------	------	------	------	------	53.1	319.9
Total	947.6	5,259.6	541.9	3,220.2	2,815.8	15,124.6	259.8	1,627.8	24.5	137.7	4,589.6	25,369.9
Raw materials:[3]												
Special naphthas	------	------	29.6	155.3	------	------	------	------	------	------	29.6	155.3
Lubes[4] and waxes	------	------	32.8	196.6	20.6	124.9	------	------	------	------	53.4	321.5
Petroleum coke[5]	------	------	27.7	166.9	------	------	------	------	------	------	27.7	166.9
Asphalt and road oil	152.0	1,008.7	------	------	------	------	------	------	------	------	152.0	1,008.7
Petrochemical feedstock offtake:												
Liquefied refinery gas	------	------	44.7	179.3	------	------	------	------	------	------	44.7	179.3
Liquefied petroleum gas[6]	------	------	151.6	608.1	------	------	------	------	------	------	151.6	608.1
Naphtha (−400 degrees)	------	------	57.6	302.3	------	------	------	------	------	------	57.6	302.3
Still gas	------	------	10.0	60.0	------	------	------	------	------	------	10.0	60.0
Miscellaneous (+400 degrees)	------	------	27.1	157.9	------	------	------	------	------	------	27.1	157.9
Total	152.0	1,008.7	381.1	1,826.4	20.6	124.9	------	------	------	------	553.7	2,960.0
Miscellaneous and unaccounted for	------	------	------	------	------	------	------	------	16.6	91.4	16.6	91.4
Total domestic product demand	1,099.6	6,268.3	923.0	5,046.6	2,836.4	15,249.5	259.8	1,627.8	41.1	229.1	5,159.9	28,421.3

See footnotes at end of table.

Table 12.—Petroleum consumption, by major products and by major consuming sectors [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
1970 p												
Fuel and power:												
Liquefied gases	180.2	722.8	27.0	108.3	31.8	127.5	-------	-------	5.4	21.7	244.4	980.3
Jet fuels:												
Naphtha type	-------	-------	-------	-------	90.9	486.8	-------	-------	-------	-------	90.9	486.8
Kerosine type	-------	-------	-------	-------	261.4	1,482.1	-------	-------	-------	-------	261.4	1,482.1
Total	-------	-------	-------	-------	352.3	1,968.9	-------	-------	-------	-------	352.3	1,968.9
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	17.1	99.6	11.1	64.6	927.3	5,401.5
Residual fuel	186.6	1,173.1	176.6	1,110.3	117.1	736.2	316.7	1,991.1	7.3	45.9	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	2,902.1	15,588.1	333.8	2,090.7	23.8	132.2	4,771.5	26,433.4
Raw materials: [3]												
Special naphthas	-------	-------	31.2	163.7	-------	-------	-------	-------	-------	-------	31.2	163.7
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	-------	-------	41.2	165.3	-------	-------	-------	-------	-------	-------	41.2	165.3
Liquefied petroleum gas [6]	-------	-------	161.6	648.2	-------	-------	-------	-------	-------	-------	161.6	648.2
Naphtha (−400 degrees)	-------	-------	57.3	300.7	-------	-------	-------	-------	-------	-------	57.3	300.7
Still gas	-------	-------	12.6	75.6	-------	-------	-------	-------	-------	-------	12.6	75.6
Miscellaneous (+400 degrees)	-------	-------	31.2	181.7	-------	-------	-------	-------	-------	-------	31.2	181.7
Total	163.1	1,082.3	393.5	1,885.9	21.0	127.4	-------	-------	-------	-------	577.6	3,095.6
Miscellaneous and unaccounted for	-------	-------	-------	-------	-------	-------	-------	-------	14.9	82.2	14.9	82.2
Total domestic product demand	1,128.4	6,453.1	940.0	5,137.5	2,923.1	15,715.5	333.8	2,090.7	38.7	214.4	5,364.0	29,611.2

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

Table 13.—Net supply of principal minerals, by components [1]

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

Commodity and mineral content measured	Total net supply		Percent change	Components as percent of total, before subtracting exports						Exports as percent of gross supply	
				Primary shipments		Old scrap		Imports			
	1969	1970		1969	1970	1969	1970	1969	1970	1969	1970
FERROUS METALS											
Iron ore ... thousand long tons	125,427	126,561	+1	69	66	-------	-------	31	34	4	4
Pig iron	95,833	92,131	−4	100	100	-------	-------	(2)	(2)	(2)	(2)
Steel ingot	149,766	138,000	−8	91	90	-------	-------	9	10	4	5
Chromite (Cr_2O_3)	457	606	+33	-------	-------	-------	-------	100	100	10	6
Cobalt	12	12	-------	58	52	-------	-------	42	48	12	8
Manganese	966	831	−14	1	1	-------	-------	99	99	2	2
Molybdenum	23	27	+17	100	100	-------	-------	(2)	(2)	56	51
Nickel	129	163	+26	10	8	11	12	79	80	21	16
Tungsten	20	2	−90	97	95	-------	-------	3	5	15	80
OTHER METALS											
Aluminum	3,952	3,881	−2	84	86	4	4	12	10	13	14
Antimony	39	38	−3	2	3	54	48	44	49	1	1
Beryl ore (BeO)	W	W	W	W	W	-------	-------	W	W	W	W
Cadmium	6	4	−33	92	73	-------	-------	8	27	8	4
Copper	2,496	2,578	+3	62	65	23	19	15	16	(2)	3
Lead	1,421	1,358	−4	36	42	36	37	28	21	1	1
Magnesium	119	87	−27	97	98	10	-------	3	2	21	28
Mercury ... 76-pound flasks	74,707	52,510	−30	39	48	18	14	43	38	1	8
Platinum group ... thousand troy ounces	1,114	1,382	+24	1	1	23	19	76	79	31	23
Tin ... thousand long tons	70	69	−1	(2)	NA	29	26	70	74	10	9
Titanium concentrate (TiO_2):											
Ilmenite and slag	586	713	+22	81	68	-------	-------	19	47	1	1
Rutile	205	243	+19	-------	-------	-------	-------	100	100	-------	-------
Uranium concentrate (U_3O_8)	13	14	+8	88	95	-------	-------	12	5	-------	-------
Zinc	1,542	1,353	−12	36	39	6	7	58	53	1	(2)
NONMETALS											
Asbestos	786	736	−6	15	16	-------	-------	85	84	4	5
Barite, crude	1,691	1,560	−8	64	55	-------	-------	36	45	-------	-------
Bromine	168	175	+4	100	100	-------	-------	-------	-------	-------	-------
Clays	57,202	52,864	−8	100	100	-------	-------	(2)	(2)	3	4
Fluorspar, finished	1,329	1,347	+1	14	20	-------	-------	86	80	(2)	11
Gypsum	25,049	23,974	−4	77	75	-------	-------	23	26	(2)	(2)
Mica (except scrap)	124	112	−10	96	95	-------	-------	4	5	5	7
Phosphate rock (P_2O_5)	8,139	8,606	+6	99	99	-------	-------	1	1	31	29
Potash (K_2O equivalent)	4,700	4,709	(2)	57	51	-------	-------	43	49	13	11
Salt, common	46,831	48,917	+4	93	93	-------	-------	7	7	2	1
Sand and gravel ... million tons	936	944	+1	100	100	-------	-------	(2)	(2)	(2)	(2)
Stone, crushed ... do	859	871	+1	100	100	-------	-------	NA	NA	(2)	(2)
Sulfur, all forms ... thousand long tons	9,784	9,783	(2)	84	85	-------	-------	16	15	14	13
Talc and allied minerals	980	953	−3	98	97	-------	-------	2	3	7	10

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

[1] Net supply is the 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]
1966	$45,651	$23,707	$21,944	$46,879	$24,285	$22,594	$6,909	$3,305	$3,604
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	r 57,137	26,493	r 30,644	58,491	r 27,281	r 31,210	r 7,657	r 3,896	r 3,761
1970	57,022	25,837	31,185	56,289	25,793	30,496	6,914	3,851	3,063
1970:									
January	4,931	2,365	2,566	4,658	1,963	2,695	7,235	3,446	3,789
February	4,957	2,213	2,744	4,309	1,813	2,496	6,805	3,125	3,680
March	4,994	2,229	2,765	4,547	1,948	2,599	6,660	3,036	3,624
April	4,724	1,960	2,764	4,739	2,036	2,703	6,973	3,292	3,681
May	5,071	2,292	2,779	4,874	2,234	2,640	7,061	3,427	3,634
June	5,205	2,386	2,819	4,932	2,302	2,630	7,159	3,527	3,632
July	4,440	2,114	2,326	4,894	2,387	2,507	7,162	3,656	3,506
August	4,701	2,205	2,496	4,842	2,310	2,532	7,066	3,678	3,388
September	4,955	2,311	2,644	4,709	2,253	2,456	6,726	3,509	3,217
October	4,509	1,960	2,549	4,348	1,977	2,371	6,481	3,417	3,064
November	4,266	1,844	2,422	4,544	2,057	2,487	6,573	3,465	3,108
December	4,269	1,958	2,311	4,962	2,586	2,376	6,914	3,851	3,063

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. 47–51, No. 3, March 1967–71, 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: Total	Metals: Iron ore	Metals: Other ferrous	Metals: Nonferrous	Nonmetals [1]
1966	100	88	94	35	99	115
1967	100	100	100	100	100	100
1968	121	120	123	119	100	123
1969	118	104	106	83	107	136
1970 p	131	113	118	93	106	154

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: Total	Metals: Iron	Metals: Other ferrous	Metals: Base nonferrous	Metals: Other nonferrous	Nonmetals [1]
1966	102	102	101	81	112	93	98
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 p	108	108	93	140	128	92	99

p Preliminary.
1 Excludes fuels.

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

(Producers' stocks, unless otherwise indicated)

Fuels	1966	1967	1968	1969	1970 p
Coal and related products: [1]					
Bituminous coal and lignite [2] short tons	76,808,024	95,408,000	85,525,000	80,482,000	92,275,000
Coke do	3,078,768	5,467,532	5,985,025	3,120,000	4,113,000
Petroleum and related products:					
Carbon black thousand pounds	233,145	264,247	224,170	208,020	296,087
Crude petroleum and petroleum products thousand barrels	881,105	944,111	999,572	980,123	1,017,861
Crude petroleum do	238,391	248,970	272,193	265,227	276,367
Natural gas liquids do	40,423	(3)	(3)	(3)	(3)
Natural gasoline, plant condensate, and isopentane thousand barrels	(4)	5,782	5,466	5,704	7,046
Gasoline do	194,177	207,980	211,526	217,392	214,348
Special naphthas do	5,583	5,748	5,829	6,292	6,193
Liquefied gases do	(4)	[5] 64,165	[5] 76,160	[5] 59,602	[5] 67,043
Distillate fuel oil do	158,076	159,703	173,158	171,714	195,271
Residual fuel oil do	63,856	65,597	67,359	58,395	53,994
Petroleum asphalt do	17,309	19,939	20,055	16,753	15,779
Other products do	163,290	166,227	167,826	173,340	174,774
Natural gas [6] billion cubic feet	2,506	2,648	2,746	2,852	3,207

p Preliminary.
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 Prior to 1967, included in natural gas liquids.
5 Includes ethane.
6 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, and glass products	Primary metals: Blast furnace and steel mills	Primary metals: Other primary metals [1]	Primary metals: Total
1966: December	$1,869	$1,746	$4,043	$3,066	$7,109
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
January	2,313	2,492	4,265	3,849	8,114
February	2,328	2,527	4,251	3,873	8,124
March	2,345	2,535	4,358	3,896	8,254
April	2,374	2,574	4,571	3,973	8,544
May	2,414	2,573	4,589	4,020	8,609
June	2,446	2,558	4,608	3,990	8,598
July	2,380	2,587	4,658	3,983	8,641
August	2,422	2,626	4,726	4,012	8,738
September	2,417	2,658	4,669	4,065	8,734
October	2,461	2,684	4,747	4,119	8,866
November	2,555	2,688	4,823	4,160	8,983

[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. 47–51, No. 3, March 1967–71, pp. S–5, S–6.

Table 19.—Value of selected minerals and mineral products imported and exported by the United States in 1970, by commodity groups and commodities [1]

(Thousands)

SITC code [2]	Commodity	Exports	Imports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	$92,121	$8,743
273	Stone, sand and gravel	15,483	27,922
274	Sulfur and unroasted iron pyrites	33,166	34,811
275	Natural abrasives (including industrial diamonds)	36,539	50,747
276	Other crude minerals	141,778	162,655
	Total	[3] 319,088	284,878
	Metals (crude and scrap):		
281	Iron ores and concentrates	67,899	479,380
282	Iron and steel scrap	447,368	13,551
283	Ores and concentrates of nonferrous base metals	234,527	536,231
284	Nonferrous metal scrap	163,474	51,408
285	Platinum and platinum-group metal ores and concentrates	24,683	18,985
286	Uranium and thorium ores and concentrates	288	427
	Total	938,239	[3] 1,099,983
	Mineral energy resources and related products:		
321	Coal, coke, and briquets (including peat)	1,044,069	17,583
331	Petroleum, crude and partly refined	18,450	1,425,583
332	Petroleum products, except chemicals	468,867	1,307,798
341	Gas, natural and manufactured	62,702	293,182
	Total	1,594,088	3,044,146
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, and halogen salts	286,708	306,785
514	Other inorganic chemicals	141,366	63,518
515	Radioactive and associated materials except uranium and thorium	144,798	32,179
521	Mineral tar, crude chemicals from coal, petroleum, and natural gas	49,794	8,387
	Total	622,666	410,869
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, and fabricated building materials, except glass and clay	15,107	68,579
662	Clay and refractory construction materials	70,241	37,071
663	Mineral manufactures, not elsewhere specified	79,085	30,116
	Total	164,433	135,766
	Metals (manufactured):		
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot, and ferroalloys	80,527	76,332
672	Iron or steel ingots and other primary forms	322,273	30,041
673	Iron or steel bars, rods, angles, shapes, and sections	117,310	485,736
674	Iron or steel universals, plates, or sheets	335,218	908,123
675	Iron or steel hoops and strips	73,296	46,550
676	Iron or steel rails and railway track construction materials	15,866	4,312
677	Iron or steel wire (excluding wire rod)	13,490	118,919
678	Iron or steel tubes, pipes, and fittings	225,653	349,818
679	Iron or steel castings or forgings, unworked	86,471	11,042
681	Silver, platinum, and platinum-group metals	71,333	151,065
682	Copper and copper alloys	357,941	528,617
683	Nickel and nickel alloys	66,631	316,906
684	Aluminum and aluminum alloys	358,331	238,069
685	Lead and lead alloys	4,757	74,543
686	Zinc and zinc alloys	6,922	77,807
687	Tin and tin alloys	16,425	190,380
688	Uranium and thorium metals and alloys	86	---------
689	Miscellaneous nonferrous base metals	81,448	72,580
	Total	2,233,978	[3] 3,680,841
	Grand total	5,872,492	8,656,483

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

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports General and Consumption. FT 135, December 1970, table 1. U.S. Exports, Commodity and Country. FT 410, December 1970, table 1.

Table 20.—Percentage distribution of exports of selected minerals and mineral fuels and related products by area of destination, 1970

SITC code [1]	Commodity	North America [2]	South America	Europe	Asia	Africa	Oceania	Soviet bloc [3]	Undesignated areas [4]
271	Fertilizers, crude	28	6	34	31	----	(5)	1	(5)
273	Stone, sand and gravel	75	5	10	4	(5)	1	----	(5)
274	Sulfur and unroasted iron pyrites	8	18	63	2	1	8	----	(5)
275	Natural abrasives, including industrial diamonds	13	3	48	29	3	3	(5)	1
276	Crude minerals, not elsewhere classified	30	5	44	15	1	4	(5)	1
281	Iron ore and concentrates	40	----	4	55	(5)	(5)	----	(5)
282	Iron and steel scrap	13	2	26	59	(5)	(5)	(5)	(5)
283	Ores and concentrates of nonferrous base metal	6	1	55	31	(5)	1	6	(5)
284	Nonferrous metal scrap	9	(5)	60	30	(5)	(5)	1	(5)
286	Uranium and thorium ores and concentrates	98	----	----	----	----	----	----	2
321	Coke, coal, and briquets, including peat	22	6	30	39	(5)	(5)	3	(5)
331	Petroleum, crude and partly refined	87	----	8	5	----	----	----	(5)
332	Petroleum products, except chemicals	22	10	31	29	4	3	(5)	1
341	Gas, natural and manufactured	53	1	6	40	(5)	(5)	----	(5)
513	Inorganic chemical elements, oxides, and halogen salts	35	10	29	10	5	3	7	1
514	Other inorganic chemicals	32	14	28	17	2	4	1	2
515	Radioactive and associated materials	28	(5)	56	16	(5)	(5)	----	(5)
521	Mineral tar and crude chemicals from coal, petroleum, and natural gas	10	7	71	10	1	(5)	(5)	1
661	Lime, cement, and fabricated building materials except glass and clay	46	2	31	9	1	6	----	5
662	Clay and refractory construction materials	49	11	23	9	3	2	(5)	3
663	Mineral manufactures, not elsewhere specified	38	7	33	11	3	4	(5)	4
671	Pig iron, sponge iron, iron or steel powders and shot, and ferroalloys	16	8	48	21	(5)	2	5	(5)
672	Iron and steel ingots and other primary forms	14	14	64	6	2	(5)	----	(5)
673	Iron and steel bars, rods, angles, shapes, and sections	44	7	23	20	4	1	(5)	1
674	Iron and steel plates and sheets	17	11	39	26	2	1	3	1
675	Iron and steel hoop and strip	24	9	56	8	1	1	(5)	1
676	Iron and steel rails and railway track construction material	28	46	2	9	13	1	----	1
677	Iron and steel wire (except insulated electric)	44	5	16	26	2	3	----	4
678	Iron and steel tubes, pipes, and fittings	39	16	13	17	11	2	(5)	2
679	Iron and steel castings and forgings (rough)	74	4	13	7	1	(5)	(5)	1
681	Silver, platinum, and platinum-group metals	3	1	75	21	(5)	(5)	----	(5)
682	Copper and copper alloys	10	12	58	14	(5)	(5)	6	(5)
683	Nickel and nickel alloys	20	6	57	14	1	1	----	1
684	Aluminum and aluminum alloys	22	10	42	20	3	1	2	(5)
685	Lead and lead alloys	24	8	45	15	1	----	----	7
686	Zinc and zinc alloys	39	6	39	11	(5)	(5)	----	5
687	Tin and tin alloys	10	2	10	77	----	----	----	1
688	Uranium and thorium and their alloys	20	----	----	69	----	----	----	11
689	Base metals and alloys, not elsewhere classified	16	5	62	14	1	1	(5)	1

[1] Standard Industrial Trade Classification.
[2] Includes Trinidad and Netherlands Antilles.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, mainland 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. FT410, December 1970, table 2.

Table 21.—Percentage distribution of imports of principal minerals and mineral fuels and related products by area of origin, 1970

SITC code [1]	Commodity	North America	South America	Europe	Asia	Africa	Oceania	Soviet bloc [2]
2713000	Phosphates, crude and apatite	99	--	1	--	--	--	--
2732100	Gypsum	99	([3])	1	([3])	--	--	--
2743000	Sulfur	100	--	([3])	--	--	--	--
2752400	Natural abrasives	2	([3])	98	([3])	([3])	([3])	([3])
2762220	Graphite, natural	34	--	31	14	21	--	--
2762500	Magnesia, refractory and caustic calcined, and crude magnesite	2	--	77	7	--	1	13
2763000	Salt	84	11	1	--	3	--	1
2764000	Asbestos	93	--	([3])	([3])	7	--	([3])
2765200	Mica, including scrap	([3])	29	2	60	9	--	--
2765420	Fluorspar	69	1	29	--	1	--	--
2769300	Barite, crude	30	25	40	([3])	5	--	--
2769500	Talc	9	--	72	19	--	--	--
2810000	Iron ore and concentrates	62	32	([3])	([3])	4	2	--
2820000	Iron and steel scrap	99	--	1	([3])	([3])	--	--
2831100	Copper ores and concentrates	20	28	([3])	50	--	2	([3])
2833000	Bauxite	72	28	([3])	--	([3])	--	--
2834000	Lead ores and concentrates	57	25	([3])	--	([3])	18	--
2835000	Zinc ores and concentrates	83	13	2	([3])	1	1	--
2836000	Tin ores and concentrates	--	100	--	--	--	--	--
2837000	Manganese ores and concentrates	3	34	2	4	53	4	--
2839100	Chrome ores	--	--	23	19	15	--	43
2839200	Tungsten ores and concentrates	95	5	--	--	--	--	--
2839310	Tantalum, molybdenum, and vanadium ores and concentrates	51	22	7	1	18	1	--
2839320, 2839330	Titanium ores and concentrates	2	--	--	--	7	91	--
2839340	Zirconium ore	3	--	5	--	4	88	--
2839910	Antimony ores and needles	18	36	([3])	([3])	46	--	--
2839920	Beryllium ores and concentrates	--	79	1	--	18	2	([3])
2839930	Columbium ores and concentrates	15	56	6	3	20	--	--
2840200	Copper waste and scrap	92	2	6	--	--	--	--
2840300	Nickel waste and scrap	80	--	20	([3])	--	([3])	--
2840400	Aluminum waste and scrap	82	--	15	1	--	--	2
2840500	Magnesium waste and scrap	41	--	40	10	7	2	--
2840600	Lead waste and scrap	97	--	3	--	--	--	--
2840700	Zinc waste and scrap	100	--	([3])	--	--	--	--
2840900	Tin waste and scrap	92	--	--	2	--	6	--
2850140, 2850240	Platinum-group metals, ores, concentrates, and waste	28	4	29	23	7	9	--
2860000	Thorium ores and concentrates	--	--	--	41	--	59	--
3214000, 3218000, 3219000	Coal, coke, and briquetes	81	--	19	([3])	--	--	--
3310000	Petroleum, crude and partly refined	52	28	1	12	7	([3])	--
3320000	Petroleum products, except chemicals	47	42	9	1	([3])	([3])	1
3410000	Gases, natural and manufactured	98	1	([3])	([3])	1	--	--
5132500	Mercury, including waste and scrap	83	([3])	17	--	--	--	--
5136500	Alumina	37	14	4	3	--	42	--
5210000	Mineral tar and crude chemicals from coal, petroleum, and natural gas	14	--	82	2	--	--	2
5613000	Potassic fertilizers and fertilizer materials	94	--	3	2	1	--	--

[1] Standard International Trade Classification.
[2] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, mainland 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, FT135, December 1970, table 2.

Table 22.—Consumption of major mineral products, mineral fuels, and electricity, 1969, 1970, and projections

Commodity	1969	1970 p	Projections [1]	Average annual growth rate, 1947–65 (percent)
MINERAL PRODUCTS				
Ferrous metals:				
Iron ore ... thousand long tons	140,235	135,000	240,000–330,000	+0.8
Raw steel (production) ... thousand short tons	141,262	131,514	NA	+1.5
Chromite ores (gross weight):			3,150–4,700	
Metallurgical grade ... do	898	912	NA	+4.0
Refractory grade ... do	302	278	NA	+.8
Chemical grade ... do	211	213	NA	+2.0
Manganese ore (35 percent or more Mn) ... do	2,181	2,364	3,400–4,300	+1.9
Molybdenum (Mo content) ... thousand pounds	51,622	45,337	150,500–206,500	[2] +5.2
Tungsten (W content) ... do	13,053	16,700	60,000–93,000	+3.6
Nonferrous metals:				
Aluminum (apparent consumption) ... thousand short tons	4,710	4,519	22,400–44,400	+7.4
Antimony, primary ... short tons	17,843	13,937	28,000–52,000	−1.5
Copper, refined ... thousand short tons	2,142	2,043	8,950–14,350	+1.0
Lead, primary and secondary ... do	1,389	1,361	2,520–4,140	.0
Zinc, all classes ... do	1,814	1,572	2,460–4,700	+1.3
Mercury, primary ... 76-pound flasks	77,372	61,503	120,000–180,000	+3.4
Platinum-group metals ... thousand troy ounces	1,357	1,335	2,315–4,195	+6.9
Silver (industrial consumption) ... do	141,544	128,404	280,000–560,000	NA
Ilmenite and titanium slag (estimated TiO_2 content) ... short tons	639,915	608,895	1,800,000–4,300,000	+4.8
Uranium (U_3O_8 content, production) ... do	11,610	12,900	72,000–81,000	+4.9
Nonmetals:				
Asbestos (apparent consumption) ... thousand short tons	784	728	1,285–1,865	+.8
Cement (production) ... million barrels	408	395	NA	+3.7
Clays (apparent consumption) ... thousand short tons	58,694	54,853	136,500–203,500	+2.1
Lime (sold or used) ... do	20,209	19,747	NA	+5.3
Phosphate rock (P_2O_5 content, apparent consumption) ... do	11,432	11,799	20,165–35,520	+4.9
Potash (K_2O content, apparent consumption) ... do	4,700	4,709	10,240–18,675	+6.4
Salt (apparent consumption) ... do	46,831	48,917	NA	+4.6
Sand and gravel ... million short tons	937	944	3,153–3,990	[3] +4.2
Stone, crushed (sold or used) ... do	861	873	2,460–4,025	+8.1
Sulfur, all forms (apparent consumption) ... thousand long tons	9,171	9,132	23,000–37,000	+3.0
MINERAL ENERGY RESOURCES AND ELECTRICITY				
Bituminous coal ... million short tons	507	517	1,275–2,639	−1.1
Coal carbonized for coke [4] ... do	(93)	(96)	(62)	(−.6)
Anthracite ... do	9	8	1–4	−7.1
Petroleum products and natural gas liquids ... million barrels	5,160	5,364	7,343–16,412	+4.3
Natural gas, dry [5] ... billion cubic feet	20,388	21,367	34,800–55,700	+7.3
Electricity generation, net ... million kilowatt-hours	1,552,757	1,638,010	NA	+7.6
Utilities ... do	1,442,182	1,529,581	[6] 9,036,400	+8.2
Hydropower [7] ... do	251,264	249,288	[6] 632,000	+1.9
Nuclear power ... do	13,928	21,801	[6] 5,491,000	[8] +54.0
Conventional fuel-burning plants ... do	1,181,338	1,260,453	2,961,000	+9.2
Industrial ... do	110,575	108,429	NA	+3.9
Total energy resources inputs ... trillion Btu	64,945	67,431	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. BuMines Inf. Cir. 8384, 1968, 127 pp.
[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
	1966			1967		
New England	40,184	13,883	24,877	43,361	15,437	26,496
Middle Atlantic	156,302	42,088	104,153	164,125	45,410	108,184
East North-Central	207,521	57,005	142,858	219,554	61,238	149,630
West North-Central	66,030	25,303	38,579	71,481	27,138	41,950
South Atlantic	148,757	50,920	92,723	161,567	55,692	99,916
East South-Central	112,594	29,589	81,463	115,851	31,166	83,027
West South-Central	102,760	29,753	68,071	113,125	32,739	74,872
Mountain	47,198	12,313	33,100	49,342	13,157	33,774
Pacific	154,302	44,502	103,093	164,998	48,210	108,502
Alaska and Hawaii	3,334	1,216	2,038	3,619	1,338	2,184
Total United States	1,038,982	306,572	690,955	1,107,023	331,525	728,535
	1968			1969		
New England	47,386	16,970	28,946	51,373	18,789	31,040
Middle Atlantic	176,158	49,854	115,301	190,582	54,405	124,633
East North-Central	238,138	67,080	161,679	256,212	73,409	172,953
West North-Central	77,624	29,644	45,375	84,125	32,436	48,909
South Atlantic	180,463	63,790	109,589	199,257	72,253	118,360
East South-Central	122,608	36,033	84,770	129,601	39,331	88,308
West South-Central	126,160	37,070	83,202	141,610	43,068	92,037
Mountain	53,157	14,164	36,513	59,067	15,700	40,638
Pacific	176,682	51,640	116,230	190,979	56,940	124,373
Alaska and Hawaii	3,945	1,447	2,380	4,372	1,591	2,655
Total United States	1,202,321	367,692	783,985	1,307,178	407,922	843,906

Source: Edison Electric Institute. Statistical Yearbook of the Electrical Utility Industry. 1966 through 1969.

Table 24.—Total employment in selected mineral industries

(Thousands)

	1966	1967	1968	1969	1970
MINING					
Metals:					
Iron	26.3	27.5	25.7	25.4	26.2
Copper	31.7	23.8	30.3	37.2	37.0
Total [1]	86.5	79.1	84.2	92.2	94.8
Nonmetal mining and quarrying	120.8	120.9	121.8	118.2	116.0
Fuels:					
Bituminous	129.9	135.0	132.9	129.8	138.8
Other coal	7.8	7.0	6.2	6.3	5.6
Crude petroleum and natural gas fields	152.4	149.8	148.1	144.3	141.7
Oil and gas field services	127.4	120.7	131.7	137.3	125.2
Total	417.5	412.5	418.9	417.7	411.3
Total mining	624.8	612.5	624.9	628.1	622.1
MANUFACTURING					
Minerals:					
Fertilizers, complete and mixing only	40.7	40.6	39.1	38.4	40.5
Cement, hydraulic	38.0	36.5	35.6	35.1	34.1
Blast furnaces, steelworks, and rolling mills	571.3	553.1	553.4	563.5	549.6
Nonferrous smelting and refining	78.1	75.5	79.7	87.8	86.3
Total	728.1	705.7	707.8	724.8	710.5
Fuels:					
Petroleum refining	149.6	152.8	150.5	146.3	153.4
Other petroleum and coal products	36.4	36.6	36.2	37.5	38.5
Total [2]	186.0	189.4	186.7	183.8	191.9
Total manufacturing	914.1	895.1	894.5	908.6	902.4

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for the United States, 1909–1967. Bull. 1312–5, October 1967, 851 pp. Employment and Earnings Statistics. V. 16, No. 9, March 1970, table B–2; v. 17, No. 9, March 1971, table B–2.

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

	1966	1967	1968	1969	1970
MINING					
Metals:					
Iron ores:					
Weekly earnings	$138.09	$138.60	$144.70	$153.18	$162.99
Weekly hours	42.1	42.0	41.7	41.4	41.9
Hourly earnings	$3.28	$3.30	$3.47	$3.70	$3.89
Copper ores:					
Weekly earnings	$140.07	$140.51	$162.37	$169.00	$175.67
Weekly hours	43.5	43.1	47.2	46.3	44.7
Hourly earnings	$3.22	$3.26	$3.44	$3.65	$3.93
Total: [1]					
Weekly earnings	$133.77	$136.83	$148.77	$157.61	$165.68
Weekly hours	42.2	42.1	43.5	43.3	42.7
Hourly earnings	$3.17	$3.25	$3.42	$3.64	$3.88
Nonmetallic mining and quarrying:					
Weekly earnings	$123.39	$128.65	$136.35	$149.44	$155.56
Weekly hours	45.7	45.3	45.0	45.7	44.7
Hourly earnings	$2.70	$2.84	$3.03	$3.27	$3.48
Fuels:					
Total coal mining:					
Weekly earnings	$145.95	$150.93	$151.59	$165.95	$183.96
Weekly hours	[2] 40.3	[2] 40.5	[2] 39.7	40.0	40.7
Hourly earnings	[2] $3.62	[2] $3.72	[2] $3.80	$4.17	$4.52
Bituminous coal:					
Weekly earnings	$148.44	$153.09	$153.16	$168.46	$186.46
Weekly hours	[2] 40.6	[2] 40.7	[2] 39.8	40.2	40.8
Hourly earnings	[2] $3.65	[2] $3.75	[2] $3.83	$4.21	$4.57
Crude petroleum and natural gas:					
Weekly earnings	$122.69	$130.66	$137.71	$147.19	$155.88
Weekly hours	42.6	42.7	42.9	41.0	40.7
Hourly earnings	$2.88	$3.06	$3.21	$3.59	$3.83
Total fuels: [3]					
Weekly earnings	$131.55	$138.83	$143.08	$155.97	$166.35
Weekly hours	41.7	41.8	41.7	42.4	42.1
Hourly earnings	$3.16	$3.33	$3.44	$3.70	$3.97
Total mining: [3]					
Weekly earnings	$127.73	$131.85	$141.35	$152.98	$160.07
Weekly hours	44.2	44.0	44.4	44.7	44.8
Hourly earnings	$2.90	$3.00	$3.18	$3.43	$3.66
MANUFACTURING					
Fertilizers, complete and mixing only:					
Weekly earnings	$101.38	$104.98	$108.97	$116.14	$123.68
Weekly hours	43.7	43.2	42.4	42.7	42.5
Hourly earnings	$2.32	$2.43	$2.57	$2.72	$2.91
Cement, hydraulic:					
Weekly earnings	$132.61	$133.40	$144.35	$155.87	$176.81
Weekly hours	41.7	41.3	41.6	41.9	41.8
Hourly earnings	$3.18	$3.23	$3.47	$3.72	$4.23
Blast furnaces, steel, and rolling mills:					
Weekly earnings	$145.71	$145.16	$155.86	$168.51	$168.38
Weekly hours	40.7	40.1	40.8	41.2	39.9
Hourly earnings	$3.58	$3.62	$3.82	$4.09	$4.22
Nonferrous smelting and refining:					
Weekly earnings	$129.98	$134.30	$144.08	$151.79	$157.63
Weekly hours	42.2	42.1	42.5	42.4	41.7
Hourly earnings	$3.08	$3.19	$3.39	$3.58	$3.78
Petroleum refining and related industries:					
Weekly earnings	$144.58	$152.87	$159.38	$170.83	$182.33
Weekly hours	42.4	42.7	42.5	42.6	42.7
Hourly earnings	$3.41	$3.58	$3.75	$4.01	$4.27
Petroleum refining:					
Weekly earnings	$151.56	$159.09	$166.27	$178.08	$189.93
Weekly hours	42.1	42.2	42.2	42.1	42.3
Hourly earnings	$3.60	$3.77	$3.94	$4.23	$4.49
Other petroleum and coal products:					
Weekly earnings	$120.22	$129.51	$135.91	$147.19	$157.52
Weekly hours	43.4	44.2	43.7	44.2	44.0
Hourly earnings	$2.77	$2.93	$3.11	$3.33	$3.58
Total manufacturing: [3]					
Weekly earnings	$141.83	$142.96	$153.76	$165.48	$168.76
Weekly hours	41.2	40.9	41.3	41.6	40.5
Hourly earnings	$3.44	$3.51	$3.74	$3.99	$4.16

[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 for the United States 1909–1967. Bull. 1312–5, October 1967, 852 pp. Employment and Earnings. V. 15, No. 9, March 1969, v. 16, No. 9, March 1970, and v. 17, No. 9, March 1971, table C–2.

Table 26.—Average labor-turnover rates in selected mineral industries [1]

(Per thousand employees)

Rates and year	Manu-facturing	Cement, hy-draulic	Blast fur-naces, steel and rolling mills	Non-ferrous smelting and refining	Metal mining	Iron ores	Copper ores	Petro-leum refining and related indus-tries [2]	Petro-leum refining	Coal mining
Total accession rate:										
1968	46	28	30	35	34	28	29	24	18	18
1969	47	24	33	34	38	34	32	26	17	20
1970	40	21	27	26	38	31	37	23	16	21
Total separation rate:										
1968	46	25	35	30	35	36	27	24	17	17
1969	49	24	28	33	33	31	24	26	17	18
1970	48	32	33	30	37	36	29	26	18	16
Layoff rate:										
1968	12	10	14	3	8	18	5	6	4	5
1969	12	7	4	3	3	8	1	4	3	3
1970	18	16	12	5	6	15	1	7	5	2

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 15, No. 10, April 1969; v. 16, No. 9, March 1970; and v. 17, No. 9, March 1971, table D-2.

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

	1968	1969	1970 p	Percent change 1968–69	Percent change 1969–70
Wages and salaries:					
All industries, total......millions..	r $464,862	$509,575	$541,400	+9.6	+6.2
Mining....do....	4,874	5,387	5,826	+10.5	+8.1
Manufacturing....do....	145,874	157,562	158,314	+8.0	+.5
Average earnings per full-time employee:					
All industries, total	r 6,657	7,095	7,564	+6.6	+6.6
Mining	7,964	8,619	9,262	+8.2	+7.5
Manufacturing	7,347	7,775	8,150	+5.8	+4.8

p Preliminary. r Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 51, No. 7, July 1971, table 6.

Table 28.—Labor-productivity indexes for selected minerals

(1957–59 = 100)

Year	Copper, crude ore mined per— Employee	Production worker	Production worker man-hour	Iron, crude ore mined per— Employee	Production worker	Production worker man-hour
1965	146.0	136.1	129.1	183.0	176.9	162.6
1966	148.2	138.6	131.1	186.6	183.1	163.5
1967	126.5	129.3	123.7	190.8	188.2	168.4
1968	152.8	154.9	135.7	206.5	205.4	185.2
1969 p	168.0	161.8	143.9	215.5	217.1	197.1
	Copper, recoverable metal mined per— Employee	Production worker	Production worker man-hour	Iron, usable ore mined per— Employee	Production worker	Production worker man-hour
1965	135.3	126.2	119.6	143.2	138.5	127.3
1966	134.8	126.0	119.2	147.0	144.3	128.9
1967	112.5	115.0	110.0	139.5	137.5	123.1
1968	127.9	129.6	113.6	144.2	143.5	129.4
1969 p	137.4	132.5	117.8	146.5	147.6	134.0
	Petroleum, refined per— Employee	Production worker	Production worker man-hour	Bituminous coal and lignite mined per— Employee	Production worker	Production worker man-hour
1965	163.7	166.8	167.3	176.7	176.5	154.2
1966	177.2	180.9	180.4	187.3	188.8	162.5
1967	183.9	189.6	185.1	190.4	191.6	r 165.3
1968	192.7	200.0	194.0	195.9	198.7	173.9
1969 p	205.9	222.2	215.6	195.2	197.7	174.2

p Preliminary. r Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Index of Output per Man-hour Selected Industries 1939 and 1947–69. BLS Bull. 1680, 1970, 112 pp.

Table 29.—Index of average unit mine value of minerals produced 1966–70

(1967 = 100)

	1966	1967	1968	1969	1970 p
METALS					
Ferrous	95.7	100.0	102.0	104.1	109.4
Nonferrous:					
Base	98.9	100.0	106.3	119.8	141.5
Monetary	91.6	100.0	125.4	118.0	109.2
Other	106.7	100.0	100.8	95.4	129.2
Average	99.6	100.0	107.4	115.0	135.7
Average, all metals	97.5	100.0	104.5	109.1	121.5
NONMETALS					
Construction	98.2	100.0	101.5	103.5	107.8
Chemical	95.6	100.0	102.9	97.9	87.3
Other	94.5	100.0	103.3	111.2	108.6
Average	97.4	100.0	101.9	102.6	103.2
FUELS					
Coal	98.1	100.0	101.3	108.0	134.2
Crude oil and natural gas	98.8	100.0	101.4	107.9	106.3
Average	98.5	100.0	100.4	106.1	109.9
Overall average	98.2	100.0	101.1	105.6	109.3

p Preliminary.

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

(1967 = 100)

	1966	1967	1968	1969	1970 p
METALS					
Ferrous	95.7	100.0	101.9	104.1	109.1
Nonferrous:					
Base	96.8	100.0	106.7	120.4	143.4
Monetary	91.4	100.0	125.1	118.0	109.5
Other	105.1	100.0	100.4	95.6	129.7
Average	97.1	100.0	107.2	117.7	139.8
Average, all metals	96.5	100.0	105.0	112.4	128.7
NONMETALS					
Construction	98.1	100.0	101.0	103.0	107.2
Chemical	95.4	100.0	102.4	97.8	87.4
Other	94.3	100.0	97.5	111.0	108.9
Average	97.3	100.0	101.4	102.3	103.0
FUELS					
Coal	98.1	100.0	101.2	108.0	134.2
Crude oil and natural gas	98.8	100.0	101.4	107.9	106.3
Average	98.5	100.0	100.4	106.0	109.8
Overall average	98.0	100.0	101.1	105.9	110.5

p Preliminary.

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

(1967 = 100 unless otherwise stated)

Commodity	Annual average		Percent change from 1969
	1969	1970	
Metals and metal products	108.5	116.7	+7.6
Iron and steel	107.0	115.1	+7.6
Iron ore	98.1	100.1	+2.0
Iron and steel scrap	110.8	138.9	+25.4
Semifinished steel products	107.0	112.2	+4.9
Finished steel products	107.3	114.2	+6.4
Foundry and forge shop products	106.1	112.1	+5.7
Pig iron and ferroalloys	102.1	114.6	+12.2
Nonferrous metals	113.5	125.0	+10.1
Primary metal refinery shapes	114.2	128.1	+12.2
Aluminum ingot	108.4	115.2	+6.3
Lead, pig, common	106.5	112.1	+5.3
Zinc, slab, prime western	105.5	110.3	+4.5
Nonferrous scrap	127.4	124.8	−2.0
Nonmetallic mineral products	107.7	113.3	+5.2
Concrete ingredients	106.7	114.6	+7.4
Sand, gravel, and crushed stone	107.8	113.5	+5.3
Structural clay products	106.2	109.8	+3.4
Gypsum products	103.6	100.0	−3.5
Other nonmetallic minerals	107.0	112.2	+4.9
Building lime	105.3	110.5	+4.9
Insulation materials	115.4	123.1	+6.7
Bituminous binders [1]	101.0	104.1	+3.1
Fertilizer materials	79.2	74.9	−5.4
Nitrogenates	72.0	69.3	−3.7
Phosphates	92.2	80.0	−13.2
Phosphate rock	100.0	89.9	−10.1
Potash	69.1	97.7	+41.4
Muriate, domestic	66.1	96.3	+45.7
Sulfate	84.2	104.4	+24.0
Fuels and related products and power	100.9	105.9	+5.0
Coal	112.6	150.0	+33.2
Anthracite	117.0	131.3	+12.2
Bituminous	112.3	151.5	+34.9
Coke	108.9	127.4	+17.0
Gas fuels [1]	r 124.7	138.1	+10.7
Electric power [1]	r 102.5	105.5	+2.9
Petroleum products, refined	99.6	101.1	+1.5
Crude petroleum	105.2	106.1	+.9
All commodities other than farm and food	106.0	110.0	+3.8
All commodities	106.5	110.4	+3.7

r Revised.

[1] January 1958 = 100.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January–December 1970, tables 2 and 2–A; January 1971, tables 4 and 6–A, and pp. 106–107 for rebasing data.

Table 32.—Comparative mineral energy resource prices

Fuel	1968	1969	1970
Bituminous coal: Average prices, cost of coal at merchant coke ovens dollars per net ton	$10.58	$10.75	$12.28
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:			
Chestnut dollars	13.02	14.12	15.67
Pea do	10.80	12.14	13.87
Buckwheat, No. 1 do	10.13	11.53	13.26
Petroleum and petroleum products:			
Crude petroleum, average price per barrel at well do	2.94	3.09	3.18
Gasoline, average dealers' net price (excluding taxes) of gasoline in 55 U.S. cities [1] cents per gallon	16.51	17.11	17.68
Residual fuel oil:			
No. 6 fuel, maximum 1 percent sulfur, at Philadelphia [1] dollars per barrel (refinery)	2.38	2.32	3.16
Bunker C, average price for all Gulf ports [1] do	1.67	1.47	2.44
Distillate fuel oil:			
No. 2 distillate, average of high and low prices at Philadelphia [1] cents per gallon (refinery)	10.90	10.90	11.08
No. 2 distillate, average price for all Gulf ports [1] do	9.40	9.24	9.41
Natural gas:			
Average U.S. value at well cents per thousand cubic feet	16.4	16.7	17.1
Average U.S. value at point of consumption do	50.4	51.5	53.6

[1] Platt's Oil Price Handbook.

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

(Cents per million Btu)

Region	1967			1968			1969		
	Coal	Oil	Gas	Coal	Oil	Gas	Coal	Oil	Gas
New England	34.3	30.5	32.2	34.3	29.4	32.0	36.9	28.3	33.7
Middle Atlantic	27.8	33.2	35.4	28.3	35.0	35.8	30.0	33.6	35.6
East North Central	24.7	62.9	26.7	25.2	64.6	28.0	26.4	62.0	31.6
West North Central	25.6	51.6	24.0	25.1	52.6	24.5	26.2	51.8	24.9
South Atlantic	26.6	32.5	31.7	27.0	32.3	31.6	28.4	30.4	31.6
East South Central	20.1	53.2	23.4	20.1	55.2	23.9	21.1	51.1	24.3
West South Central	------	42.4	19.9	21.5	38.2	20.1	31.1	36.9	20.5
Mountain	20.1	26.1	26.2	20.4	26.8	25.9	20.6	27.3	27.3
Pacific	------	31.4	30.8	------	32.0	30.7	------	34.5	31.2
United States	25.2	32.2	24.7	25.5	32.8	25.1	26.6	31.9	25.4

Source: National Coal Association. Steam-Electric Plant Factors. 1967 through 1969, table 2.

Table 34.—Cost of electrical energy

(Cents per kilowatt hour)

Region	1967			1968			1969		
	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial
New England	2.3	2.9	1.9	2.2	2.7	1.9	2.2	2.6	1.8
Middle Atlantic	1.8	2.6	1.5	1.9	2.6	1.5	1.8	2.5	1.5
East North-Central	1.6	2.4	1.3	1.6	2.3	1.3	1.6	2.3	1.4
West North-Central	2.0	2.5	1.7	1.9	2.4	1.6	1.9	2.4	1.6
South Atlantic	1.6	2.0	1.3	1.5	2.0	1.3	1.5	1.9	1.3
East South-Central	.9	1.3	.7	.9	1.3	.8	1.0	1.3	.8
West South-Central	1.5	2.3	1.2	1.5	2.2	1.2	1.5	2.2	1.2
Mountain	1.5	2.2	1.3	1.5	2.2	1.2	1.5	2.1	1.2
Pacific	1.2	1.7	1.0	1.2	1.7	1.0	1.2	1.6	1.0
Alaska and Hawaii	2.5	2.9	2.2	2.4	2.9	2.2	2.4	2.8	2.1
United States	1.6	2.2	1.3	1.5	2.1	1.3	1.5	2.1	1.3

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utilities Industry. 1967 through 1969.

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

(1957–59 = 100)

Year	Total	Labor	Supplies	Fuel	Electrical energy
1966	104	103	105	101	100
1967	109	111	107	104	101
1968	110	113	109	102	102
1969	114	116	113	105	103
1970 p	119	122	118	110	106

p Preliminary.

[1] Indexes constructed using the following weights derived from the 1963 Census of Mineral Industries: Labor, 54.11; explosives, 2.35; steel mill shapes and forms, 6.40; all other supplies, 26.75; fuels, 4.86; electric energy, 5.53; and data from U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes. The index is computed for iron and copper ores only because sufficient data are not available for other mining sectors.

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

(1957–59 = 100)

Year	Bituminous coal	Crude petroleum and natural gas	Year	Bituminous coal	Crude petroleum and natural gas
1966	86	100	1969	NA	NA
1967	87	100	1970	NA	NA
1968	NA	NA			

NA Not available.

[1] Indexes constructed by using data from the U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes, annual and monthly, and weights derived from data shown in the 1963 Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census. Weights used are as follows: Bituminous coal—labor, 62.98; explosives, 1.77; steel mill shapes and forms, 3.88; all other supplies, 24.92; fuels, 1.76; electric energy, 4.69; crude petroleum and natural gas—labor, 46.3; fuel, 2.6; electric energy, 3.5; and all other 47.6.

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

(1957–59 = 100)

Year	Iron ore [2]	Copper [2]	Bituminous coal	Petroleum
	INDEX OF LABOR COSTS PER UNIT OF OUTPUT			
1966	93	112	75	94
1967	97	123	77	93
1968	98	126	NA	NA
1969	101	129	NA	NA
1970 p	108	134	NA	NA
	INDEX OF VALUE OF PRODUCT PER MAN-PERIOD			
1966	120	148	151	136
1967	115	146	163	147
1968	121	165	NA	NA
1969	125	194	NA	NA
1970 p	126	245	NA	NA
	INDEX OF LABOR COSTS PER DOLLAR OF PRODUCT			
1966	100	91	82	98
1967	105	93	79	95
1968	105	87	NA	NA
1969	108	78	NA	NA
1970 p	113	67	NA	NA

p Preliminary. NA Not available.

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

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

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

[2] Indexes are for recoverable metal.

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

(1967 = 100, unless otherwise specified)

Commodity	1970 January	1970 December	Change from January (percent)	Annual average 1969	Annual average 1970	Change from 1969 (percent)
Coal	121.4	175.8	+44.8	112.6	150.0	+33.2
Coke	113.3	145.9	+28.8	108.9	127.4	+17.0
Gas fuels (January 1958 = 100)	132.4	143.7	+8.5	r 124.7	138.1	+10.7
Petroleum products, refined	98.8	107.5	+8.8	99.6	101.1	+1.5
Industrial chemicals	100.5	101.4	+.9	100.3	100.9	+.6
Lumber	117.1	111.1	−5.1	131.6	113.7	−13.6
Explosives	105.4	106.9	+1.4	104.1	106.1	+1.9
Construction machinery and equipment	113.8	119.6	+5.1	110.4	115.5	+4.6

r Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, March and December 1970, table 2; January 1971, table 6–A, January–December 1970 issues, table 2, used to figure annual average for explosives.

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

(1967 = 100)

Year	Construction machinery and equipment	Mining machinery and equipment	Oilfield machinery and tools	Power cranes, draglines, shovels, etc.	Specialized construction machinery	Portable air compressors	Scrapers and graders	Mixers, pavers, spreaders, etc.	Tractors other than farm
1966	96.5	97.1	96.5	96.7	97.9	99.2	97.5	96.3	95.8
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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January 1971, table 6–A, and in previous years, table 2–A.

Table 40.—National income originated in the mineral industries

Industry	Income, millions 1968	Income, millions 1969	Income, millions 1970 p	Change from 1969 (percent)
Mining	$6,702	$6,781	$7,448	+9.8
Metal mining	888	973	1,113	+14.4
Coal mining	1,429	1,513	1,944	+28.5
Crude petroleum and natural gas	3,153	3,045	3,140	+3.1
Mining and quarrying of nonmetallic minerals	1,232	1,250	1,251	+.1
Manufacturing	212,672	221,947	217,735	−1.9
Chemicals and allied products	15,614	16,023	16,113	+.6
Petroleum refining and related industries	6,680	6,359	6,357	− (1)
Stone, clay, and glass products	6,329	6,936	6,920	−.2
Primary metal industries	15,871	16,366	16,209	−1.0
All industries	711,140	763,660	795,887	+4.2

p Preliminary.
1 Less than ½ unit.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 51, No. 7, July 1971, table 1.12.

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

Industry	Annual profit rate (percent)			Total dividends (millions)		
	1969	1970	Change from 1969	1969	1970	Change from 1969 (percent)
All manufacturing [1]	11.5	9.3	−2.2	$15,058	$15,070	+0.1
Primary metals	9.5	7.0	−2.5	1,195	1,197	+ .2
Primary iron and steel	7.6	4.3	−3.3	615	596	−3.1
Primary nonferrous metals	12.2	10.7	−1.5	579	602	+4.0
Stone, clay, and glass products	9.2	6.9	−2.3	352	342	−2.8
Chemicals and allied products	12.8	11.5	−1.3	1,890	1,925	+1.9
Petroleum refining and related industries	11.7	11.0	−.7	3,082	3,177	+3.1
Petroleum refining	11.7	11.0	−.7	3,076	3,159	+2.7

[1] Except newspapers.

Source: Federal Trade Commission, Securities and Exchange Commission, Quarterly Financial Report for Manufacturing Corporations, 1st Quarter and 4th Quarter, 1970, tables 4 and 8.

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

Industry	1968	1969	1970
Mining: [1]			
Number of failures	57	34	54
Current liabilities, thousands	$28,773	$15,104	$59,046
Manufacturing:			
Number of failures	1,456	1,459	1,981
Current liabilities, thousands	$262,927	$391,346	$758,795
All industrial and commercial industries:			
Number of failures	9,636	9,154	10,748
Current liabilities, thousands	$940,996	$1,142,113	$1,887,754

[1] Including fuels.

Source: Dun & Bradstreet, Inc., Business Economics Department. Monthly Failure Report, K–12, No. 12, Jan. 27, 1971, 4 pp.

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

(Billions)

Industry	1968	1969	1970
Mining [1]	$1.63	$1.86	$1.89
Manufacturing:			
Primary iron and steel	2.00	1.83	1.68
Primary nonferrous metals	1.09	1.10	1.24
Stone, clay, and glass products	.86	1.07	.99
Chemical and allied products	2.83	3.10	3.44
Petroleum and coal products	5.25	5.63	5.62
All manufacturing	28.37	31.68	31.95

[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 50, No. 1, January 1970, p. 29, table 1; v. 51, No. 3, March 1971, p. 20, table 6.

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

(Millions)

Area and country	1968			1969			1970 [1]		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
Canada	$340	$669	r $854	$340	$629	$1,036	$429	$742	$1,310
Latin America	456	r 405	r 575	497	511	602	489	571	770
Europe	10	r 851	2,012	11	876	2,539	11	1,045	3,848
All other areas	r 230	r 1,386	r 749	284	1,634	784	422	1,636	1,114
Total [2]	r 1,035	r 3,311	r 4,191	1,131	3,650	4,960	1,351	3,994	7,042

r Revised.
[1] Estimated in June 1970.
[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. 50, No. 9, September 1970, p. 23.

Table 45.—Estimated gross proceeds of new corporate securities offered for cash in 1970 [1]

Type of security	Total corporate		Manufacturing		Extractive [2]	
	Millions	Percent	Millions	Percent	Millions	Percent
Bonds	$30,264	77.7	$9,191	87.4	$299	14.4
Preferred stock	1,388	3.6	51	.5	4	.2
Common stock	7,292	18.7	1,271	12.1	1,779	85.4
Total	38,944	100.0	10,513	100.0	2,082	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. 30, No. 4, April 1971, p. 12.

Table 46.—Sources of funds of direct foreign investment by U.S. mining and smelting industries [1]

(Millions)

	Net income			Funds from the United States			Funds obtained abroad			Depreciation and depletion			Total sources		
	1965	1967	1968	1965	1967	1968	1965	1967	1968	1965	1967	1968	1965	1967	1968
Canada	$241	$283	$319	$16	$ −36	$114	$75	$19	$166	$105	$115	$127	$445	$418	$737
Latin America and other Western Hemisphere	248	401	411	−33	39	190	16	16	71	85	88	89	317	584	801
European Economic Community (EEC)	-----	-----	1	2	1	-----	1	−1	−1	-----	-----	1	3	-----	1
Other Europe	6	3	6	-----	5	2	5	−3	4	4	4	4	15	8	17
Other areas	86	155	137	125	80	67	139	99	74	35	63	75	388	416	369
Total [2]	581	841	874	110	88	373	236	130	314	229	270	296	1,168	1,426	1,925

[1] No figures issued for 1966. The last report, showing 1965, appeared as table 49 in the Review of the Mineral Industries chapter of the 1968 Minerals Yearbook.
[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. 50, No. 11, November 1970, pp. 16–17.

Table 47.—Uses of funds for direct foreign investment by U.S. mining and smelting industries

(Millions)

Area	Property, plant, and equipment			Inventories			Receivables		
	1965	1967	1968	1965	1967	1968	1965	1967	1968
Canada	212	279	322	43	26	14	16	17	18
Latin American Republics and other Western Hemisphere	130	211	376	26	18	19	8	−22	3
Europe:									
European Economic Community (EEC)	---	---	1	1	---	---	2	−2	---
Other Europe including United Kingdom	4	5	7	1	1	−1	---	−2	1
Other areas	227	223	206	14	23	17	13	21	24
Total [1]	573	717	911	84	68	49	40	12	45

Area	Other assets			Income paid out			Total uses		
	1965	1967	1968	1965	1967	1968	1965	1967	1968
Canada	43	−63	214	132	159	170	445	418	737
Latin American Republics and other Western Hemisphere	19	71	91	134	306	312	317	584	801
Europe:									
European Economic Community (EEC)	---	2	---	---	---	---	3	---	1
Other Europe including United Kingdom	2	2	5	8	2	6	15	8	17
Other areas	56	48	41	77	101	82	388	416	369
Total [1]	120	60	350	351	568	570	1,168	1,426	1,925

[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. 50, No. 11, November 1970. pp. 16–17.

Table 48.—Direct private investments of U.S. companies in foreign petroleum industries in 1969 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:	$9,922	$432	$ –52	$10,447	$43,500	$1,993	$2,083	$47,701
Canada	4,094	178	95	4,359	19,535	619	937	21,075
Europe	4,636	204	–198	4,805	19,407	1,158	845	21,554
Japan	405	27	15	447	1,050	63	105	1,218
Australia, New Zealand, and Republic of South Africa	787	23	36	836	3,508	153	196	3,854
Less developed countries:	7,496	347	–7	7,830	18,753	760	500	20,000
Latin American Republics	3,014	57	11	3,079	11,033	271	362	11,667
Other Western Hemisphere	667	–1	–26	643	2,068	74	14	2,144
Other Africa	1,407	170	21	1,598	1,978	169	67	2,215
Middle East	1,656	50	–45	1,654	1,805	71	–40	1,829
Other Asia and Pacific	753	71	32	856	1,869	175	97	2,145
International, unallocated	1,469	243	(1)	1,708	2,731	316	–52	3,061
Total [2]	18,887	1,022	–59	19,985	64,983	3,070	2,532	70,763

p Preliminary.
[1] Less than ½ unit.
[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. 50, No. 10, October 1970, pp. 28–29.

Table 49.—Direct private investments of the United States in foreign mining and smelting industries in 1969 p

(Millions)

	Book value at yearend	Net capital outflows	Undistributed earnings of subsidiaries	Earnings 1	Income 2
Developed countries	$3,315	$75	$96	$330	$224
Canada	2,764	50	77	233	152
Europe	72	6	5	10	5
Japan	--------	--------	--------	--------	--------
Australia, New Zealand, and Republic of South Africa	479	19	14	87	67
Australia	395	18	12	50	37
South Africa, Republic of	84	1	2	36	29
Less developed countries	2,321	−23	72	513	439
Latin American Republics, total	1,346	−87	42	334	287
Mexico	136	13	11	18	6
Panama	19	(3)	--------	--------	--------
Brazil	99	(4)	(4)	(4)	(4)
Chile	452	−142	26	141	108
Peru	443	21	2	104	102
Other Western Hemisphere	576	56	1	116	116
Other Africa	343	(3)	29	67	39
Middle East	3	(3)	(3)	(3)	--------
Other Asia and Pacific	53	8	1	−3	−4
International, unallocated	--------	--------	--------	--------	--------
Total, all areas 5	5,635	52	168	844	664

p Preliminary.
1 Earnings is the sum of the U.S. share in net earnings of subsidiaries and branch profits.
2 Income is the sum of dividends, interest, and branch profits.
3 Less than ½ unit.
4 Combined in "other" industries in source reference.
5 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. 50, No. 10, October 1970, pp. 28–29.

Table 50.—Value of foreign direct investments in the United States

(Millions)

Industry	1965	1966	1967	1968	1969 p
Total	$8,797	r $9,054	r $9,923	$10,815	$11,818
Petroleum	1,710	1,740	1,885	2,261	2,493

p Preliminary. r Revised.

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

Table 51.—Railroad and water transportation of selected minerals and mineral energy products in the United States

(Thousand short tons)

Products	Rail [1] 1968	Rail [1] 1969	Rail [1] Change from 1968 (percent)	Water [2] 1968	Water [2] 1969	Water [2] Change from 1968 (percent)
Metals and minerals except fuels:						
Iron ore and concentrates	94,096	104,701	+11.3	69,002	78,881	+14.3
Iron and steel scrap	26,716	29,673	+11.1	1,577	1,869	+18.5
Pig iron	4,296	4,609	+7.3	648	591	−8.8
Iron and steel ingot, plates, bars, rods, tubing, and other primary products	54,291	52,726	−2.9	8,184	7,892	−3.6
Bauxite and other aluminum ores and concentrates	4,060	4,271	+5.2	904	674	−25.4
Other nonferrous ores and concentrates	13,515	17,464	+29.2	438	1,363	+211.2
Nonferrous metals and alloys	9,508	10,238	+7.7	631	642	+1.7
Nonferrous metal scrap	3,201	3,605	+12.6	46	57	+23.9
Slag	2,047	1,888	−7.8	465	524	+12.7
Sand and gravel	58,966	58,935	−.1	72,291	82,893	+14.7
Stone, crushed and broken	63,202	66,310	+4.9			
Limestone flux and calcareous stone	--------	--------	--------	33,520	33,224	−.9
Cement, building	25,309	24,207	−4.4	10,658	10,820	+1.5
Lime	5,548	6,391	+15.2	355	503	+41.7
Phosphate rock	32,973	30,870	−6.4	4,763	5,380	+13.0
Clays, ceramic and refractory materials	3,202	3,372	+5.3	2,154	1,966	−8.7
Sulfur, dry	3,160	2,891	−8.5	101	104	+3.0
Sulfur, liquid				8,485	8,021	−5.5
Gypsum and plaster rock	749	635	−15.2	765	808	+5.6
Other nonmetallic minerals except fuels	8,405	8,377	−.3	5,898	6,879	+16.6
Fertilizer and fertilizer materials	18,382	18,479	+.5	3,673	4,266	+16.1
Total	r 431,626	449,642	+4.2	r 224,558	247,357	+10.2
Mineral energy resources and related products:						
Coal:						
Anthracite	7,471	6,956	−6.9	156,103	153,035	−2.0
Bituminous and lignite	371,654	376,336	+1.3			
Coke	262	1,787	+582.1	483	615	+27.3
Crude petroleum	566	552	−2.5	107,010	109,683	+2.5
Gasoline	2,777	2,401	−13.5	82,720	85,363	+3.2
Jet fuel				12,566	14,417	+14.7
Kerosine	253	232	−8.3	8,539	7,451	−12.7
Distillate fuel oil	1,748	1,616	−7.6	74,612	77,839	+4.3
Residual fuel oil	4,456	4,637	+4.1	55,599	64,331	+15.7
Asphalt, tar, and pitches	2,933	2,755	−6.1	8,207	8,087	−1.5
Liquefied petroleum gases and coal gases	6,998	7,590	+8.5	1,036	1,342	+29.5
Other petroleum and coal products [3]	9,468	13,563	+43.3	10,713	10,350	−3.4
Total	408,586	418,425	+2.4	517,588	532,513	+2.9
Total mineral products	r 840,212	868,067	+3.3	r 742,146	779,870	+5.1
Grand total, all commodities	1,430,441	1,472,619	+2.9	887,889	927,399	+4.4
Mineral products, percent of grand total:						
Metals and minerals except fuels	r 30.2	30.5	+1.0	25.3	26.7	+5.5
Mineral energy resources and related products	28.6	28.4	−.7	58.3	57.4	−1.5
Total mineral products	r 58.8	58.9	+.2	83.6	84.1	+.6

r Revised.

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

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. Statement No. 69100–A. Issue for 1969 carries no statement number. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Part 5. National Summaries, Calendar Years 1968 and 1969, table 2.

Table 52.—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
1966	72.5	11.6	12.6	3.3	100.0
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

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

Type of gas and type of main	1965	1966	1967	1968	1969
All types:					
Field and gathering	61,760	62,980	63,710	64,440	64,914
Transmission	211,240	216,980	225,360	234,450	248,071
Distribution	494,520	519,610	539,200	562,750	578,639
Total	767,520	799,570	828,270	861,640	891,624
Natural gas:					
Field and gathering	61,760	62,980	63,710	64,440	64,914
Transmission	210,660	216,410	224,790	233,940	247,559
Distribution	484,260	509,840	529,340	554,030	569,999
Total	756,680	789,230	817,840	852,410	882,472
Manufactured gas:					
Transmission	10	--------	--------	--------	--------
Distribution	1,420	1,180	1,140	1,070	914
Total	1,430	1,180	1,140	1,070	914
Mixed gas:					
Transmission	570	570	570	510	510
Distribution	7,810	7,800	7,950	6,980	7,105
Total	8,380	8,370	8,520	7,490	7,615
Liquefied petroleum gas:					
Transmission	--------	--------	--------	(2)	2
Distribution	1,030	790	770	670	621
Total	1,030	790	770	670	623

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

Source: American Gas Association. Gas Facts, a Statistical Record of the Gas Utility Industry in 1969, p. 61. For earlier years, see Historical Statistics of the Gas Industry.

Table 54.—Petroleum pipelines, selected years
(Miles)

Year	Trunklines		Gathering lines	Total
	Crude	Products		
1956	78,594	36,420	73,526	188,540
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

Table 55.—Research and development activity

(Millions)

	Total		Funds expended: Company		Funds expended: Federal Government	
	1967	1968 p	1967	1968 p	1967	1968 p
Petroleum refining and extraction	$455	$538	$409	$463	$46	$75
Percent of all industries	2.8	3.1	5.1	5.3	0.5	0.9
Chemicals and allied products	$1,569	$1,640	$1,357	$1,440	$211	$201
Percent of all industries	9.6	9.4	16.9	16.2	2.5	2.3
All industries	$16,415	$17,435	$8,020	$8,876	$8,395	$8,559

p Preliminary.

Source: National Science Foundation. Research and Development in Industry 1968. NSF 70-29, July 1970, tables 6, 8, 44, 45.

Table 56.—Federal obligated funds for metallurgy and material research

(Thousands)

Federal agency	Fiscal year 1970 e			Fiscal year 1971 e		
	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	$20,987	$44,123	$65,110	$23,229	$58,384	$81,613
Atomic Energy Commission	12,152	15,876	28,028	11,909	15,701	27,610
National Aeronautics and Space Administration	16,408	9,286	25,694	15,590	9,101	24,691
Bureau of Mines	1,782	12,356	14,138	2,280	14,230	16,510
National Science Foundation	2,385	417	2,802	2,257	623	2,880
Department of Agriculture	-------	-------	-------	-------	-------	-------
Department of Commerce	1,465	1,072	2,537	1,520	1,182	2,702
Federal Highway Administration	1,350	5,955	7,305	1,800	10,580	12,380
Other	25	736	761	30	1,067	1,097
Total	56,554	89,821	146,375	58,615	110,868	169,483

e Estimate.

Source: National Science Foundation. Federal Funds for Research, Development, and other Scientific Activities. NSF 70-38, v. 19, September 1970, tables C-24, C-25, C-43, C-44, C-62, C-63.

Table 57.—Bureau of Mines obligations for mining and mineral research and development

(Thousands)

Fiscal year	Applied research	Basic research	Development	Total
1967	$23,148	$4,841	$4,423	$32,412
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 e	31,599	6,457	19,993	58,049

e Estimate.

Table 58.—Bureau of Mines obligations for total research, by field of science

(Thousands)

	Fiscal year		
	1969	1970	1971 e
Engineering sciences	$19,547	$24,040	$27,411
Physical sciences	8,192	7,462	7,355
Mathematical sciences	689	571	750
Environmental sciences	1,557	1,821	2,540
Total	29,985	33,894	38,056

e Estimate.

Table 59.—Summary of government inventories of strategic and critical materials December 31, 1970

	Acquisition cost	Market value [1]
Total inventories:		
National stockpile	$4,247,835,600	$5,080,712,000
Supplemental stockpile	1,420,581,700	1,587,296,600
Defense Production Act	704,821,500	436,806,700
Commodity Credit Corporation	44,300	43,500
Total on hand	6,373,283,100	7,104,858,800
On order	------------	------------
Inventories within objective: Total on hand	3,602,049,300	4,386,237,100
Inventories excess to objective: Total on hand	2,771,233,800	2,718,621,700

[1] Market values are estimated from prices at which similar materials are being traded; or in the absence of trading data, at an estimate of the price which would prevail in the market. Prices used are unadjusted for normal premiums and discounts relating to contained qualities or for normal freight allowances. The market values do not necessarily reflect the amount that would be realized at time of sale. Stockpile value is based on inventories in storage and includes quantities sold but not shipped.

Source: Executive Office of the President, Office of Emergency Preparedness. Stockpile Report to the Congress, July–December 1970, p. 4.

Table 60.—U.S. Government stockpile disposal of mineral commodities, 1970

Commodity	Sales commitments	
	Quantity	Sales value
NATIONAL AND SUPPLEMENTAL STOCKPILE OBJECTIVES		
Aluminum short tons	17,168	$9,630,754
Aluminum oxide do	50	4,175
Asbestos, amosite do	1,540	272,840
Asbestos, chrysotile do	1,677	291,992
Asbestos, crocidolite do	8,092	1,519,674
Bauxite, Surinam long dry tons	123,529	2,367,499
Beryl ore short tons	2,026	851,605
Bismuth pounds	2,113,565	3,385,925
Cadmium do	6,200	18,820
Chromite, chemical short dry tons	676,225	9,637,381
Chromite, metallurgical do	39,240	1,906,315
Chromite, refractory do	20,582	575,150
Cobalt pounds	114,954	248,376
Corundum short tons	1,964	39,051
Diamond stones carats	1,500,000	4,878,750
Fluorspar, acid-grade short dry tons	100,159	5,999,205
Graphite, natural, Malagasy short tons	330	40,227
Graphite, natural, Ceylon do	386	121,973
Lead do	12,181	3,222,277
Magnesium do	15,472	9,871,094
Manganese, battery grade, synthetic dioxide short dry tons	1,001	343,332
Manganese, metallurgical do	41,093	778,870
Mica, n.e.c. pounds	36,837	67,724
Mica, muscovite block do	362,814	223,811
Mica, muscovite film do	3,453	2,504
Mica, muscovite, splittings do	337,800	119,992
Mica, phlogopite splittings do	19,384	6,807
Molybdenum do	3,445,271	6,121,622
Nickel do	(1)	3,551,158
Quartz crystals do	93,955	375,032
Rare earths short dry tons	182	92,102
Talc short tons	26	4,358
Thorium pounds	5,000	9,650
Tin long tons	3,074	11,692,938
Tungsten pounds	397,892	1,343,961
Vanadium short tons	1,604	[2] 9,248,789
Zinc do	20,075	6,423,748
Zirconium ore, baddeleyite short dry tons	390	7,722
Total	----------	95,297,203
DEFENSE PRODUCTION ACT (DPA) INVENTORY		
Aluminum short tons	1,527	856,913
Asbestos, chrysotile do	305	56,425
Chromite, metallurgical short dry tons	900,778	6,491,077
Cobalt pounds	2,350,330	5,179,679
Columbium do	616,698	1,242,480
Copper short tons	[3] 667	798,334
Manganese, metallurgical short dry tons	6,884	74,159
Mica, muscovite block pounds	518,273	495,645
Titanium short tons	−536	[4] −1,124,857
Tungsten pounds	14,758,395	45,367,253
Total DPA	----------	59,437,108
OTHER		
Bauxite long dry tons	110,000	500,000
Copper short tons	----------	[5] 6,287
Mercury flasks	3,403	1,287,460
Silver (fine) troy ounces	----------	[6] 30,738,919
Total	----------	32,532,666
Grand total	----------	187,266,977

[1] Government use.
[2] Includes negative sales figure of $5,573 representing adjustment of earlier disposal contracts.
[3] Represents that portion of copper made available to the U.S. mint for coinage purposes.
[4] Negative sales figure represents adjustment of sales contract made in a previous report period.
[5] Represents that portion of sales proceeds of Treasury silver copper alloy in excess of $0.4215 per pound. Some 454,840 pounds of Treasury copper were sold at an average price of $0.44 per pound.
[6] Represents that portion of the total proceeds in excess of the U.S. monetary value based on $1.2929 per ounce. Some 34,623,905 ounces of silver were sold at an average price of $1.75 per ounce, and 32,491,283 ounces were sold at an average price of $1.73 per ounce.

Source: Executive Office of the President, Office of Emergency Preparedness. Stockpile Report to the Congress. January–June 1970, pp. 21–22; July–December 1970, pp. 14–15.

Table 61.—United Nations indexes of world [1] mineral industry production

(1963 =100)

Industry sector and geographic area	1968	1969	1970	1970 by quarters 1st	2nd	3rd	4th
EXTRACTIVE INDUSTRIES							
Metals:							
Non-Communist world	121	126	134	126	138	138	135
Industrialized countries [2]	122	124	135	125	140	139	136
United States and Canada	123	124	141	131	147	147	141
Europe	116	120	120	107	129	116	128
European Economic Community [3]	95	96	90	93	90	84	91
European Free Trade Association [4]	134	135	131	105	151	123	147
Australia and New Zealand	159	184	194	171	197	205	203
Less industrialized countries [5]	121	130	133	129	134	137	131
Latin America [6]	124	133	136	134	138	139	134
Asia [7]	120	126	138	128	136	145	144
Communist Europe [8]	160	167	181	182	179	182	180
World	130	135	145	139	147	148	145
Coal:							
Non-Communist world	91	89	89	90	90	85	91
Industrialized countries [2]	89	87	86	87	87	82	89
United States and Canada	114	114	124	116	126	120	132
Europe	80	77	74	77	74	69	75
European Economic Community [3]	80	79	77	78	76	74	80
European Free Trade Association [4]	77	71	66	73	70	58	63
Australia and New Zealand	151	168	182	158	186	199	181
Less industrialized countries [5]	114	120	120	120	121	116	121
Latin America [6]	131	135	138	NA	NA	NA	NA
Asia [7]	114	119	118	120	121	113	119
Communist Europe [8]	112	116	121	120	118	119	126
World	100	101	103	103	102	99	106
Crude petroleum and natural gas:							
Non-Communist world	136	147	159	156	156	157	165
Industrialized countries [2]	119	124	131	131	128	127	136
United States and Canada	120	123	130	129	126	126	135
Europe	131	143	158	165	151	148	169
European Economic Community [3]	133	147	164	173	157	152	177
European Free Trade Association [4]	NA	NA	NA	NA	NA	NA	NA
Australia and New Zealand	NA	NA	NA	NA	NA	NA	NA
Less industrialized countries [5]	158	177	196	189	194	196	204
Latin America [6]	117	118	121	120	120	122	123
Asia [7]	155	173	191	183	187	192	201
Communist Europe [8]	155	162	174	176	176	174	169
World	140	150	162	160	160	160	166
Total extractive industry:							
Non-Communist world	124	131	140	137	139	139	145
Industrialized countries [2]	115	117	124	122	123	122	128
United States and Canada	120	123	131	127	130	130	135
Europe	101	103	108	112	106	101	114
European Economic Community [3]	105	111	120	127	113	110	129
European Free Trade Association [4]	90	86	83	83	88	77	81
Australia and New Zealand	149	166	175	154	179	188	180
Less industrialized countries [5]	147	163	177	171	176	177	183
Latin America [6]	119	123	126	124	125	128	127
Asia [7]	149	165	180	174	178	180	189
Communist Europe [8]	138	142	151	151	152	150	151
World	129	135	143	142	143	142	147
PROCESSING INDUSTRIES							
Base metals:							
Non-Communist world	134	148	150	153	155	145	145
Industrialized countries [2]	133	148	149	153	155	143	144
United States and Canada	122	132	126	131	133	122	117
Europe	130	142	146	151	152	136	144
European Economic Community [3]	133	148	151	157	159	144	147
European Free Trade Association [4]	117	123	124	131	129	110	127
Australia and New Zealand	136	143	150	144	149	153	155
Less industrialized countries [5]	139	157	160	154	155	164	167
Latin America [6]	140	164	168	154	163	178	178
Asia [7]	139	151	150	157	147	145	154
Communist Europe [8]	147	155	165	165	165	165	166
World	138	150	154	157	158	151	152
Nonmetallic mineral products:							
Non-Communist world	131	141	144	129	149	151	148
Industrialized countries [2]	130	139	141	125	145	148	144
United States and Canada	124	132	128	120	132	134	127
Europe	129	137	142	119	149	152	150
European Economic Community [3]	125	133	140	111	148	153	147
European Free Trade Association [4]	130	136	135	123	140	135	140
Australia and New Zealand	132	147	151	140	153	158	151
Less industrialized countries [5]	143	157	172	161	177	173	178
Latin America [6]	144	152	166	155	166	168	173
Asia [7]	141	163	181	167	188	185	183
Communist Europe [8]	153	164	182	180	184	180	185
World	140	150	159	149	163	162	162

See footnotes at end of table.

Table 61.—United Nations indexes of world[1] mineral industry production—Continued

(1963 =100)

Industry sector and geographic area	1968	1969	1970	1970 by quarters			
				1st	2nd	3rd	4th
PROCESSING INDUSTRIES—Continued							
Chemicals, petroleum and coal products:							
Non-Communist world	154	168	178	176	180	176	182
Industrialized countries[2]	155	169	179	177	180	176	182
United States and Canada	146	157	158	158	160	157	159
Europe	161	178	194	192	197	188	199
European Economic Community[3]	166	184	201	201	204	196	204
European Free Trade Association[4]	145	159	171	167	175	163	176
Australia and New Zealand	147	159	174	159	176	177	184
Less industrialized countries[5]	147	160	174	170	171	177	179
Latin America[6]	146	159	176	NA	NA	NA	NA
Asia[7]	147	160	172	165	167	173	182
Communist Europe[8]	177	199	212	203	209	211	225
World	159	175	185	182	186	183	191
OVERALL INDUSTRIAL PRODUCTION							
Non-Communist world	135	145	150	148	151	146	152
Industrialized countries[2]	134	144	148	147	150	143	150
United States and Canada	133	139	136	138	138	134	133
Europe	128	139	146	144	149	137	154
European Economic Community[3]	128	141	150	148	152	140	158
European Free Trade Association[4]	123	129	133	132	135	123	140
Australia and New Zealand	136	146	154	145	154	156	160
Less industrialized countries[5]	142	155	165	159	165	166	170
Latin America[6]	136	145	154	NA	NA	NA	NA
Asia[7]	144	158	169	165	167	169	176
Communist Europe[8]	151	162	177	177	178	173	179
World	140	150	157	156	159	153	160

NA Not available.

[1] Excludes a number of countries of the Near East and Africa as well as mainland 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, South 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 1971, pp. x–xxiii.

Table 62.—Comparisons of world and U.S. production and U.S. imports of principal minerals and mineral fuels in 1970

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) 1970	Total U.S. production and imports (percentage of world total) 1969 r
METALLIC ORES AND CONCENTRATES					
Bauxite ---------- thousand long tons --	57,072	3.6	22.1	25.7	27.0
Chromite	6,517	----------	21.6	21.6	18.8
Copper (content of ore and concentrate)	6,527	26.3	4.4	30.8	28.8
Iron ore ---------- thousand long tons --	754,298	11.9	5.9	17.8	18.3
Lead (content of ore and concentrate)	3,750	15.3	1.1	16.4	17.5
Mercury ---- thousand 76-pound flasks --	284	9.6	7.7	17.3	21.2
Molybdenum (content of ore and concentrates) ---- short tons --	81,824	68.0	(1)	68.1	70.0
Nickel (content of ore and concentrates)	685	2.3	22.8	25.1	27.4
Platinum group (Pt, Pd, etc.) thousand troy ounces --	4,216	(1)	18.7	19.1	23.1
Silver ---- do ----	301,740	14.9	20.6	35.6	39.2
Titanium concentrates:					
Ilmenite [2]	3,942	22.0	6.6	28.7	37.6
Rutile [2]	461	----------	52.8	52.8	46.9
Tungsten concentrate (60-percent tungsten dioxide) ---- short tons --	37,009	11.0	1.7	12.7	11.9
Zinc (content of ore and concentrate)	6,060	8.8	7.4	16.2	18.9
METALS, SMELTER BASIS					
Aluminum	10,655	37.3	4.4	41.7	43.8
Copper	6,877	23.3	1.9	25.3	23.0
Iron, pig	479,000	19.3	.1	19.3	20.7
Lead	3,637	18.3	6.8	25.2	26.0
Magnesium	243	46.0	1.2	47.2	46.6
Steel ingots and castings	654,000	20.1	2.1	22.2	24.5
Tin ---------- thousand long tons --	222	----------	24.8	24.8	24.7
Uranium oxide [2] ---------- short tons --	23,997	53.8	2.5	56.3	56.9
Zinc	5,407	17.6	5.0	22.6	26.2
NONMETALS					
Asbestos	3,826	3.3	17.0	20.3	22.6
Cement --- thousand 376-pound barrels --	3,350,142	12.1	.4	12.2	13.1
Diamond ---------- thousand carats --	42,355	----------	41.6	41.6	45.9
Feldspar ---------- thousand long tons --	2,308	28.1	9.7	37.8	30.7
Fluorspar	4,600	5.9	23.7	29.6	31.5
Gypsum	55,583	17.0	11.0	28.0	27.9
Mica (including scrap)	174	68.4	3.4	71.8	78.4
Nitrogen, agricultural [3] [4]	42,747	25.6	5.8	31.4	31.8
Phosphate rock	93,858	41.3	.1	41.4	42.0
Potash (K_2O equivalent)	20,443	13.3	12.8	26.1	27.3
Salt [3]	156,365	29.8	2.3	32.1	32.0
Sulfur, elemental --- thousand long tons --	21,748	43.9	7.1	51.0	54.0
MINERAL ENERGY RESOURCES					
Crude petroleum ---- thousand barrels --	16,689,672	21.1	2.9	24.0	25.5
Natural gas ---------- million cubic feet --	37,820,609	58.0	2.2	60.1	62.4
Bituminous coal and lignite	3,086,447	19.5	(1)	19.5	18.8
Anthracite	201,629	4.8	----------	4.8	5.3

r Revised. p Preliminary.
[1] Less than ½ unit.
[2] World total exclusive of the U.S.S.R.
[3] Including Puerto Rico.
[4] Year ended June 30 of year stated.

Table 63.—Value of world export trade in major mineral commodity groups

(Million U.S. dollars)

Commodity group [1]	1965	1966	1967	1968	1969
Metals:					
All ores, concentrates and scrap	4,580	4,770	5,050	r 5,590	6,410
Iron and steel	9,700	9,670	10,330	r 11,430	13,690
Nonferrous metals	6,690	8,020	8,030	r 9,470	10,890
Subtotal	20,970	22,460	23,410	r 26,490	30,990
Nonmetals (crude only)	1,760	1,900	2,010	r 2,180	2,260
Mineral fuels	17,920	18,890	20,660	r 23,120	24,930
Total	40,650	43,250	46,080	r 51,790	58,180
All commodities	186,390	203,400	214,190	r 239,140	272,710

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 64.—Mineral commodity export price indexes

(1963 =100)

Year and quarter	Metal ores	Fuels	All crude minerals
1968	108	100	102
1969	114	100	104
1970:			
First quarter	124	103	108
Second quarter	122	104	108
Third quarter	121	106	110
Fourth quarter	121	108	110
Annual average	122	105	109

Source: United Nations. Monthly Bulletin of Statistics. New York, September 1971, p. 13.

Table 65.—Analysis of export price indexes

(1963 =100)

Year and quarter	Developed areas		Less developed areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1968	104	142	102	165
1969	107	158	103	187
1970:				
First quarter	118	176	104	211
Second quarter	120	174	104	205
Third quarter	124	162	104	181
Fourth quarter	126	154	104	166
Annual average	122	167	104	191

Source: United Nations. Monthly Bulletin of Statistics. New York, September 1971, p. 13.

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

By John L. Morning [1]

MINING TRENDS

The metals and nonmetals mineral industries had a good year despite an off-year for the national economy; value of production in 1970 increased nearly 8 percent to $9.64 billion. To accomplish this, over 4 billion tons of material was handled in producing nearly 2.7 billion tons of crude ore. Surface mining continued to dominate output of both material handled and crude ore, as output of ore at underground operations dropped significantly compared with that of 1969. Exploration and development work decreased compared with that of 1969, but total footage reported was the second highest on record.

The Market Research Department of the Engineering and Mining Journal in the past several years has conducted surveys to gain insight into the number and types of equipment used in the mineral industry. During 1970, a survey was published on front-end loaders and bulldozers along with a survey on mineral processing equipment. Both were for metal and nonmetal mining. Also published, were market reports for lubricating oil, grease, diesel fuel, and hydraulic fluid for both the metal and nonmetal mining industries, and for the coal industry. A market report on manual values was also published. In May, domestic and Candian readers of Engineering and Mining Journal were invited to join a panel that would be asked to respond to one survey per month for a period of 1 year.

Total quantity of water used (including recirculated or reused) by the minerals industry in 1968 was estimated to total 3.7 trillion gallons.[2] The Bureau of Census survey was limited to those establishments that used more than 20 million gallons annually, and covered over 1,700 plants. In a more comprehensive study conducted by the Bureau of Mines for the year 1962, with over 15,000 respondents, water usage totaled 3.4 trillion gallons. Based on value of total mineral output in 1970 dollars, over 3.9 trillion gallons were probably used in the mineral industry in 1968, and 4.2 trillion gallons in 1970.

Materials Handled.—In 1970, output of ore and waste at metal and nonmetal mines in the United States totaled 4,087 million tons, an increase of 3 percent over that of 1969. In 1960 and 1965 output was 2,783 and 3,213 million tons, respectively. In 1970 crude ore output totaled 2,677 million tons, compared with 2,030 million tons in 1960 and 2,402 million tons in 1965. In 1970 metal mines accounted for 586 million tons of crude ore, compared with 421 million tons in 1960 and 477 million tons in 1965. Copper and iron ore accounted for 85 percent of metal crude ore production, whereas phosphate rock, sand and gravel, and stone accounted for 93 percent of the nonmetal mine crude ore output. On a comparison basis, the percentages for these selected commodities for 1960 were 74 percent and 90 percent, re-

[1] Physical scientist, Division of Ferrous Metals.

[2] Bureau of the Census. 1967 Census of Mineral Industries. Water Use in the Minerals Industry: 1968 preliminary report MIC67(P)-3, October 1970.

spectively, and for 1965, 79 percent and 92 percent, respectively.

Waste handled in 1970 totaled 1,410 million tons, a 6-percent increase over that of 1969. Metal mines accounted for 69 percent and nonmetal mines 31 percent of total waste handled.

Nine States reported handling more than 100 million tons of material during the year. Ohio, Montana, and Wyoming dropped from the list of States and Texas was added. Five States indicated output of between 90 and 100 million tons. Arizona and Florida continued to lead the Nation in total material handled and California and Minnesota led in output of ore.

Magnitude of the Mining Industry.—Excluding sand and gravel operations, a total of 8,346 mines reported crude ore production during the year compared with 8,596 mines in 1969; sand and gravel operations totaled 8,808. Excluding stone and sand and gravel operations, metal mines accounted for 32 percent, and nonmetal mines accounted for 68 percent of the operating mines. Excluding clay, sand and gravel, and stone operations, 18 mines reported treating more than 10 million tons of crude ore; one more mine than in 1969. Copper led the list with eight mines, followed by iron ore with five, phosphate rock with four, and molybdenum with one. The Utah Copper Co. mine of Kennecott Copper Corp. was the leader in both output of ore and total material handled for metal mines. The Fort Mead mine of Mobil Chemical Co., treating phosphate rock, was the leader in output of crude ore; the Kingsford phosphate rock mine of International Minerals and Chemical Co. was the leader in total materials handled for nonmetal mines.

Comparison of Production From Surface and Underground Mines.—Surface mining contributed 94 percent of crude ore and 96 percent of total material handled in 1970. Both percentages were unchanged from those of 1969, although there were some minor shifts among the various commodities. Crude ore and waste handled at surface metal mines were 19 percent of total ore and 69 percent of total waste handled compared with 17 percent and 68 percent respectively in 1960 and 16 percent and 62 percent in 1965. Crude nonmetal material and waste material handled from surface mines were 91 percent of total nonmetal material and 60 percent of total waste handled.

Three metal commodities—antimony, lead, and manganese ore—and three nonmetal commodities—potassium salts, sodium carbonate, and wollastonite—were mined entirely by underground methods. Eight metal commodities and three nonmetal commodities were mined entirely by surface methods.

Underground mining continued to account for substantial percentages of crude ore handled in the following five States: Colorado, 41 percent; New Mexico, 32 percent; Missouri, 30 percent; Wyoming, 23 percent; and Tennessee, 21 percent. Eleven States reported no underground activity.

Ratio of Ore to Marketable Product.—The ratio of ore to marketable product varies with the mineral commodity and depends on grade of ore and type of valuable mineral content. The ratio for most metal mineral commodities with respect to time indicates rising ratios as grade of ore declines. For many nonmetal commodities, the ratio is 1 to 1. No discernable trend was evident in 1970 because many ratios remained virtually unchanged, and commodity ratios that increased were offset by those that decreased. The ratio of material handled to marketable product also varies with the mineral commodity and is mainly affected by the amount of development work and content of the valuable marketable material. The 1970 ratios tended to decrease for metal mines and to increase for nonmetal operations compared with those of 1969.

Exploration and Development.—Exploration and development work declined in 1970, the first time since 1966, but was the second highest footage reported since collection of data was initiated in 1958. The data is comparable with that of 1969, but does not include clay and stone mines reported in previous years. For metal mines, significant decreases were recorded for copper and uranium and for nonmetal mines, phosphate rock. Significant increases were noted for lead, silver, and zinc compared with those of 1969. Rotary drilling accounted for most of the decrease footage reported and most was accounted for in copper and uranium, although gypsum and phosphate rock footage was notably down.

Six States each reported over 1 million feet of exploration and development work. Wyoming led with 25 percent of the total, followed by Texas, 18 percent; New Mexico, 17 percent; and Arizona, 11 percent. Rotary drilling accounted for 73 percent of total activity. Shaft and winze sinking, raising, and diamond drilling indicated increased activity, but other categories indicated decreases compared with 1969 activity.

Stripping activities in phosphate rock accounted for 43 percent of the total material produced by exploration and development activities. Total tonnage produced decreased 22 percent compared with that of 1969. Arizona was the only State reporting over 100 million tons of material handled from exploration and development activities.

Explosives.—Explosives statistics for 1970 were released too late for incorporation into this chapter. Over 2.2 billion pounds of industrial explosives were reported consumed in the United States in 1969. The total was 14 percent higher than in 1968 and broke the record high that was established in 1966. Coal mining accounted for 37 percent, metal mining, 21 percent, and nonmetal mining, 20 percent. The mining industry accounted for over 1.7 billion pounds of the explosives used. Over 74 percent of the total used was ammonium nitrate, the use of which continued to dominate explosives used in mining.

The five top ranking States in order of total quality of explosives and blasting agents consumed were as follows: Kentucky, Pennsylvania, Ohio, Indiana, and Arizona. Kentucky replaced Pennsylvania, which was the 1968 leader. In 1969, the ranking States consumed 857 million pounds of the industrial explosives or 39 percent of the total. Eight States reported consumption of over 100 million pounds of explosives.

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

Table 1.—Material handled at surface and underground mines, by commodities, in 1970

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
METALS									
Bauxite	[1] 3,144	[1] 5,417	[1] 8,561	W	W	W	3,144	5,417	8,561
Copper	232,558	606,321	838,879	27,390	883	28,273	259,948	607,204	867,152
Gold:									
Lode	1,964	8,342	10,306	2,175	280	2,455	4,139	8,622	12,761
Placer	1,504	895	2,399	---	---	---	1,504	895	2,399
Iron ore	221,187	206,451	427,638	14,794	2,234	17,028	235,981	208,685	444,666
Lead	6	5	11	10,816	803	11,619	10,822	808	11,630
Mercury	269	1,773	2,042	173	24	197	442	1,797	2,239
Molybdenum	5,360	48,533	53,893	16,701	107	16,808	22,061	48,640	70,701
Nickel	1,138	600	1,738	---	---	---	1,138	600	1,738
Silver	25	135	160	737	190	927	762	325	1,087
Titanium: Ilmenite	23,698	2,946	26,644	---	---	---	23,698	2,946	26,644
Tungsten	20	---	20	711	14	725	731	14	745
Uranium	2,746	84,750	87,496	3,643	1,061	4,704	6,389	85,811	92,200
Zinc	379	244	623	9,629	1,650	11,279	10,008	1,894	11,902
Other [2]	4,513	2,047	6,560	16	7	23	4,529	2,054	6,583
Total metals	499,000	968,000	1,467,000	87,000	7,000	94,000	586,000	975,000	1,561,000
NONMETALS									
Abrasives [3]	217	7	224	40	---	40	257	7	264
Asbestos	1,595	1,669	3,264	21	---	21	1,616	1,669	3,285
Barite	3,886	1,660	5,546	107	2	109	3,993	1,662	5,655
Boron minerals	12,350	16,871	29,221	---	---	---	12,350	16,871	29,221
Clays	53,668	e 47,000	100,668	1,096	e 16	1,112	54,764	47,016	101,780
Diatomite	611	2,515	3,126	---	---	---	611	2,515	3,126
Feldspar	1,553	559	2,112	7	---	7	1,560	559	2,119
Fluorspar	31	33	64	776	5	781	807	38	845
Gypsum	7,161	15,307	22,468	2,258	132	2,390	9,419	15,439	24,858
Mica	341	419	760	---	---	---	341	419	760
Perlite	636	---	636	4	---	4	640	---	640
Phosphate rock	124,951	265,128	390,079	415	4	419	125,366	265,132	390,498
Potassium salts	---	---	---	16,604	933	17,537	16,604	933	17,537
Pumice	3,230	88	3,318	---	---	---	3,230	88	3,318
Salt	5,898	2	5,900	15,284	280	15,564	21,182	282	21,464
Sand and gravel	943,941	---	943,941	---	---	---	943,941	---	943,941
Sodium carbonate (natural)	---	---	---	4,221	2,673	6,894	4,221	2,673	6,894
Stone:									
Crushed and broken	833,964	e 70,000	903,964	38,693	e 270	38,963	872,657	70,270	942,927
Dimension	e 5,400	e 1,900	e 7,300	32	---	32	5,432	1,900	7,332
Sulfur: Frasch	7,932	---	7,932	---	---	---	7,932	---	7,932
Talc, soapstone, pyrophyllite	565	981	1,546	463	16	479	1,028	997	2,025
Vermiculite	1,445	4,108	5,553	---	---	---	1,445	4,108	5,553
Other [4]	2,078	1,753	3,831	72	---	72	2,150	1,753	3,903
Total nonmetals	2,011,000	431,000	2,442,000	80,000	4,000	84,000	2,091,000	435,000	2,526,000
Grand total	2,510,000	1,399,000	3,909,000	167,000	11,000	178,000	2,677,000	1,410,000	4,087,000

e Estimated. W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground; Bureau of Mines not at liberty to publish separately.
[2] Antimony, beryllium, magnesium, manganese, platinum-group metals, rare-earth metals, and vanadium.
[3] Emery, garnet, and tripoli.
[4] Aplite, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, olivine, pyrites, and wollastonite.

Table 2.—Material handled at surface and underground mines (including sand and gravel and stone), by States, in 1970[1]

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	30,672	23,921	54,593	2,070	207	2,277	32,742	24,128	56,870
Alaska	35,753	1,251	37,004	5	3	8	35,758	1,254	37,012
Arizona	157,550	350,273	507,823	16,947	625	17,572	174,497	350,898	525,395
Arkansas	32,209	6,247	38,456	830	2	832	33,039	6,249	39,288
California	218,834	67,205	286,039	2,187	179	2,366	221,021	67,384	288,405
Colorado	26,818	133	26,951	18,708	894	19,602	45,526	1,027	46,553
Connecticut	15,476	40	15,516	—	—	—	15,476	40	15,516
Florida	183,039	220,944	403,983	—	—	—	183,039	220,944	403,983
Georgia	39,708	49	39,757	1,008	—	1,008	40,716	49	40,765
Idaho	20,914	16,675	37,589	1,546	276	1,822	22,460	16,951	39,411
Illinois	99,534	—	99,534	2,764	—	2,764	102,298	—	102,298
Indiana	50,464	—	50,464	866	35	901	51,330	35	51,365
Iowa	46,716	5,966	52,682	1,964	—	1,964	48,680	5,966	54,646
Kansas	27,887	—	27,887	2,818	56	2,874	30,705	56	30,761
Kentucky	33,914	1	33,915	5,373	1	5,374	39,287	2	39,289
Louisiana	32,595	—	32,595	6,277	20	6,297	38,872	20	38,892
Maine	14,232	1,039	15,271	32	—	32	14,264	1,039	15,303
Maryland	29,980	—	29,980	126	—	126	30,106	—	30,106
Massachusetts	26,345	—	26,345	—	—	—	26,345	—	26,345
Michigan	128,884	16,062	144,896	12,715	244	12,959	141,549	16,306	157,855
Minnesota	208,007	106,631	314,638	—	—	—	208,007	106,631	314,638
Mississippi	13,051	—	13,051	—	—	—	13,051	—	13,051
Missouri	50,218	1,162	51,380	21,860	1,081	22,941	72,078	2,243	74,321
Montana	46,453	43,291	89,744	730	180	910	47,183	43,471	90,654
Nebraska	16,499	—	16,499	37	—	37	16,536	—	16,536
Nevada	32,725	64,057	96,782	78	36	114	32,803	64,093	96,896
New Hampshire	6,966	—	6,966	—	—	—	6,966	—	6,966
New Jersey	33,895	234	34,129	169	1	170	34,064	235	34,299
New Mexico	41,074	122,357	163,431	19,316	1,423	20,739	60,390	123,780	184,170
New York	82,035	4,016	86,051	6,302	202	6,504	88,337	4,218	92,555
North Carolina	51,728	15,021	66,749	100	—	100	51,828	15,021	66,849
North Dakota	8,280	—	8,280	—	—	—	8,280	—	8,280
Ohio	91,077	—	91,077	6,087	100	6,187	97,164	100	97,264
Oklahoma	24,799	6,411	31,210	992	—	992	25,791	6,411	32,202
Oregon	33,318	609	33,927	53	1	54	33,371	610	33,981
Pennsylvania	84,501	975	85,476	6,946	928	7,874	91,447	1,903	93,350
Rhode Island	2,808	—	2,808	—	—	—	2,808	—	2,808
South Carolina	18,007	263	18,270	—	—	—	18,007	263	18,270
South Dakota	18,865	4,649	23,514	1,994	146	2,140	20,859	4,795	25,654
Tennessee	43,334	8,862	52,196	11,852	705	12,557	55,186	9,567	64,753
Texas	92,297	11,909	104,206	628	5	633	92,925	11,914	104,839
Utah	61,848	101,558	163,406	1,630	402	2,032	63,478	101,960	165,438
Vermont	6,548	621	7,169	191	6	197	6,739	627	7,366
Virginia	46,951	35	46,986	2,997	628	3,625	49,948	663	50,611
Washington	39,712	1,217	40,929	299	160	459	40,011	1,377	41,388
West Virginia	12,178	—	12,178	2,380	—	2,380	14,558	—	14,558
Wisconsin	61,098	3,692	64,790	837	42	879	61,935	3,734	65,669
Wyoming	18,220	72,159	90,379	5,347	2,713	8,060	23,567	74,872	98,439
Other States[2]	8,792	22	8,814	—	—	—	8,792	22	8,814
Total	2,507,000	1,279,000	3,786,000	167,000	11,000	178,000	2,674,000	1,290,000	3,964,000

[1] Partially estimated data in table 1 not included in State totals.
[2] Delaware and Hawaii.

Table 3.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States, in 1970

(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] $9.57	[1] $0.81	[1] $10.38	W	W	W	$9.57	$0.81	$10.38
Copper	7.06	.39	7.45	$11.72	$1.00	$12.72	7.56	.46	8.02
Gold:									
Lode	5.14	---------	5.14	11.58	2.53	14.11	7.88	1.07	8.95
Placer	.92	---------	.92	---------	---------	---------	.92	---------	.92
Iron ore	3.71	---------	3.71	7.45	.22	7.67	3.95	.01	3.96
Lead	9.16	8.33	17.49	14.71	5.84	20.55	14.71	5.84	20.55
Mercury	16.05	---------	16.05	38.14	---------	38.14	24.53	---------	24.53
Molybdenum	3.13	---------	3.13	7.03	.37	7.40	6.06	.28	6.34
Silver	3.04	.77	3.81	38.53	10.73	49.26	37.51	10.44	47.95
Titanium: Ilmenite	.78	.23	1.01	---------	---------	---------	.78	.23	1.01
Tungsten	16.85	---------	16.85	21.93	4.88	26.81	21.79	4.75	26.54
Uranium	24.59	---------	24.59	22.21	6.03	28.24	23.25	3.41	26.66
Zinc	7.37	1.89	9.26	12.01	3.21	15.22	11.83	3.16	14.99
Average value [2]	5.36	.20	5.56	11.29	1.94	13.23	6.25	.46	6.71
NONMETALS									
Asbestos	6.25	.01	6.26	28.23	---------	28.23	6.54	.01	6.55
Barite	2.68	.03	2.71	15.64	---------	15.64	3.03	.03	3.06
Clays	4.81	---------	4.81	6.61	---------	6.61	4.85	---------	4.85
Diatomite	53.52	---------	53.52	---------	---------	---------	53.52	---------	53.52
Feldspar	5.89	.25	6.14	8.00	.14	8.14	5.90	.25	6.15
Fluorspar	29.03	---------	29.03	16.72	4.26	20.98	17.20	4.09	21.29
Gypsum	3.36	---------	3.36	4.82	---------	4.82	3.72	---------	3.72
Mica	20.89	.03	20.92	---------	---------	---------	20.89	.03	20.92
Perlite	[1] 8.64	---------	[1] 8.64	W	---------	W	8.64	---------	8.64
Phosphate rock	1.60	.04	1.64	7.46	---------	7.46	1.62	.04	1.66
Potassium salts	---------	---------	---------	5.26	---------	5.26	5.26	---------	5.26
Pumice	1.49	---------	1.49	---------	---------	---------	1.49	---------	1.49
Salt	17.89	1.11	19.00	6.60	.60	7.20	9.78	.75	10.53
Sand and gravel	1.18	---------	1.18	---------	---------	---------	1.18	---------	1.18
Stone:									
Crushed and broken	1.57	.01	1.58	1.68	---------	1.68	1.56	---------	1.56
Dimension	41.57	.09	41.66	150.28	---------	150.28	43.01	.09	43.10
Sulfur: Frasch	21.11	---------	21.11	---------	---------	---------	21.11	---------	21.11
Talc, soapstone, pyrophyllite	6.58	---------	6.58	8.75	---------	8.75	7.56	---------	7.56
Tripoli	12.53	---------	12.53	4.22	---------	4.22	7.64	---------	7.64
Vermiculite	5.54	---------	5.54	---------	---------	---------	5.54	---------	5.54
Average value [2]	1.72	.02	1.74	4.32	.15	4.47	1.82	.02	1.84
Average value—metal and nonmetals [2]	2.44	.06	2.50	8.03	1.03	9.06	2.79	.12	2.91
Average value—nonmetals (excluding stone, and sand and gravel) [2]	4.05	.17	4.22	6.74	.30	7.04	4.46	.19	4.65
Average value—metals and nonmetals (excluding stone, and sand and gravel) [2]	4.95	.19	5.14	9.85	1.43	11.28	5.68	.38	6.06

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.

Table 4.—Crude ore and total material handled at surface and underground mines, by commodities, in 1970

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	---	100	72	28
Bauxite	[1] 100	W	[1] 100	W
Beryllium	97	3	97	3
Copper	90	10	97	3
Gold:				
Lode	48	52	81	19
Placer	100	---	100	---
Iron ore	94	6	96	4
Lead	---	100	---	100
Magnesium	100	---	100	---
Manganese ore	---	100	---	100
Manganiferrous ore	100	---	100	---
Mercury	60	40	91	9
Molybdenum	24	76	76	24
Nickel	100	---	100	---
Platinum-group metals	100	---	100	---
Rare-earth metals	100	---	100	---
Silver	2	98	15	85
Tin	100	---	100	---
Titanium: Ilmenite	100	---	100	---
Tungsten	3	97	3	97
Uranium	44	56	95	5
Vanadium	100	---	100	---
Zinc	4	96	5	95
Total metals	85	15	94	6
NONMETALS				
Abrasives:				
Emery	100	---	100	---
Garnet	100	---	100	---
Tripoli	41	59	47	53
Aplite	100	---	100	---
Asbestos	99	1	99	1
NONMETALS—Continued				
Barite	97	3	98	2
Boron minerals	100	---	100	---
Clays	98	2	98	2
Diatomite	100	---	100	---
Feldspar	100	---	100	---
Fluorspar	4	96	8	92
Graphite	100	---	100	---
Greensand marl	100	---	100	---
Gypsum	76	24	90	10
Kyanite	100	---	100	---
Lithium minerals	100	---	100	---
Magnesite	100	---	100	---
Mica	100	---	100	---
Olivine	100	---	100	---
Perlite	99	1	99	1
Phosphate rock	100	---	100	---
Potassium salts	---	100	---	100
Pumice	100	---	100	---
Pyrites	100	---	100	---
Salt	28	72	28	72
Sand and gravel	100	---	100	---
Sodium carbonate (natural)	---	100	---	100
Stone:				
Crushed and broken	96	4	96	4
Dimension	99	1	99	1
Sulfur: Frasch process mines	100	---	100	---
Talc, soapstone, pyrophyllite	55	45	76	24
Vermiculite	100	---	100	---
Wollastonite	---	100	---	100
Total nonmetals	96	4	97	3
Grand total	94	6	95	5

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 States, in 1970

(Percent)

	Crude ore		Total material			Crude ore		Total material	
	Surface	Underground	Surface	Underground		Surface	Underground	Surface	Underground
STATE									
Alabama	94	6	96	4	Nebraska	100	---	100	---
Alaska	100	---	100	---	Nevada	100	---	100	---
Arizona	90	10	97	3	New Hampshire	100	---	100	---
Arkansas	97	3	98	2	New Jersey	100	---	100	---
California	99	1	99	1	New Mexico	68	32	89	11
Colorado	59	41	58	42	New York	93	7	93	7
Connecticut	100	---	100	---	North Carolina	100	---	100	---
Delaware	100	---	100	---	North Dakota	100	---	100	---
Florida	100	---	100	---	Ohio	94	6	94	6
Georgia	98	2	98	2	Oklahoma	96	4	97	3
Hawaii	100	---	100	---	Oregon	100	---	100	---
Idaho	93	7	95	5	Pennsylvania	92	8	92	8
Illinois	97	3	97	3	Rhode Island	100	---	100	---
Indiana	98	2	98	2	South Carolina	100	---	100	---
Iowa	96	4	96	4	South Dakota	90	10	92	8
Kansas	91	9	91	9	Tennessee	79	21	81	19
Kentucky	86	14	86	14	Texas	99	1	99	1
Louisiana	84	16	84	16	Utah	98	2	99	1
Maine	100	---	100	---	Vermont	97	3	97	3
Maryland	100	---	100	---	Virginia	94	6	93	7
Massachusetts	100	---	100	---	Washington	99	1	99	1
Michigan	91	9	92	8	West Virginia	84	16	84	16
Minnesota	100	---	100	---	Wisconsin	99	1	99	1
Mississippi	100	---	100	---	Wyoming	77	23	92	8
Missouri	70	30	69	31					
Montana	99	1	99	1	Total	94	6	95	5

Table 6.—Number of domestic metal and nonmetal mines in 1970, by commodity and magnitude of crude ore production

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	26	---	1	19	5	1	---
Copper	105	39	10	14	7	27	8
Gold:							
Lode	37	31	1	1	2	2	---
Placer	60	38	12	9	---	1	---
Iron ore	74	---	7	6	25	31	5
Lead	77	50	9	3	12	3	---
Mercury	80	46	20	14	---	---	---
Molybdenum	3	---	---	---	---	2	1
Nickel	1	---	---	---	---	1	---
Silver	94	56	29	7	2	---	---
Titanium: Ilmenite	6	---	---	---	1	5	---
Tungsten	36	11	23	1	1	---	---
Uranium	286	76	122	62	26	---	---
Zinc	72	15	9	24	24	---	---
Other [1]	27	15	4	2	4	2	---
Total metals	984	377	247	162	109	75	14
NONMETALS							
Abrasives [2]	20	13	3	3	1	---	---
Asbestos	9	3	1	2	3	---	---
Barite	36	3	5	17	10	1	---
Boron minerals	3	1	---	---	---	2	---
Diatomite	13	3	3	6	1	---	---
Feldspar	63	36	14	7	6	---	---
Fluorspar	15	1	7	4	3	---	---
Gypsum	66	1	5	24	36	---	---
Mica	17	7	7	2	1	---	---
Perlite	15	1	6	6	2	---	---
Phosphate rock	60	---	7	10	23	16	4
Potassium salts	10	---	---	---	4	6	---
Pumice	115	21	38	43	13	---	---
Salt	58	2	7	16	26	7	---
Sodium carbonate (natural)	3	---	---	---	1	2	---
Sulfur: Frasch-process mines	19	---	1	5	10	3	---
Talc, soapstone, pyrophyllite	64	16	24	23	1	---	---
Vermiculite	4	1	1	---	1	1	---
Other [3]	18	3	4	5	5	1	---
Total nonmetals	[4] 608	112	133	173	147	39	4
Grand total	1,592	489	380	335	256	114	18

[1] Antimony, beryllium, magnesium, manganese ore, manganiferrous ore, platinum-group metals, rare-earth metals, tin, and vanadium.
[2] Emery, garnet, and tripoli.
[3] Aplite, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, olivine, wollastonite, and zeolite.
[4] In addition, there were 1,523 clay mines, 8,808 sand and gravel operations, 4,600 crushed and broken stone operations, and 631 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 1970, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
METALS				
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Hoyt Lake	do	Pickands Mather & Co	do	Do.
Minntac	do	United States Steel Corp	do	Do.
Berkeley Pit	Mont	The Anaconda Company	Copper	Do.
Morenci	Ariz	Phelps Dodge Corp	do	Do.
San Manuel	do	Magma Copper Co	do	Caving.
Pima	do	Pima Mining Co	do	Open pit.
Climax	Colo	American Metal Climax, Inc	Molybdenum	Caving.
Sierrita	Ariz	Duval Sierrita Corp	Copper	Open pit.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Do.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Do.
Empire	Mich	Cleveland-Cliffs Iron Co	Iron ore	Do.
New Cornelia	Ariz	Phelps Dodge Corp	Copper	Do.
Inspiration	do	Inspiration Consolidated Copper Co.	do	Do.
Tyrone	N. Mex	Phelps Dodge Corp	do	Do.
Butler	Minn	The Hanna Mining Co	Iron ore	Do.
Republic	Mich	Cleveland-Cliffs Iron Co	do	Do.
Twin Buttes	Ariz	The Anaconda Co	Copper	Do.
Chino	N. Mex	Kennecott Copper Corp	do	Do.
Yerington	Nev	The Anaconda Co	do	Do.
Mission	Ariz	American Smelting and Refining Co.	do	Do.
Highland	Fla	E. I. du Pont de Nemours Co., Inc.	Ilmenite	Dredging.
White Pine	Mich	White Pine Copper Co	Copper	Open stopes.
Trail Ridge	Fla	E. I. du Pont de Nemours Co., Inc.	Ilmenite	Dredging.
NONMETALS				
Ft. Meade	Fla	Mobil Chemical Co	Phosphate rock	Open pit.
Suwannee	do	Occidental Chemical Co	do	Do.
Kingsford	do	International Minerals & Chemical Co.	do	Do.
Noralyn	do	do	do	Do.
Payne Creek	do	Agrico Chemical Co	do	Do.
Palmetto	do	do	do	Do.
Rockland	do	U.S.S. Agri-Chemicals Inc	do	Do.
Chicora	do	American Cyanamid Co	do	Do.
Silver City	do	Swift Agricultural Chemical Corp.	do	Do.
Saddle Creek	do	Agrico Chemical Co	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Clear Spring	do	International Minerals & Chemical Co.	do	Do.
Tampa Agricultural Chemical Operation.	do	Cities Service Co	do	Do.
Tenoroc	do	Borden Chemical Co	do	Do.
Bartow	do	U.S.S. Agri-Chemicals, Inc	do	Do.
Lee Creek	N.C	Texas Gulf Sulphur Co	do	Do.
Retsof	N.Y	International Salt Co	Salt	Open stopes.
Shafts I	N. Mex	Southwest Potash Co	Potassium salts	Do.
Watson	Fla	Swift Agricultural Chemicals Corp.	Phosphate rock	Open pit.
PCA	N. Mex	Potash Co. of America	Potassium salts	Open stopes.
International	do	International Minerals & Chemical Co.	do	Do.
Hobbs	do	Kerr-McGee Corp	do	Do.
Boron	Calif	United States Borax & Chemical Corp.	Boron minerals	Open pit.
Westvaco	Wyo	FMC Corp., Inorganic Chemicals Division.	Sodium compounds.	Stoping.
Belle Isle	La	Cargill, Inc	Salt	Open stopes.

[1] Clay, sand and gravel, stone, brines, and materials from wells excepted.

Table 8.—Twenty-five leading metal and nonmetal [1] mines in the United States in 1970, in order of output of total materials handled

Mines	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.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Do.
Hoyt Lake	Minn	Pickands Mather & Co	do	Do.
Berkeley Pit	Mont	The Anaconda Company	Copper	Do.
Questa	N. Mex	Molybdenum Corp of America.	Molybdenum	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Tyrone	N. Mex	Phelps Dodge Corp	Copper	Do.
Pima	Ariz	Pima Mining Co	do	Do.
Ray Pit	do	Kennecott Copper Corp	do	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Chino	N. Mex	Kennecott Copper Corp	Copper	Do.
Inspiration	Ariz	Inspiration Consolidated Copper Co.	do	Do.
Mission	do	American Smelting and Refining Co.	do	Do.
New Cornelia	do	Phelps Dodge Corp	do	Do.
Copper Cities Unit	do	Cities Service Co	do	Do.
North Walker	Wyo	Kerr-McGee Corp	Uranium	Do.
Yerington	Nev	The Anaconda Company	Copper	Do.
Lavender	Ariz	Phelps Dodge Corp	do	Do.
Sherman	Minn	United States Steel Corp	Iron ore	Do.
Dave Group	Wyo	Getty Oil Co	Uranium	Do.
San Manuel	Ariz	Magma Copper Corp	Copper	Caving.
Climax	Colo	American Metal Climax, Inc	Molybdenum	Do.
NONMETALS				
Kingsford	Fla	International Minerals & Chemical Co.	Phosphate rock	Open pit.
Ft. Meade	do	Mobil Chemical Co	do	Do.
Payne Creek	do	Agrico Chemical Co	do	Do.
Palmetto	do	do	do	Do.
Noralyn	do	International Minerals & Chemical Co.	do	Do.
Suwannee	do	Occidental Chemical Co	do	Do.
Rockland	do	U.S.S. Agri-Chemicals, Inc	do	Do.
Boron	Calif	United States Borax & Chemical Corp.	Boron minerals	Do.
Bonny Lake	Fla	W. R. Grace & Co	Phosphate rock	Do.
Saddle Creek	do	Agrico Chemical Co	do	Do.
Lee Creek	N.C	Texas Gulf Sulphur Co	do	Do.
Bartow	Fla	U.S.S. Agri-Chemicals Inc	do	Do.
Chicora	do	American Cyanamid Co	do	Do.
Tenoroc	do	Borden Chemical Co	do	Do.
Silber City	do	Swift Agricultural Chemicals Corp.	do	Do.
Tampa Agricultural Chemical Operations.	do	Cities Service Co	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
Clear Spring	Fla	International Minerals & Chemical Co.	do	Do.
Watson	do	Swift Agricultural Chemicals Corp.	do	Do.
Sydney	do	American Cyanamid Co	do	Do.
Westvaco	Wyo	FMC Corp., Inorganic Chemicals Division.	Sodium compounds.	Stoping.
Henry	Idaho	Monsanto Co	Phosphate rock	Open pit.
Williamson County Mine	Tenn	do	do	Do.
Retsof	N.Y	International Salt Co	Salt	Open stopes.
Shafts I	N. Mex	Southwest Potash Co	Potassium salts	Do.

[1] Clay, sand and gravel, stone, brines, and materials from wells, excepted.

Table 9.—Kind of surface mining operation, by commodities and States, in 1970

(Percent of crude ore)

	Strip and single bench	Multiple bench
COMMODITY		
METALS		
Antimony	100	---
Bauxite	74	26
Beryllium	100	---
Copper	27	73
Gold:		
Lode	---	100
Placer	100	---
Iron ore	20	80
Lead	100	---
Manganiferrous ore	100	---
Mercury	43	57
Molybdenum	---	100
Nickel	---	100
Rare-earth minerals	---	100
Silver	100	---
Titanium: Ilmenite	28	72
Tungsten	100	---
Uranium	24	76
Vanadium	---	100
Zinc	4	96
NONMETALS		
Abrasives:		
Emery	100	---
Garnet	3	97
Tripoli	100	---
Aplite	100	---
NONMETALS—Continued		
Asbestos	99	1
Barite	89	11
Boron minerals	---	100
Clays	98	2
Diatomite	87	13
Feldspar	75	25
Fluorspar	19	81
Graphite	100	---
Greensand marl	100	---
Gypsum	85	15
Kyanite	48	52
Lithium minerals	---	100
Magnesite	100	---
Mica	100	---
Olivine	100	---
Perlite	91	9
Phosphate rock	99	1
Potassium salts	100	---
Pumice	97	3
Salt	100	---
Sand and gravel	100	---
Stone:		
Crushed and broken	99	1
Dimension	100	---
Talc, soapstone, pyrophyllite	51	49
Vermiculite	12	88

	Strip and single bench	Multiple bench
STATE		
Alabama	100	---
Alaska	100	---
Arizona	19	81
Arkansas	90	10
California	78	22
Colorado	100	---
Connecticut	100	---
Delaware	100	---
Florida	100	---
Georgia	100	---
Hawaii	99	1
Idaho	89	11
Illinois	100	---
Indiana	100	---
Iowa	96	4
Kansas	100	---
Kentucky	100	---
Louisiana	100	---
Maine	92	8
Maryland	100	---
Massachusetts	100	---
Michigan	81	19
Minnesota	23	77
Mississippi	100	---
Missouri	100	---
Montana	94	6
Nebraska	100	---
Nevada	32	68
New Hampshire	100	---
New Jersey	100	---
New Mexico	45	55
New York	90	10
North Carolina	98	2
North Dakota	100	---
Ohio	99	1
Oklahoma	99	1
Oregon	95	5
Pennsylvania	100	---
Rhode Island	100	---
South Carolina	94	6
South Dakota	100	---
Tennessee	98	2
Texas	98	2
Utah	16	
Vermont	100	--
Virginia	100	---
Washington	96	4
West Virginia	91	9
Wisconsin	100	---
Wyoming	28	72

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States, by commodities, in 1970

Commodity	Unit of marketable product	Surface			Underground			Total		
		Ore (thousand short tons)	Marketable product, units	Ratio of units of ore to units of marketable product	Ore (thousand short tons)	Marketable product, units	Ratio of units of ore to units of marketable product	Ore (thousand short tons)	Marketable product, units	Ratio of units of ore to units of marketable product
METALS										
Bauxite	Thousand long tons	[1] 3,144	[1] 2,082	[1] 1.5:1	W	W	W	3,144	2,082	1.5:1
Copper	Thousand short tons	232,558	1,414	163.3:1	27,390	278	98.5:1	259,948	1,692	152.6:1
Gold:										
Lode	Thousand troy ounces	1,964	410	7.1:1	2,175	685	3.1:1	4,139	1,095	4.6:1
Placer	do	1,504	38	39.6:1	---	---	---	1,504	38	39.6:1
Iron ore	Thousand long tons	221,187	77,548	2.9:1	14,794	9,389	1.6:1	235,981	86,937	2.7:1
Lead	Thousand short tons	6	---	---	10,816	509	21.2:1	10,822	509	21.3:1
Mercury	Thousand flasks	269	10	27.9:1	173	16	10.9:1	442	26	17.4:1
Nickel	Thousand short tons	1,138	16	71.1:1	---	---	---	1,138	16	71.1:1
Silver	Thousand troy ounces	25	40	0.6:1	737	16,211	0.04:1	762	16,251	0.04:1
Titanium: Ilmenite	Thousand short tons	23,698	921	25.7:1	---	---	---	23,698	921	25.7:1
Uranium	do	2,746	6	465.3:1	3,643	9	404.0:1	6,389	15	428.5:1
Zinc	do	379	9	43.1:1	9,629	378	25.5:1	10,008	387	25.9:1
NONMETALS										
Asbestos	do	1,595	120	13.5:1	21	5	4.2:1	1,616	125	13.1:1
Barite	do	3,886	767	5.3:1	107	79	1.4:1	3,993	846	4.9:1
Boron minerals	do	12,350	994	12.5:1	---	---	---	12,350	994	12.5:1
Clays	do	53,668	53,752	1.0:1	1,096	1,100	1.0:1	54,764	54,852	1.0:1
Diatomite	do	611	597	1.0:1	---	---	---	611	597	1.0:1
Feldspar	Thousand long tons	1,553	610	2.5:1	7	6	1.2:1	1,560	616	2.5:1
Fluorspar	Thousand short tons	31	27	1.2:1	776	243	3.2:1	807	270	3.0:1
Garnet	do	186	17	11.0:1	---	---	---	186	17	11.0:1
Gypsum	do	7,161	7,102	1.0:1	2,258	2,222	1.0:1	9,419	9,324	1.0:1
Mica	do	341	81	1.2:1	---	---	---	341	81	1.2:1
Perlite	do	636	450	1.3:1	4	4	1.0:1	640	454	1.2:1
Phosphate rock	Thousand long tons	124,951	34,282	3.6:1	415	306	1.4:1	125,366	34,588	3.6:1
Potassium salts	Thousand short tons	---	---	---	16,604	2,467	6.7:1	16,604	2,467	6.7:1
Pumice	do	3,230	3,135	1.0:1	---	---	---	3,230	3,135	1.0:1
Salt	do	5,898	5,367	1.1:1	15,284	13,654	1.1:1	21,182	19,021	1.1:1
Sand and gravel	do	943,941	943,941	1.0:1	---	---	---	943,941	943,941	1.0:1
Sodium carbonate (natural)	do	---	---	---	4,221	2,549	2.4:1	4,221	2,549	2.4:1
Stone:										
Crushed and broken	do	833,964	834,531	1.0:1	38,693	38,062	1.0:1	872,657	872,593	1.0:1
Dimension	do	[e] 5,400	2,362	2.3:1	32	32	1.0:1	5,432	2,394	2.3:1
Sulfur: Frasch	Thousand long tons	7,932	6,419	1.1:1	---	---	---	7,932	6,419	1.1:1
Talc, soapstone, pyrophyllite	Thousand short tons	565	565	1.0:1	463	463	1.0:1	1,028	1,028	1.0:1
Tripoli	do	28	28	1.0:1	40	40	1.0:1	68	68	1.0:1
Vermiculite	do	1,445	286	4.1:1	---	---	---	1,445	286	4.1:1

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

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities, in 1970

Commodity	Unit of marketable product	Surface: Total material handled (thousand short tons)	Surface: Marketable product, units	Surface: Ratio of units of material handled to units of marketable products	Underground: Total material handled (thousand short tons)	Underground: Marketable product, units	Underground: Ratio of units of material handled to units of marketable products	Total: Total material handled (thousand short tons)	Total: Marketable product, units	Total: Ratio of units of material handled to units of marketable products
METALS										
Bauxite	Thousand long tons	[1] 8,561	[1] 2,082	[1] 4.1:1	W	W	W	8,561	2,082	4.1:1
Copper	Thousand short tons	838,879	1,414	529.6:1	28,273	278	101.7:1	867,152	1,692	455.1:1
Gold:										
Lode	Thousand troy ounces	10,306	410	25.1:1	2,455	685	3.6:1	12,761	1,095	11.7:1
Placer	do	2,399	38	63.1:1	----	----	----	2,399	38	63.1:1
Iron ore	Thousand long tons	427,638	77,548	5.5:1	17,028	9,389	1.8:1	444,666	86,937	5.1:1
Lead	Thousand short tons	11	----	----	11,619	509	22.8:1	11,630	509	22.8:1
Mercury	Thousand flasks	2,042	10	204.2:1	197	16	12.3:1	2,239	26	86.1:1
Nickel	Thousand short tons	1,738	16	108.6:1	----	----	----	1,738	16	108.6:1
Silver	Thousand troy ounces	160	40	4.0:1	927	16,211	0.1:1	1,087	16,251	0.1:1
Titanium: Ilmenite	Thousand short tons	26,644	921	28.9:1	----	----	----	26,644	921	28.9:1
Uranium	Short tons	87,496	6,000	14.6:1	4,704	9,000	0.5:1	92,200	15,000	6.1:1
Zinc	Thousand short tons	623	9	69.2:1	11,279	378	29.8:1	11,902	387	30.8:1
NONMETALS										
Asbestos	do	3,264	120	27.2:1	21	5	4.2:1	3,285	125	26.3:1
Barite	do	5,546	767	7.2:1	109	79	1.4:1	5,655	846	6.7:1
Boron minerals	do	29,221	994	29.4:1	----	----	----	29,221	994	29.4:1
Clays	do	100,668	53,752	1.9:1	1,112	1,100	1.0:1	101,780	54,852	1.9:1
Diatomite	do	3,126	597	5.2:1	----	----	----	3,126	597	5.2:1
Feldspar	Thousand long tons	2,112	610	3.5:1	7	6	1.2:1	2,119	616	3.4:1
Fluorspar	Thousand short tons	64	27	2.4:1	781	243	3.2:1	845	270	3.1:1
Garnet	do	186	17	10.9:1	----	----	----	186	17	10.9:1
Gypsum	do	22,468	7,102	3.2:1	2,390	2,222	1.1:1	24,858	9,324	2.7:1
Mica	do	760	81	9.4:1	----	----	----	760	81	9.4:1
Perlite	do	636	450	1.4:1	4	4	1.0:1	640	454	1.4:1
Phosphate rock	Thousand long tons	390,079	34,282	11.4:1	419	306	1.4:1	390,498	34,588	11.3:1
Potassium salts	Thousand short tons	----	----	----	17,537	2,467	7.1:1	17,537	2,467	7.1:1
Pumice	do	3,318	3,135	1.1:1	----	----	----	3,318	3,135	1.1:1
Salt	do	5,900	5,367	1.1:1	15,564	13,654	1.1:1	21,464	19,021	1.1:1
Sand and gravel	do	943,941	943,941	1.0:1	----	----	----	943,941	943,941	1.0:1
Sodium carbonate (natural)	do	----	133	----	6,894	2,416	2.9:1	6,894	2,549	2.7:1
Stone:										
Crushed and broken	do	903,964	834,531	1.1:1	38,963	38,062	1.0:1	942,927	872,593	1.1:1
Dimension	do	[e] 7,300	2,362	3.1:1	32	32	1.0:1	7,332	2,394	3.1:1
Sulfur: Frasch	Thousand long tons	7,932	6,419	1.2:1	----	----	----	7,932	6,419	1.2:1
Talc, soapstone, pyrophyllite	Thousand short tons	1,546	565	2.7:3	479	463	1.0:1	2,025	1,028	2.0:1
Tripoli	do	35	28	1.3:1	40	40	1.0:1	75	68	1.1:1
Vermiculite	do	5,553	286	19.4:1	----	----	----	5,553	286	19.4:1

[e] Estimated. W Withheld to avoid disclosing individual company confidential data.

[1] Includes underground data; Bureau of Mines not at liberty to publish separately.

Table 12.—Mining methods used in open-pit mining, by commodities, in 1970

(Percent)

Commodity	Total material handled		Commodity	Total material handled	
	Preceded by drilling and blasting	Not preceded by drilling and blasting		Preceded by drilling and blasting	Not preceded by drilling and blasting
METALS			NONMETALS—Continued		
Antimony	72	28	Boron minerals	100	---
Bauxite	82	18	Clays	---	100
Beryllium	1	99	Diatomite	---	100
Copper	91	9	Emery	100	---
Gold:			Feldspar	53	47
Lode	100	---	Fluorspar	89	11
Placer	3	97	Graphite	100	---
Iron ore	82	18	Greensand marl	---	100
Lead	63	37	Gypsum	93	7
Mercury	33	67	Kyanite	100	---
Molybdenum	100	---	Magnesite	100	---
Nickel	17	83	Mica	2	98
Platinum-group metals	---	100	Olivine	100	---
Rare-earth metals	100	---	Perlite	53	47
Silver	44	56	Phosphate rock	2	98
Titanium: Ilmenite	22	78	Pumice	3	97
Uranium	28	72	Sand and gravel	---	100
Vanadium	20	80	Stone:		
Zinc	100	---	Crushed and broken	3	97
			Dimension	---	100
NONMETALS			Talc, soapstone, pyrophyllite	49	51
Aplite	18	82	Vermiculite	66	34
Asbestos	89	11			
Barite	9	91	Total	33	67

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

Method	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
			1969			
Shaft and winze sinking	23,708	0.1	2,469	0.3	26,177	0.1
Raising	183,671	.6	11,612	r 1.3	195,283	.6
Drifting and crosscutting	870,558	2.8	24,922	2.8	895,480	2.8
Diamond drilling	2,155,272	7.0	88,905	9.9	2,244,177	7.1
Churn drilling	462,689	1.5	----------	--------	462,689	1.5
Rotary drilling	23,442,268	76.1	608,978	68.1	24,051,246	75.8
Percussion drilling	3,435,209	11.1	147,480	16.5	3,582,689	11.3
Trenching	101,099	.3	689	.1	101,788	.3
Other	141,181	.5	9,242	1.0	150,423	.5
Total	30,815,655	100.0	894,297	100.0	31,709,952	100.0
			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

r Revised.

Table 14.—Exploration and development by methods and selected metals and nonmetals, in 1970

(Feet)

Commodity	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
METALS										
Copper	14,022	82,725	90,856	4,730	1,056,167	47,836	325,147	69,423	42,242	1,733,148
Gold	628	10,921	35,589	2,300	67,814	2,832	52,695	11,869	837	185,485
Iron ore	----------	21,340	109,434	1,000	141,132	3,000	16,081	5,339	344	297,670
Lead	2,584	15,276	68,157	27,766	295,661	38,080	29,554	690,641	134,126	1,301,845
Mercury	259	4,410	9,501	140	28,631	----------	7,342	66,759	----------	117,042
Molybdenum	2,248	420	78,319	----------	88,609	----------	10,286	----------	2,221	182,108
Silver	2,454	7,388	31,941	4,341	90,253	----------	887	288,094	4,273	429,631
Tungsten	321	3,393	15,742	8,560	20,131	----------	----------	800	10,000	58,947
Uranium	5,961	17,660	203,194	13,804	180,515	4,503	19,484,046	740,335	80,242	20,730,260
Zinc	1,390	23,287	97,491	3,134	243,490	5,016	7,686	1,035,881	600	1,417,975
Other [1]	76	1,900	47,770	1,078	105,713	24,225	685,589	158,642	494,595	1,519,588
Total	29,943	188,720	787,994	66,853	2,318,116	125,492	20,619,313	3,067,783	769,480	27,973,694
NONMETALS										
Asbestos	----------	420	1,320	----------	----------	----------	----------	----------	----------	1,740
Barite	20	513	4,788	2,741	1,004	6,803	6,095	59,368	2,360	83,692
Fluorspar	240	1,195	4,118	----------	80,886	----------	----------	1,600	592	88,631
Gypsum	368	117	5,610	----------	2,500	850	70,233	100,180	----------	179,858
Phosphate rock	----------	982	118	800	2,610	----------	254,070	----------	----------	258,580
Talc, soapstone, pyrophyllite	2,000	4,294	5,583	----------	14,045	----------	160	22,000	----------	48,082
Other [2]	----------	----------	----------	12,701	29,050	9,100	59,654	3,700	18,310	132,515
Total	2,628	7,521	21,537	16,242	130,095	16,753	390,212	186,848	21,262	793,098
Grand total	32,571	196,241	809,531	83,095	2,448,211	142,245	21,009,525	3,254,631	790,742	28,766,792

[1] Antimony, bauxite, beryllium, columbium-tantalum, ilmenite, manganese ore, nickel, platinum-group metals, rare-earth metals, and vanadium.
[2] Boron minerals, diatomite, feldspar, mica (scrap), perlite, pumice, sulfur (Frasch), and tripoli.

Table 15.—Exploration and development by methods and States, in 1970

(Feet)

State	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
Alabama						21,300	415,001		80,230	516,531
Alaska		530	600	440	1,382	7,157			3,074	13,183
Arizona	14,197	66,243	58,064	5,815	566,527	33,886	2,348,803	52,832	41,000	3,187,367
Arkansas		513	15,364		10,062		100,869		10,275	137,083
California	1,970	9,104	28,558	845	109,647	1,350	10,412	87,903	12,511	262,300
Colorado	4,653	10,977	153,348	2,913	280,313	5,003	557,050	180,488	407,018	1,601,763
Florida							15,200			15,200
Georgia						6,803	4,075		1,500	12,378
Idaho	2,090	14,174	45,290	3,100	68,646		193,918	1,789,189	2,922	2,119,329
Illinois	30	890	2,940		88,852		9,395			102,107
Indiana	368									368
Iowa							4,032			4,032
Kansas						100	890			990
Kentucky	60	84	1,190		3,028			3,400		7,762
Maine				300	14,940			2,000		17,240
Michigan		8,626	24,768		35,106					68,500
Minnesota					231,038		1,526	2,264		234,828
Missouri	500	7,524	86,722	29,052	248,009	38,080	23,566	20,000	99,154	552,607
Montana	115	7,523	21,521	2,675	42,309	10,250	50	1,728	680	86,851
Nebraska							40,058			40,058
Nevada	605	1,335	4,931	11,470	68,704	600	86,737	163,003	510	337,895
New Jersey		1,443	859						5,885	8,187
New Mexico	384	26,258	197,022	340	109,230	1,200	4,045,908	538,684	58,481	4,977,507
New York	28	14,666	8,462		64,882			1,225		89,263
North Carolina	21	960	3,640		10,000	7,400			5,580	27,601
Oklahoma				361			97,651			98,012
Oregon	10	15	611	50			12,324	294		13,304
Pennsylvania	162	422	14,152		15,454					30,190
South Dakota		9,807	28,340	200	48,745		318,660	200		405,952
Tennessee	698	4,602	54,721		71,200		50,398	157,269	600	339,488
Texas	100	300	970		11,125		5,275,310		2,221	5,290,026
Utah	5,420	6,953	25,272	12,134	221,338	4,200	227,516	215,199	27,548	745,580
Vermont	800	500	1,660		1,800			22,000		26,760
Virginia		2,420	8,647		18,424		29,743	2,647		61,881
Washington		250	7,634	200	31,104		11,897	1,000	12,630	64,715
Wisconsin			3,501		39,973	4,916	2,200	12,306		62,896
Wyoming	360	122	10,744	13,200	36,373		7,126,336	1,000	18,923	7,207,058
Total	32,571	196,241	809,531	83,095	2,448,211	142,245	21,009,525	3,254,631	790,742	28,766,792

Table 16.—Total material (ore and waste) produced by exploration and development in the United States, by commodities and States, in 1970

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting and crosscutting	Trenching	Stripping	Total
COMMODITIES						
METALS						
Antimony	---	1	1	6	12	20
Bauxite	---	---	33	---	4,762	4,795
Copper	114	122	267	6	144,335	144,844
Gold:						
Lode	1	19	66	3	12	101
Placer	---	---	---	3	74	77
Iron ore	---	23	574	1	99,758	100,356
Lead	10	27	228	63	4	332
Mercury	---	5	14	---	1,781	1,800
Molybdenum	33	1	332	---	-------	366
Silver	11	18	79	17	104	229
Tungsten	---	5	54	3	-------	62
Uranium	19	18	471	83	64,330	64,921
Zinc	4	25	517	3	245	794
Other [1]	---	1	76	---	2,083	2,160
Total metals [2]	194	262	2,713	189	317,502	320,860
NONMETALS						
Barite	---	1	7	9	127	144
Fluorspar	---	3	12	---	13	28
Gypsum	2	---	29	---	13,974	14,005
Phosphate rock	---	2	---	4	257,308	257,314
Talc, soapstone, pyrophyllite	13	7	25	---	697	742
Other [3]	---	---	2	5	2,522	2,529
Total nonmetals [2]	15	13	75	19	274,640	274,762
Grand total [2]	209	277	2,788	209	592,144	595,627
STATE						
Alabama	---	---	---	---	432	432
Alaska	---	---	1	2	262	265
Arizona	114	76	175	6	67,938	68,309
Arkansas	---	1	40	---	6,249	6,290
California	13	15	120	1	3,732	3,881
Colorado	42	16	496	53	15	622
Florida	---	---	---	---	220,942	220,942
Georgia	---	---	---	---	49	49
Idaho	13	29	114	3	14,474	14,633
Illinois	---	3	10	---	-------	13
Indiana	2	---	---	---	35	37
Iowa	---	---	---	---	5,966	5,966
Kentucky	---	---	2	---	1	3
Michigan	---	5	52	---	16,062	16,119
Minnesota	---	---	---	---	84,857	84,857
Missouri	2	11	544	67	-------	624
Montana	---	25	61	12	5	103
Nevada	1	2	13	17	33,635	33,668
New Jersey	---	1	1	---	234	236
New Mexico	1	38	453	2	47,465	47,959
New York	---	14	18	---	-------	32
North Carolina	---	1	10	---	10,932	10,943
Pennsylvania	1	---	51	---	951	1,003
South Carolina	---	---	---	---	5	5
South Dakota	---	17	51	1	4,646	4,715
Tennessee	1	4	398	---	8,831	9,234
Texas	---	---	1	---	8,240	8,241
Utah	16	15	57	5	1,712	1,805
Vermont	2	1	3	---	-------	6
Virginia	---	2	38	---	8	48
Washington	---	1	19	---	607	627
Wisconsin	---	---	27	---	-------	27
Wyoming	1	---	32	39	47,453	47,525
Other [4]	---	---	1	1	6,406	6,408
Total	209	277	2,788	209	592,144	595,627

[1] Beryllium, ilmenite, manganiferrous ore, rare-earth metals, and vanadium.
[2] Data may not add to totals shown because of independent rounding.
[3] Asbestos, diatomite, feldspar, graphite, mica, perlite, pumice, and salt.
[4] Connecticut, Maine, Oklahoma, and Oregon.

Table 17.—U.S. consumption of industrial explosives
(Thousand pounds)

	Black blasting powder		High explosives		Blasting agents		
	Granular	Pellets	Permissible	Other than permissible	Ammonium nitrate, processed and unprocessed	Liquid oxygen explosives	Total
1965	464	372	76,040	542,318	1,260,107	5,598	1,884,899
1966	240	223	74,527	[1] 538,968	1,343,104	13,094	1,970,156
1967	242	182	68,770	[1] 537,997	1,287,506	10,017	1,904,714
1968	257	170	64,130	[1] 535,364	1,347,816	------	1,947,737
1969	209	61	60,364	[1] 541,279	1,624,564	------	2,226,477

[1] Includes blasting agents, rigidly cartridged, and water gels and slurries.

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		
1965	73,564	79	1,520	75,163
1966	71,091	95	1,957	73,143
1967	65,284	161	2,238	67,683
1968	60,943	267	1,394	62,604
1969	57,528	58	1,193	58,779
		OTHER HIGH EXPLOSIVES [1]		
1965	22,090	123,862	141,050	287,002
1966	19,591	118,900	141,117	279,608
1967	30,942	161,181	146,018	338,141
1968	29,482	195,315	144,663	369,460
1969	30,904	205,841	151,478	388,223
		AMMONIUM NITRATE BLASTING AGENTS		
1965	493,571	232,770	228,284	954,625
1966	514,549	234,336	252,794	1,001,679
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
		PELLET BLACK BLASTING POWDER		
1965	126	-------	61	187
1966	77	-------	25	102
1967	32	1	23	56
1968	-------	-------	11	11
1969	2	-------	21	23
		GRANULAR BLACK BLASTING POWDER		
1965	15	4	120	139
1966	245	-------	390	635
1967	3	3	101	107
1968	-------	3	98	101
1969	1	-------	94	95
		TOTAL EXPLOSIVES		
1965	589,366	356,715	371,035	1,317,116
1966	605,553	353,331	396,283	1,355,167
1967	651,564	327,596	409,525	1,388,685
1968	684,166	403,444	397,998	1,485,608
1969	820,114	470,791	438,789	1,729,694

[1] Includes blasting agents, rigidly cartridged, and water gels and slurries.

FLOTATION TRENDS [3]

The growth in beneficiation of ore by flotation methods was shown in 1970, by a record 405 million tons of ore processed. This is compared with 279 million tons processed in 1965 and 198 million tons processed in 1960. Most of the growth was in the large-volume commodities such as copper, copper-molybdenum, iron ore, and phosphate rock. Sulfide ore treatment continued to dominate the statistics, but treatment of other ores have shown higher growth rates.

A major advance in flotation equipment in the past 5 years has been the development and use of larger flotation cells, thereby keeping pace with increasing size of other processing equipment. Cell sizes of 300 to 500 cubic feet in volume were being installed at a rapid rate throughout the world, and at least one installation employed cells of up to 2,000 cubic feet in volume. Larger cells provide the advantage of lower operating and maintenance costs, and lower capital investment per ton of ore processed. Reports have been made that larger cells now outperform smaller cells because of a reduction in reagent consumption, better recovery, and lower horsepower consumption per unit volume. An additional advantage of these larger cells is the reduction in the number of instruments required for automatic control. Automatic control for flotation circuits is growing rapidly and allows continous monitoring and on-line analysis of the flotation process.

Research on various aspects of flotation was prolific during the 5-year period and is summarized annually in trade journals. The Annual Review issue of World Mining (London) published by the Mining Journal devotes considerable space to flotation developments. The Dow Chemical Co. annually prepares a literature index on worldwide flotation papers.

A considerable portion of published research concerns applied research for individual commodities and flotation reagents, but basic research on surface chemistry and kinetics is not neglected. Two English translations of Soviet material, partially sponsored by the Department of the Interior, were published during 1970 and indicate the interest of Soviet researchers in flotation processes.[4]

Research on flotation of metal oxide, carbonate, and nonmetal ores is expected to continue during the next decade, and the development and improvement in processes for treating these types of ore accelerated. An example of what can occur with increased technology was shown in iron ore during the past 5-year interval. The quantity of crude iron ore that was treated nearly doubled. The grade of concentrate rose 5 percent and recovery of iron values rose 11 percent. At the same time, great economies were made in reagent consumption, which declined 0.369 pound per ton and nearly 4 cents in value per ton of ore treated.

Magnitude of Flotation.—The number of flotation plants reporting operations in the United States during 1970 totaled 240, a decrease of 15 from that of 1965. Despite the reduced number of plants reporting, ore treated rose to a record high of 405 million tons, from 279 million tons in 1965 and 198 million tons in 1960. Concentrates produced rose to 54.1 million tons, from 38.7 million tons in 1965 and 21.5 million tons in 1960. Capacity rose significantly from 900,000 tons per day in 1965, to nearly 1.4 million tons per day in 1970. Ores were processed by froth flotation methods to recover various ferrous, nonferrous, and nonmetallic ores and coal. Twenty-nine different commodities were recovered.

Distribution of Flotation Plants.—The 240 reporting flotation plants were located in 33 States. West Virginia led with 34, followed by Arizona (21), New Mexico (17), Florida (17), Colorado (15), and Pennsylvania (15). Plants located in West Virginia and Pennsylvania primarily reflected a high level of activity in coal; those in Florida, phosphate rock; those in Arizona, copper; and those in New Mexico and Colorado, base metals. The number of

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[3] Prepared by John L. Morning and Gertrude Greenspoon, mineral specialist, Division of Nonferrous Metals.

[4] Glembotskii, V. A., G. M. Dmitrieva, and M. M. Sorokin. Nonpolar Flotation Agents. (Translated from Russian, Available from National Technical Information Services, Springfield, Va., TT70-50061, 1970, 115 pp.)

Solnyshkin, V. I. Flotation Agents and Effects. (Translated from Russian, Available from National Technical Information Services, Springfield, Va., TT70-50023, 1970, 97 pp.)

States reporting 10 or more plants increased to nine, compared with seven States in 1965. A number of plants changed categories from 1965 when flotation circuits were added to recover byproduct or coproduct materials.

Consumption of Energy, Water, and Grinding Media, Including Mill Liners.— Energy consumption in the operation of flotation plants increased significantly rising to over 5.9 billion kilowatt-hours in 1970, from 4.1 billion kilowatt-hours in 1965. A small part of the increase in total energy requirements was the result of better reporting, but most was accounted for by the growth in treating large-volume commodities such as copper, copper-molybdenum, iron ore, and phosphate rock. Energy used per ton of ore treated ranged from 8.2 kilowatt-hours to 64.1 kilowatt-hours, with an average of 15.3 kilowatt-hours for total ore treated. This compares with an average of 15.4 kilowatt-hours reported in 1965. Energy consumption included all that was consumed by processes preceding or following flotation, such as crushing, filtering, and material-handling.

Flotation plants used nearly 488 billion gallons of water in processing ore, a significant increase from 322 billion gallons reported in 1965, and 222 billion gallons in 1960. Consumption, per ton of ore treated, ranged from 3,359 gallons in the phosphate rock industry to 285 gallons in the potash industry. Average consumption for total ore treated was 1,310 gallons in 1970, compared with 1,240 gallons in 1965, and 1,140 gallons in 1960. Phosphate rock accounted for nearly 50 percent of water used. Total quantities reported included recirculated and new or makeup water.

The use of grinding media in preparation of ores for flotation increased nearly in direct proportion to the quantity of ore treated when compared with 1965. Total consumption for the industry during the year was rods, 72.9 million pounds; balls, 301 million pounds; and liners 32.0 million pounds. On a per-ton-of-ore-treated basis, consumption was rods, 0.539 pound; balls, 1.095 pounds; and liners, 0.143 pound; compared with 1965 consumption of rods, 0.549 pound; balls, 1.088 pounds; and liners 0.138 pound.

Consumption of Reagents.—Total consumption of flotation reagents in 1970 increased to over 2,067 million pounds, from 1,244 million pounds in 1965 and 849 million pounds in 1960. The average consumption of reagents per ton of ore treated rose from 4.297 pounds in 1960 and 4.507 pounds in 1965, to 5.114 pounds in 1970. Most categories of reagents indicated an increase in usage per ton of ore treated, however, the use of frothers decreased slightly and the use of flocculants decreased nearly 50 percent.

Value of reagents consumed during the year totaled $50.9 million, compared with $31.0 million in 1965, and $21.8 million in 1960. The average cost of reagents per ton of total ore treated was $0.126, compared with $0.112 in 1965 and $0.110 in 1960.

The following classification of reagents is used in this chapter:

Modifiers.—Reagents used to control alkalinity and to eliminate harmful effects of colloidal material and soluble salts.

Activators.—Reagents used to assist or improve the flotation of minerals that do not respond to a simple collector-froth combination.

Depressants.—Reagents used to improve the selective separation of minerals by lowering the floatability of specific minerals.

Collectors.—Reagents used to provide a water-repellent surface on the mineral to be floated so as to improve adherence of the mineral to air bubbles.

Frothers.—Reagents used to produce a froth of adequate durability to permit removal of mineral-carrying bubbles from the flotation machine.

Flocculants.—Reagents used to flocculate solids in aqueous suspension and thereby facilitate thickening and filtering operations.

Whenever possible, the chemical names rather than the trade names of reagents are reported. For those reagents whose chemical compositions are unkown or too complex for simple presentation, the trade names are shown. Included in those categories are Aero Depressants, Aerofloats, Aerofroths, Aero Promoters, Aeroflocs, and Superflocs (products of American Cyanamid Co.). Dowfroth, Dow–Z–200, and Separan (products of The Dow Chemical Co.); Minerec (product of Minerec Corp.) and Nalco (product of Nalco Chemical Co.). Also, to avoid disclosing confidential information, some reagents are not identified, but are included under "other", or information on two or more reagents is combined.

Sulfide Ores.—Flotation plants treating sulfide ores decreased from 108 in 1965, to 105 in 1970; however, daily capacity rose 39 percent. In continuing the past trend, ore treated and concentrate produced increased 40 percent and 23 percent, respectively, over that of 1965. In comparison, the increase reported for 1965 over that of 1960 was 29 percent and 23 percent, respectively. Sulfide ore treated during the year respresented 70 percent of total ore treated, compared with 72 percent in 1965, and 78 percent in 1960. Also, concentrate produced represented 16 percent of total concentrate recovered, compared with 19 percent in 1965, and 27 percent in 1960. Although there has been a sustained growth in treatment of sulfide ores during the past decade, flotation treatment of other ores have shown higher growth rates.

Reflecting the continued decline in grade of copper-bearing ores, ratio of concentration increased, rising to 31.8 to 1 in 1970, from 27.8 to 1, in 1965, and 26.5 to 1 in 1960. Reagents consumption during the past decade increased over 1 pound per ton of ore treated, rising to 4.556 pounds per ton of ore. Most of the increase was in modifiers.

Metal Oxides and Carbonates.—This group includes iron oxide, tungsten, ilmenite, and limestone. Although the number of plants in the group decreased by one compared with that of 1965, the daily average capacity increased 36 percent, owing primarily to increased capacity at iron ore plants. Ore treated and production of concentrate both rose 84 percent compared with that of 1965, and the ratio of concentration remained at 2.3 to 1. The quantity of ore treated during the year represented 7 percent of total material processed, compared with 6 percent in 1965, and over 1 percent in 1960. Concentrate recovered as a percent of total concentrate produced, rose to 24 percent, compared with 18 percent in 1965, and 4 percent in 1960.

Reagent consumption per ton of ore treated continued to decrease compared with previous years by decreasing to 2.244 pounds per ton of ore, compared with 2.614 pounds in 1965 and 12.036 pounds in 1960. With the exception of modifiers, other reagents indicated a substantial reduction in use on a per-ton-of-ore-treated basis.

Nonmetallic Ores.—Capacity of plants treating nonmetallic ore nearly doubled compared with that of 1965, despite a reduction in the number of plants reporting, from 64 in 1965 to 56 in 1970. Ore treated rose 54 percent, and concentrated produced rose 37 percent. Most of the increase was accounted for by the phosphate rock industry. The quantity of ore treated during the year represented 20 percent of total ore processed, compared with 19 percent in 1965 and 18 percent in 1960. Concentrate produced was 44 percent of total concentrate recovered, compared with 45 percent in 1965 and 55 percent in 1960. Ratio of concentration increased to 3.4 to 1, compared with 3.0 to 1 reported in 1965 and 1960.

Reagents consumption increased sharply for this classification of ores and rose 72 percent on a per-ton-of-ore-treated basis compared with that of 1965. Nearly all of the increase was the result of increased usage of modifiers and collectors in the phosphate rock industry.

Solid Mineral Fuels.—The number of reporting plants treating bituminous and anthracite coal decreased from 69 in 1965 to 66 in 1970. Despite the decrease in number of plants, daily tonnage capacity increased 33 percent. During the 5-year interval, the quantity of raw coal treated rose 37 percent, and the quantity of clean coal produced increased 20 percent. Although the growth rate for raw coal treated was significant, it was well below that for the period of 1960–65. Solid fuels accounted for 3 percent of total material handled, the same as in 1965, but was 2 percent higher than in 1960. Clean coal recovered dropped to 16 percent of total material recovered from 18 percent reported in 1965.

Consumption of reagents on a per ton of coal processed basis increased 36 percent compared with that of 1965. The use of modifiers increased substantially, whereas flocculant usage decreased sharply. Collectors accounted for more than half of total reagents consumed.

Copper.—Seventeen flotation plants reported treating copper ore in 1970, compared with 16 plants in 1965. During the 5-year interval, four plants became inactive and six new plants initiated operations. Three plants changed categories when flotation circuits were either deleted or added for molybdenum recovery. Plant capacity rose 27 percent over that of 1965, and ore treated increased more than 24 million tons. Production of concentrate increased 564,000 tons. Grade of ore treated decreased to 0.87-percent copper in 1970, from 0.92 percent copper reported in 1965 and 1960. Recovery of copper dropped from 84 percent in 1965 and 1960, to 80 percent in 1970. Coproduct gold and silver recovery was about the same as in 1965, although the average grade in 1970 was slightly higher. Despite a reagent consumption increase of nearly 0.7 pound per ton of ore treated compared with that of 1965, value of reagents consumed per ton was about the same. Plants treating copper ore were located in Arizona (six), New Mexico (four), Montana (two), Nevada (two), Oklahoma (one), Michigan (one), and Utah (one).

Copper-Molybdenum.—Plants treating copper-molybdenum ore increased to 16, compared with 13 in 1965. Daily capacity increased 53 percent, rising to 465,000 tons per day as two new mines entered production and two mines installed molybdenum circuits. During the 5-year interval, one mine shut down its molybdenum circuit. Ore treated rose from 107 million tons in 1965, to nearly 156 million tons in 1970, as the average grade of ore declined from 0.79 percent copper to 0.68 percent in 1970. Concentrate produced rose to over 3.5 million tons in 1970, from 2.8 million tons in 1965, of which 99 percent represented copper concentrate. Recovery of copper values increased slightly to 84 percent in 1970, from 83 percent in 1965; gold values recovered dropped to 64 percent, from 77 percent in 1965; and silver values recovered increased to 76 percent in 1970 from 73 percent in 1965. Molybdenum values recovered were not reported in 1965, but totaled 59 percent in 1970. The industry continued to make improvements in economies as reagent consumption decreased 0.6 pound per ton of ore treated in quantity and 1 cent in value compared with that of 1965.

Arizona led in number of plants treating copper-molybdenum ore with 12, followed by Utah (two), Nevada (one), and New Mexico (one).

Copper-Lead-Zinc.—The number of flotation plants treating copper-lead-zinc ore totaled 15 in 1970, an increase of one from that of 1965. Capacity rose to 40,200 tons per day in 1970, from 30,000 tons per day in 1965. Along with the increase in capacity, ore treated in 1970 increased 10 percent, rising to 9.4 million tons; concentrate produced rose 91 percent to 656,000 tons compared with that of 1965. The large increase in concentrate production was primarily accounted for by the increase in grade of ore treated. Although the copper content of ores treated remained at the same level as in 1965, the lead content rose to 4.21 percent in 1970, from 2.62 percent in 1965; zinc content nearly doubled, rising to 1.20 percent from 0.66 percent. Recovery of metal values approximated those reported in 1965. Average reagent consumption per ton of ore treated decreased nearly 0.8 pound, but average cost increased nearly 3 cents per pound compared with that of 1965.

Plants treating copper-lead-zinc ores were located in six States, led by Missouri (five), followed by Colorado (three), Idaho (three), New Mexico (two), Arizona (one), and Maine (one).

Copper-Zinc-Iron Sulfide.—Four plants, with a combined capacity of 11,000 tons per day, treated copper-zinc-iron sulfide ore in 1970; the same as in 1965. Ore treated dropped 3 percent compared with that of 1965, but concentrate produced increased 3 percent owing primarily to a reduction in grade of concentrate produced. In 1970 average grade of ore treated compared with that of 1965 remained the same for copper, increased 0.3 percent for zinc, and decreased 2.8 percent for iron sulfide. Average recoveries of copper, zinc, and iron sulfide decreased 2, 7, and 3 percent, respectively, from that of 1965. Reagent consumption per ton of ore treated increased 2.846 pounds and nearly 4 cents in value compared with that of 1965. Two plants in Pennsylvania and one each in Arizona and Tennessee reported treating copper-zinc-iron sulfide ores in 1970.

Gold-Silver.—Four plants reported treating gold-silver ores in 1970, compared with seven in 1965. Daily capacity continued a downward trend, dropping to 700 tons per day in 1970, from 1,600 tons per day in 1960 and 1,100 tons per day in 1965. Ore treated decreased 44 percent and concentrate produced dropped 62 percent compared with that of 1965. However, operating plants increased the ratio of concentration and, as a result, grade of concentrate produced increased significantly. Recovery of gold and silver values rose 16 and 22 percent, respectively, indicating improved operating performance. In addition to improved recoveries, improved economies were made in average consumption of reagent and costs per ton of ore treated, which decreased from 2.545 pounds and $0.169, respectively, in 1965 to 2.224 pounds and $0.088 respectively, in 1970. Although grade of ore for gold increased slightly, silver values more than doubled.

One plant each from California, Montana, Nevada, and Washington reported treating gold-silver ore.

Lead-Zinc.—Lead-zinc ore was treated at 11 flotation plants in 1970, compared with 10 in 1965. Daily capacity nearly doubled in the past 5 years, rising to 19,700 tons. In addition to increased capacity, the quantity of ore treated rose 60 percent to over 4.1 million tons. Production of lead concentrate increased to 175,000 tons compared with 27,000 tons in 1965; output of zinc concentrate decreased slightly from 229,000 tons in 1965 to 220,000 tons in 1970. The large increase in output of lead concentrate was accounted for by a shift in average grade of ore treated—lead content rose to 3.65 percent in 1970, compared with 1.04 percent in 1965. Zinc content dropped from 5.79 percent in 1965 to 3.40 in 1970. Average lead recovery rose to 97 percent in 1970, from 93 percent in 1965; zinc recovery decreased from 89 percent in 1965 to 87 percent in 1970. There was little change in average consumption of reagents per ton of ore, but average cost rose 4 cents per ton of ore treated.

Wisconsin had four plants treating lead-zinc ore, followed by Missouri, with two and one plant each operated in Colorado, Illinois, New York, Oklahoma, and Virginia.

Lead-Zinc-Silver.—Twenty-two flotation plants reported treating lead-zinc-silver ore in 1970; down nine plants from the 31 reported in 1965. As a result, capacity decreased from 30,000 tons per day in 1965, to 15,800 tons per day in 1970. Also, the quantity of ore treated declined 38 percent, to 3.235 million tons in 1970. Despite the decrease in ore treated, output of lead concentrate was about the same as in 1965 owing to the increase in the grade of ore treated, which rose to 4.4 percent lead in 1970, from 2.9 percent lead in 1965. At the same time, recovery of lead values decreased from 90 percent in 1965 to 87 percent in 1970. Output of zinc concentrate declined 28 percent despite an increase in grade of ore from 4.9 percent zinc in 1965 to 6.08 percent in 1970. Recovery of values dropped from 87 percent in 1965 to 82 percent in 1970. Reagent consumption reported was not strictly comparable with that of 1965, but data indicated that quantity and cost per ton of ore treated increased. Plants reporting treatment of lead-zinc-silver ore were located in Colorado (seven), Idaho (six), Utah (three), New Mexico (two), Washington (two), and one each in Arizona and California.

Zinc.—Flotation plants treating zinc ore decreased from 10 in 1965 to eight in 1970. Despite the reduction in number of plants, capacity increased to 16,100 tons per day in 1970, from 15,000 tons per day in 1965. The quantity of ore treated was about the same as in 1965, but concentrate produced declined slightly; recovery of values decreased from 95 percent in 1965, to 93 percent in 1970. Average grade of ore treated remained at nearly 5 percent zinc, the same as in 1965, but was down from the nearly 6 percent reported in 1960. Average consumption of reagents dropped from 1.036 in 1965, to 0.840 pound in 1970, but average cost rose 1 cent per ton. Most of the plants treating zinc ore were in Tennessee (five), with one each in Kentucky, New York, and Pennsylvania.

Feldspar, Mica, and Quartz.—Data on these commodities were combined to avoid disclosing individual company confidential information. Flotation plants treating ores of these minerals in 1970 decreased to 14, from 18 reporting in 1965, but capacity decreased only slightly to 10,000 tons per day. The quantity of ore treated increased 154,400 tons and concentrate produced increased by 148,451 tons compared with 1965. Most of the increased output was accounted for by quartz, which rose 186,680 tons, followed by feldspar, 41,406 tons; output of mica decreased 17,477 tons, and other products declined 62,158 tons.

Fluorspar.—Four plants reported treating fluorspar ore during the year compared with six plants in 1965. As a result, plant capacity, ore treated, and output of concentrate and recovery of byproducts decreased. Recovery of fluorspar dropped to 84 percent in 1970, compared with 92 percent in 1965, but was higher than the 77 percent recovered in 1960. Average total consumption of reagents increased, rising to 19.498 pounds per ton of ore treated compared with 14.834 pounds per ton in 1965, and 7.011 pounds per ton in 1960.

Three reporting plants were located in Illinois and one was located in Colorado. Heavy media preconcentration of ore was reported by three plants.

Iron.—In 1970 the number of iron ore flotation plants remained at six, the same as that of 1965, but capacity increased from 40,000 tons per day to 55,700 tons per day. Great strides were made during the 5-year interval as ore treated nearly doubled. More significant was the increase in iron content of concentrate produced which rose to 63.9 percent in 1970, compared with 58.8 percent in 1965. Also, reported recovery of iron rose from 72 percent in 1965, to 83 percent in 1970. Along with these accomplishments, reagent consumption dropped from 2.230 pounds per ton of ore treated in 1965, to 1.861 pounds per ton of ore in 1970, and value of reagents consumed decreased from $0.121 to $0.086 per ton of ore treated. Although modifiers increased both in quantity and value per ton of ore treated, increased effectiveness in usage of collectors accounted for decreased total reagent consumption. Plants treating iron ore by flotation were located in Michigan, (four), Missouri, (one), and New York, (one).

Limestone and Magnesite.—Because of the similar reagents used in the flotation of limestone and magnesite and to avoid disclosing confidential information, the data from these operations have been combined. The number of plants processing these materials in 1970 declined from five in 1965 to four in 1970; daily capacity, ore treated, and concentrate produced rose slightly. Reagent data are not comparable with 1965 and 1960 data. Plants were located in California, (one), Maryland, (one), Nevada, (one), and Texas, (one).

Phosphate.—Plants treating phosphate materials by flotation in 1970 increased by one, but daily capacity increased 2½ times that of 1965. Ore treated rose from 32 million tons in 1965 to nearly 65 million tons in 1970; concentrate produced increased from 11 million tons in 1965 to 18.6 million tons in 1970. With the vast quantity of ore treated, grade of ore decreased from 14.7 percent P_2O_5 in 1965, to 12.1 percent in 1970. Other changes include average grade of concentrate produced which declined to 32.9 percent P_2O_5 in 1970, from 34.3 percent P_2O_5 in 1965, and recovery of values decreased from 80 percent in 1965 to 78 percent. Reagent consumption increased 3.102 pounds per ton of ore treated over that of 1965, returning to the level of that consumed in 1960. Of the 19 reporting plants treating phosphate material, 17 were in Florida and one each was in North Carolina and Utah.

Potash.—Flotation plants treating potash ore in 1970 decreased to eight from nine reporting in 1965, but capacity increased to 52,200 tons per day from 50,000 tons per day. Despite the slight increase in capacity, quantity of ore processed declined 27 percent, to nearly 12 million tons owing to development of new mines in Canada that produce lower cost potash. Grade of ore treated increased 1.5 percent, to 18.76 percent potassium oxide (K_2O) from the 17.28 percent reported in 1965. As a result of the higher grade ore treated, concentrate production dropped only 23 percent, and grade of concentrate remained at 57 percent potassium oxide. Recovery of values decreased to 85 percent, compared with 87 percent in 1965. Total reagent consumption rose to 2.089 pounds per ton of ore treated in 1970, from 0.959 pound in 1965; cost per ton increased from $0.136 in 1965 to $0.204 in 1970. Reporting plants were located in New Mexico (six) and Utah (two).

Anthracite.—Four flotation plants reported treating anthracite in 1970, compared with five in 1965 and 1960. Raw coal treated rose 66 percent, to 1.236 million tons, but clean coal produced dropped 13 percent to 355,000 tons compared with that of 1965. Much of the recovered coal was the result of salvaging operations in treating material such as river silt bank fines. Reagent consumption per ton of raw coal treated rose 0.493 pound and 1 cent in value, to 3.156 pounds and 10.3 cents, respectively, compared with that of 1965. All plants treating anthracite were in Pennsylvania.

Bituminous Coal.—Reporting bituminous coal flotation plants dropped to 62 in 1970 from 64 in 1965, but capacity increased to 58.400 tons per day from 42,000 tons per day. Corresponding with the increased capacity, total raw coal treated rose 34 percent, and clean coal produced increased 22 percent compared with those of 1965; raw coal reached to 11.8 million tons, and treated coal reached 8.1 million tons. Reagent consumption per ton of raw coal treated rose 0.254 pound in quantity and nearly 3 cents in value compared with that of 1965. Similar to anthracite, many of the producers used flotation for salvaging coal values from washer-plant water or recovery of values from extremely fine material. West Virginia led in number of plants treating bituminous coal with 34, followed by Virginia (nine), Pennsylvania (eight), Kentucky (five), Alabama (three), and Colorado, New Mexico, and Utah with one each.

Miscellaneous.—Data for some flotation operations are not shown separately to avoid disclosing company confidential information. Also, because of dissimilarity of data for various plants, it would be inappropriate to combine the data. However, the data have been included in the totals to present complete information on flotation in the minerals industry.

Flotation plants for which data have been handled in this manner included the following:

Commodity	Number and State
Antimony	1 in Idaho.
Barite	2 in Arkansas.
Do	1 in Georgia.
Bastnaesite	1 in California.
Garnet	1 in New York.
Ilmenite	1 in New York.
Do	1 in Virginia.
Kyanite	1 in Georgia.
Do	2 in Virginia.
Mercury	4 in Alaska.
Molybdenum	2 in Colorado.
Do	1 in New Mexico.
Talc	1 in Alabama.
Do	1 in Vermont.
Tungsten	1 in California.
Vermiculite	1 in Montana.

Table 19.—Froth flotation plants in 1970, by States

State	Number	State	Number
Alabama	4	New Jersey	2
Alaska	4	New Mexico	17
Arizona	21	New York	5
Arkansas	2	North Carolina	7
California	8	Ohio	1
Colorado	15	Oklahoma	2
Florida	17	Pennsylvania	15
Georgia	3	South Carolina	1
Idaho	10	Tennessee	6
Illinois	4	Texas	1
Kentucky	6	Utah	10
Maine	1	Vermont	1
Maryland	1	Virginia	13
Michigan	5	Washington	3
Missouri	8	West Virginia	34
Montana	4	Wisconsin	4
Nevada	5	Total	240

Table 20.—Froth flotation in 1970

Plants: Type	Plants: Number	Plants: Capacity (short tons per day)	Ore treated (short tons)	Concentrates produced (short tons)	Energy used (kilowatt-hours): Total (million)	Energy used: Per ton	Water used (gallons): Total (million)	Water used: Per ton	Rod consumption (pounds): Total	Rod consumption: Per ton	Ball consumption (pounds): Total	Ball consumption: Per ton	Liner consumption (pounds): Total	Liner consumption: Per ton
Antimony	1	W	W	W	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	17	230,000	79,828,000	2,386,447	1,270.5	16.0	59,803.5	750	11,359,333	0.344	64,564,580	0.992	3,848,676	0.112
Copper-molybdenum	16	465,000	155,939,200	3,518,093	2,281.7	14.6	111,501.9	715	37,938,608	.614	191,602,876	1.304	21,410,426	.151
Copper-lead-zinc	15	40,200	9,443,600	656,227	159.7	16.9	4,812.6	510	1,528,187	.198	2,596,678	.287	691,135	.097
Copper-zinc-iron	4	11,000	3,193,000	1,061,876	69.2	21.7	2,573.3	805	868,520	.280	1,978,114	.620	W	W
Gold-silver	4	700	97,700	961	NA	NA	NA	NA	W	W	28,403	.303	1,749	.022
Lead-zinc	11	19,700	4,153,000	395,121	88.2	19.5	3,007.6	725	1,006,739	.279	963,612	.248	77,356	.051
Lead-zinc-silver	22	15,800	3,235,000	511,220	86.2	26.6	2,624.7	810	738,149	.864	4,444,150	1.545	448,112	.228
Zinc	8	16,100	3,751,000	285,601	53.6	14.3	1,872.4	500	890,964	.241	652,349	.201	105,364	.044
Barite	3	W	W	W	W	W	W	W	----------	----	W	W	W	W
Bastnaesite	1	W	W	W	W	W	W	W	W	W	W	W	----------	-----
Feldspar-mica-quartz	14	10,000	2,365,400	1,418,311	44.5	18.8	5,558.6	2,350	999,710	.812	W	W	124,436	.108
Fluorspar	4	1,750	418,500	179,212	26.8	64.1	652.7	1,560	----------	----	338,799	.810	108,265	.285
Garnet	1	W	W	W	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ilmenite	2	W	W	W	W	W	W	W	W	W	W	W	W	W
Iron ores	6	55,700	27,286,100	11,927,496	795.7	29.2	53,450.0	1,960	14,296,675	.928	21,937,656	1.426	4,636,630	.174
Kyanite	3	W	W	W	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Limestone-magnesite	4	4,600	1,094,400	863,621	NA	NA	NA	NA	W	W	W	W	W	W
Mercury	4	W	W	W	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	3	W	W	W	W	W	W	W	W	W	W	W	W	W
Phosphate	19	305,900	64,790,900	18,559,945	529.3	8.2	234,119.1	3,615	W	W	----------	----	----------	-----
Potash	8	52,200	11,702,000	3,271,965	184.0	15.7	3,348.5	285	NA	NA	NA	NA	NA	NA
Talc	2	W	W	W	W	W	W	W	NA	NA	W	W	NA	NA
Tungsten	1	W	W	W	W	W	W	W	W	W	W	W	----------	-----
Vermiculite	1	W	W	W	NA	NA	NA	NA	W	W	----------	----	----------	-----
Anthracite	4	4,000	1,236,000	355,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bituminous coal	62	58,400	11,770,200	8,063,200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	240	1,366,900	405,254,000	54,144,206	5,940.2	15.3	487,806.3	1,310	72,918,142	.539	301,266,472	1.095	32,045,965	.143

NA Not available. W Withheld to avoid disclosing individual company confidential data; included in "Total."

Table 21.—Consumption of reagents by types and plants in froth flotation in 1970

Type of plant	Reagent consumption (pounds)													
	Modifiers		Activators		Depressants		Collectors		Frothers		Flocculants		Total	
	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Copper	640,370,297	8.063	158,388	0.078	63,229	0.006	6,953,885	0.087	3,799,912	0.048	337,308	0.006	651,683,019	8.169
Copper-molybdenum	497,176,970	3.188	---	---	6,135,382	.054	9,911,134	.064	12,718,876	.082	2,154,075	.028	[1] 528,123,127	[1] 3.387
Copper-lead-zinc	5,437,763	1.000	941,291	.110	5,827,811	.626	1,089,490	.116	375,550	.040	28,062	.012	13,699,967	1.464
Copper-zinc-iron	26,605,063	9.098	1,268,438	.716	332,523	.191	990,692	.310	306,432	.096	13,813	.005	29,516,961	9.244
Gold-silver	187,310	2.495	---	---	---	---	25,524	.263	742	.040	2,102	.028	215,678	2.224
Lead-zinc	2,964,458	.885	1,664,698	.414	1,079,914	.269	604,799	.151	354,029	.088	14,077	.077	[1] 6,772,600	[1] 1.685
Lead-zinc-silver	5,314,197	2.081	2,584,263	.938	1,553,862	.564	760,455	.274	495,397	.178	21,219	.014	[1] 10,748,178	[1] 3.870
Zinc	798,165	3.369	1,854,761	.494	28,248	.070	250,072	.067	220,766	.059	---	---	3,152,012	.840
Barite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Bastnaesite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Feldspar-mica-quartz	8,093,208	3.953	---	---	301,500	.900	3,547,776	1.664	353,823	.264	26,761	.059	12,323,068	5.779
Fluorspar	6,207,827	14.835	365,588	.946	1,041,121	2.695	419,652	1.003	124,376	.322	963	.030	8,159,527	19.498
Garnet	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Ilmenite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Iron ores	23,630,257	4.379	---	---	210,518	.343	26,672,577	.978	51,811	.024	205,029	.016	50,770,192	1.861
Kyanite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Limestone-magnesite	888,853	4.441	---	---	993,730	4.965	3,171,029	2.898	59,342	.219	15,242	.015	5,128,196	4.686
Mercury	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Molybdenum	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Phosphate	134,346,171	2.150	---	---	---	---	515,594,226	7.958	688,683	.069	28,000	.056	650,657,080	10.042
Potash	10,888,518	1.200	---	---	6,220,460	.641	5,021,954	.429	1,670,253	.143	646,314	.063	24,447,499	2.089
Talc	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Tungsten	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Vermiculite	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Anthracite	---	---	---	---	---	---	3,505,729	2.836	395,019	.320	---	---	3,900,748	3.156
Bituminous coal	2,716,208	2.861	---	---	---	---	4,265,992	1.657	2,168,955	.192	2,204,030	.209	11,355,185	.965
Total	1,396,337,689	3.938	8,971,913	.382	28,937,078	.164	600,392,057	1.521	26,204,468	.082	5,798,638	.032	[1] 2,066,777,943	[1] 5.114

W Withheld to avoid disclosing individual company confidential data; included in "Total."

[1] Includes other reagents as follows: Copper-molybdenum, 26,690 pounds (0.003 pound per ton); lead-zinc, 90,625 pounds (0.060 pound per ton); lead-zinc-silver, 18,785 pounds (0.080 pound per ton); and total, 136,100 pounds (0.014 pound per ton).

Table 22.—Froth flotation of sulfide ores

Operating data	1960	1965	1970
Plants:			
Number	95	108	105
Capacity .... short tons per day	545,700	622,300	861,900
Ore treated .... short tons	155,125,000	200,754,000	281,660,000
Concentrates produced .... do	5,855,000	7,213,000	8,863,000
Ratio of concentration	26.5:1	27.8:1	31.8:1

CONSUMPTION OF REAGENTS

Type	Total (pounds)			Pounds per ton		
	1960	1965	1970	1960	1965	1970
Modifier	489,706,448	765,676,534	1,198,742,990	3.710	4.114	4.408
Activator	7,858,889	8,983,093	8,487,774	.353	.281	.371
Depressant	6,338,230	10,863,482	17,061,189	.089	.101	.104
Collector	25,346,078	23,982,758	32,132,931	.163	.120	.114
Frother	12,411,044	15,501,516	20,612,413	.080	.077	.073
Flocculant	1,129,430	551,362	2,623,618	.026	.007	.018
Other	----------	112,349,217	136,100	-----	4.867	.014
Total	542,790,119	937,907,962	1,279,797,015	3.499	4.684	4.556

Table 23.—Froth flotation of metallic carbonate and oxide ores

Operating data	1960	1965	1970
Plants:			
Number	13	14	13
Capacity .... short tons per day	13,600	47,500	64,800
Ore treated .... short tons	2,854,000	16,079,000	29,625,000
Concentrates produced .... do	941,000	7,086,000	13,040,000
Ratio of concentrates	3.0:1	2.3:1	2.3:1

CONSUMPTION OF REAGENTS

Type	Total (pounds)			Pounds per ton		
	1960	1965	1970	1960	1965	1970
Modifier	6,639,418	15,279,991	31,635,105	2.368	3.444	4.713
Activator	1,280,205	----------	----------	5.000	-----	-----
Depressant	609,809	1,588,578	2,626,525	.320	1.466	1.276
Collector	22,572,698	23,694,707	31,818,552	8.049	1.479	1.074
Frother	1,344,778	864,657	164,497	1.333	.090	.046
Flocculant	1,306,029	458,285	220,271	1.618	.250	.016
Total	33,752,937	41,886,218	66,464,950	12.036	2.614	2.244

Table 24.—Froth flotation of nonmetallic ores

Operating data	1960	1965	1970
Plants:			
Number	55	64	56
Capacity short tons per day	143,500	191,400	377,800
Ore treated short tons	36,191,000	52,653,000	80,963,000
Concentrates produced do	11,888,000	17,376,000	23,823,000
Ratio of concentration	3.0:1	3.0:1	3.4:1

CONSUMPTION OF REAGENTS

Type	Total (pounds)			Pounds per ton		
	1960	1965	1970	1960	1965	1970
Modifier	82,455,910	54,889,380	163,243,386	3.566	1.278	2.178
Activator	2,987,585	511,677	484,139	.887	1.038	.820
Depressant	9,231,057	4,346,025	9,249,364	.755	.451	.870
Collector	163,967,377	188,118,763	528,668,853	4.576	3.741	6.585
Frother	2,475,037	4,869,852	2,863,584	.166	.219	.119
Flocculant	874,974	3,206,689	750,719	.129	.187	.062
Total	261,991,940	255,942,386	705,260,045	7.311	5.089	8.749

Table 25.—Froth flotation of anthracite and bituminous coal

Operating data	1960	1965	1970
Plants:			
Number	31	69	66
Capacity short tons per day	26,500	47,000	62,400
Raw coal treated short tons	4,112,000	9,500,000	13,006,000
Clean coal produced do	2,795,000	7,033,000	8,418,000

CONSUMPTION OF REAGENTS

Type	Total (pounds)			Pounds per ton		
	1960	1965	1970	1960	1965	1970
Modifier	1,609,352	298,274	2,716,208	3.841	1.922	2.861
Collector	8,142,058	4,055,306	7,771,721	3.015	1.988	2.039
Frother	584,798	1,554,801	2,563,974	.175	.166	.204
Flocculant	393,885	2,301,001	2,204,030	.332	.365	.209
Total	10,730,093	8,209,382	15,255,933	2.610	.864	1.173

Table 26.—Froth flotation of copper ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	17	Total ... millions	59,803.5
Capacity ... short tons per day	230,000	Per ton	750
Ore treated:		Rod consumption, pounds:	
Short tons	79,828,000	Total	11,359,333
Grade:		Per ton	0.344
Copper ... percent	0.87	Ball consumption, pounds:	
Gold ... ounce per ton	0.0026	Total	64,564,580
Silver ... do	0.1325	Per ton	0.992
Energy used, kilowatt-hours:		Liner consumption, pounds:	
Total ... millions	1,270.5	Total	3,848,676
Per ton	16.0	Per ton	0.112

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade			Recovery (percent)		
		Copper (percent)	Gold (ounce per ton)	Silver (ounces per ton)	Copper	Gold	Silver
Copper	2,386,447	23.34	0.0608	3.3138	80	71	83

CONSUMPTION OF FLOTATION REAGENTS [1]

Function and name	Total	Per ton
Modifier: Calgon, lime, Nalco, phosphates, sulfuric acid:		
Pounds	640,370,297	8.063
Value	$4,315,523	$0.054
Activator: Sodium sulfide:		
Pounds	158,388	0.078
Value	$12,482	$0.006
Depressant:		
Pounds	63,229	0.006
Value	$5,691	$0.0005
Collector: Aerofloat 31, Aerofloat 244, Aero Promoter 404, Aero Promoter 3501, Dow Z-200, Minerec, potassium amyl xanthate, sodium isobutyl xanthate, sodium isopropyl xanthate, Thiocarbamate:		
Pounds	6,953,885	0.087
Value	$2,828,937	$0.035
Frother: Aerofroth 65, cresylic acid, Dowfroth 250, methyl isobutyl carbinol, pine oil:		
Pounds	3,799,912	0.048
Value	$805,883	$0.010
Flocculant: Nalco, Separan:		
Pounds	337,308	0.006
Value	$283,246	$0.005
Total reagents:		
Pounds	651,683,019	8.169
Value	$8,251,762	$0.103

[1] Based on 14 operations.

Table 27.—Froth flotation of copper-molybdenum ores in 1970

OPERATING DATA

Plants:	
Number	16
Capacity short tons per day	465,000
Ore treated:	
Short tons	155,939,200
Grade:	
Copper percent	0.68
Gold ounce per ton	0.0052
Silver do	0.0558
Molybdenum percent	0.020
Energy used, kilowatt-hours:	
Total millions	2,281.7
Per ton	14.6
Water used, gallons:	
Total millions	111,501.9
Per ton	715
Rod consumption, pounds:	
Total	37,938,608
Per ton	0.614
Ball consumption, percent:	
Total	191,602,876
Per ton	1.304
Liner consumption, pounds:	
Total	21,410,426
Per ton	0.151

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Copper (percent)	Grade: Gold (ounce per ton)	Grade: Silver (ounces per ton)	Grade: Molybdenum (percent)	Recovery (percent): Copper	Recovery (percent): Gold	Recovery (percent): Silver	Recovery (percent): Molybdenum
Copper	3,486,509	25.27	0.1373	2.3067	-------	84	64	76	-------
Molybdenite	31,584	-------	-------	-------	53.73	------	------	------	[1] 59

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Calgon, lime, Nalco, phosphates, sodium carbonate, sodium hydroxide, sodium silicate, sulfuric acid, other:		
Pounds	497,176,970	3.188
Value	$4,351,750	$0.028
Depressant: Dextrine, Nokes Reagent, phosphorus pentasulfide, sodium cyanide, sodium ferrocyanide, sodium hydrosulfide:		
Pounds	6,135,382	0.054
Value	$490,837	$0.004
Collector: Aerofloat 235, Aerofloat 238, Aerofloat 3302, Aero Promoter 404, burner oil, Dow Z-200, fuel oil, kerosine, Minerec, potassium amyl xanthate, Sodium Aerofloat, sodium ethyl xanthate, sodium isopropyl xanthate, Stepanflote, stove oil, xanthate:		
Pounds	9,911,134	0.064
Value	$2,079,727	$0.013
Frother: Aerofroth 65, Aerofroth 71, Aerofroth 73, creosote, cresylic acid, Dowfroth, methyl isobutyl carbinol, pine oil, Shellfroth:		
Pounds	12,718,876	0.082
Value	$2,121,877	$0.014
Flocculant: Aerofloc 550, Nalco, Polyhall M-59, Separan:		
Pounds	2,154,075	0.028
Value	$2,822,936	$0.037
Other:		
Pounds	26,690	0.003
Value	$5,909	$0.001
Total reagents:		
Pounds	528,123,127	3.387
Value	$11,873,036	$0.076

[1] Based on 15 operations.

Table 28.—Froth flotation of copper-lead-zinc ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	15	Total ----- millions	4,812.6
Capacity ----- short tons per day	40,200	Per ton	510
Ore treated:		Rod consumption, pounds:	
Short tons	9,443,600	Total	1,528,187
Grade:		Per ton	0.198
Copper ----- percent	0.40	Ball consumption, pounds:	
Lead ----- do	4.21	Total	2,596,678
Zinc ----- do	1.20	Per ton	0.287
Gold ----- ounce per ton	0.0187	Liner consumption, pounds:	
Silver ----- ounces per ton	5.2023	Total	691,135
Energy used, kilowatt-hours:		Per ton	0.097
Total ----- millions	159.7		
Per ton	16.9		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Copper (percent)	Grade: Lead (percent)	Grade: Zinc (percent)	Grade: Gold (ounce per ton)	Grade: Silver (ounces per ton)	Recovery (percent): Copper	Recovery (percent): Lead	Recovery (percent): Zinc	Recovery (percent): Gold	Recovery (percent): Silver
Copper	117,092	25.47	6.20	6.03	0.1658	185.4593	77	1	6	40	87
Lead	435,858	.88	72.83	1.60	.5090	4.0184	3	95	3	27	8
Zinc	103,277	1.06	1.79	54.40	.0452	8.7967	1	----	70	5	2

CONSUMPTION OF FLOTATION REAGENTS [1]

Function and name	Total	Per ton
Modifier: Lime, sulfuric acid, other:		
Pounds	5,437,763	1.000
Value	$78,510	$0.014
Activator: Copper sulfate, sodium sulfide:		
Pounds	941,291	0.110
Value	$191,556	$0.022
Depressant: Santosite, sodium cyanide, sodium dichromate, sodium hydroxide, sodium sulfite, starch, sulfur dioxide, zinc sulfate:		
Pounds	5,827,811	0.626
Value	$440,164	$0.047
Collector: Aerofloat 31, Aerofloat 242, Aero Promoter 404, Aero Promoter 3477, Aero Promoter 3501, Dow Z-200, potassium amyl xanthate, potassium ethyl xanthate, Sodium Aerofloat, sodium isopropyl xanthate, other:		
Pounds	1,089,490	0.116
Value	$420,899	$0.045
Frother: Aerofroth 65, Aerofroth 71, Barrett oil, Dowfroth, methyl isobutyl carbinol, pine oil:		
Pounds	375,550	0.040
Value	$66,073	$0.007
Flocculant: Aerosol, Separan, other:		
Pounds	28,062	0.012
Value	$7,768	$0.003
Total reagents:		
Pounds	13,699,967	1.464
Value	$1,204,970	$0.129

[1] Based on 13 operations accounting for 99 percent of total ore.

Table 29.—Froth flotation of copper-zinc-iron sulfide ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	4	Total ... millions	2,573.3
Capacity ... short tons per day	11,000	Per ton	805
Ore treated:		Rod consumption, pounds:	
Short tons	3,193,000	Total	868,520
Grade, percent:		Per ton	0.280
Copper	0.82	Ball consumption, pounds:	
Zinc	1.89	Total	1,978,114
Iron sulfide	33.28	Per ton	0.620
Energy used, kilowatt-hours:			
Total ... millions	69.2		
Per ton	21.7		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Gold (ounce per ton)	Grade: Silver (ounces per ton)	Grade: Copper (percent)	Grade: Zinc (percent)	Grade: Iron sulfide (percent)	Recovery (percent): Copper	Recovery (percent): Zinc	Recovery (percent): Iron
Copper	116,682	0.0096	1.1288	18.64			90		
Zinc	40,644				50.65			61	
Iron	904,550					91.22			80

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Lime, sodium silicate, sulfur dioxide, sulfuric acid:		
Pounds	26,605,063	9.098
Value	$242,373	$0.083
Activator: Copper sulfate:		
Pounds	1,268,438	0.716
Value	$132,461	$0.075
Depressant: Guar, sodium cyanide, zinc sulfate:		
Pounds	332,523	0.191
Value	$59,876	$0.034
Collector: Aero Promoter 404, potassium amyl xanthate, sodium ethyl xanthate, sodium isopropyl xanthate, sodium secondary-butyl xanthate:		
Pounds	990,692	0.310
Value	$119,356	$0.037
Frother: Cresylic acid, Dowfroth 250, methyl isobutyl carbinol, pine oil:		
Pounds	306,432	0.096
Value	$62,203	$0.019
Flocculant: Aerofloc 550, Nalco, Separan:		
Pounds	13,813	0.005
Value	$13,177	$0.005
Total reagents:		
Pounds	29,516,961	9.244
Value	$629,446	$0.197

Table 30.—Froth flotation of gold-silver ores in 1970

OPERATING DATA

Plants:		Ball consumption:	
Number	4	Total ... pounds	28,403
Capacity ... short tons per day	700	Per ton	0.303
Ore treated:		Liner consumption:	
Short tons	97,700	Total ... pounds	1,749
Grade, ounces per ton:		Per ton	0.022
Gold	0.6065		
Silver	5.4575		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	(Grade (ounces per ton)		Recovery (percent)	
		Gold	Silver	Gold	Silver
Gold-Silver	961	57.8913	510.9938	94	92

CONSUMPTION OF FLOTATION REAGENTS [1]

Function and name	Total	Per ton
Modifier:		
Pounds	187,310	2.495
Value	$2,997	$0.040
Collector: Aerofloat 31, Aerofloat 208, Aero Promoter 404, Dow Z-200, sodium secondary-butyl xanthate:		
Pounds	25,524	0.263
Value	$3,736	$0.039
Frother:		
Pounds	742	0.040
Value	$139	$0.007
Flocculant:		
Pounds	2,102	0.028
Value	$1,682	$0.022
Total reagents:		
Pounds	215,678	2.224
Value	$8,554	$0.088

[1] Based on 3 operations accounting for 99 percent of total ore.

Table 31.—Froth flotation of lead-zinc ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	11	Total ... millions	3,007.6
Capacity ... short tons per day	19,700	Per ton	725
Ore treated:		Rod consumption, pounds:	
Short tons	4,153,000	Total	1,006,739
Grade, percent:		Per ton	0.279
Lead	3.65	Ball consumption, pounds:	
Zinc	3.40	Total	963,612
Energy used, kilowatt-hours:		Per ton	0.248
Total ... millions	88.2	Liner consumption, pounds:	
Per ton	19.5	Total	77,356
		Per ton	0.051

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade			Recovery (percent)	
		Lead (percent)	Zinc (percent)	Silver (ounces per ton)	Lead	Zinc
Lead	175,423	74.80	----------	1.2898	97	----------
Zinc	219,698	----------	56.83	9.6782	----------	87

CONSUMPTION OF FLOTATION REAGENTS [1]

Function and name	Total	Per ton
Modifier: Lime, soda ash:		
Pounds	2,964,458	0.885
Value	$34,476	$0.010
Activator: Copper sulfate:		
Pounds	1,664,698	0.414
Value	$380,368	$0.095
Depressant: Calcium cyanide, sodium cyanide, zinc sulfate:		
Pounds	1,079,914	0.269
Value	$142,746	$0.036
Collector: Aerofloat 31, Aerofloat 211, Aerofloat 242, Aero Promoter 404, Dow Z-200, Sodium Aerofloat, sodium ethyl xanthate, sodium isopropyl xanthate, sodium secondary-butyl xanthate, xanthate:		
Total	604,799	0.151
Value	$182,637	$0.045
Frother: Aerofroth 65, Aerofroth 70, methyl isobutyl carbinol, pine oil:		
Pounds	354,029	0.088
Value	$59,616	$0.015
Flocculant: Aerofloc 550, Separan, Superfloc:		
Pounds	14,077	0.007
Value	$16,630	$0.008
Other:		
Pounds	90,625	0.060
Value	$18,524	$0.012
Total reagents:		
Pounds	6,772,600	1.685
Value	$834,997	$0.208

[1] Based on 10 operations accounting for 97 percent of total ore.

Table 32.—Froth flotation of lead-zinc-silver ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	22	Total ... millions	2,624.7
Capacity ... short tons per day	15,800	Per ton	810
Ore treated:		Rod consumption, pounds:	
Short tons	3,235,000	Total	738,149
Grade:		Per ton	0.864
Lead ... percent	4.40	Ball consumption, pounds:	
Zinc ... percent	6.08	Total	4,444,150
Copper ... percent	0.35	Per ton	1.545
Gold ... ounces per ton	0.0733	Liner consumption, pounds:	
Silver ... ounces per ton	4.9449	Total	448,112
Energy used, kilowatt-hours:		Per ton	0.228
Total ... millions	86.2		
Per ton	26.6		

CONCENTRATES PRODUCED

Type	Quantity (short tons)	Grade: Copper (percent)	Grade: Lead (percent)	Grade: Zinc (percent)	Grade: Gold (ounces per ton)	Grade: Silver (ounces per ton)	Recovery (percent): Copper	Recovery (percent): Lead	Recovery (percent): Zinc	Recovery (percent): Gold	Recovery (percent): Silver
Lead	218,005	3.10	57.48	7.41	0.5941	47.3321	70	87	9	79	83
Zinc	293,215	0.65	4.00	53.22	0.0614	3.7643	14	8	82	6	8

CONSUMPTION OF FLOTATION REAGENTS [1]

Function and name	Total	Per ton
Modifier: Lime, soda ash:		
Pounds	5,314,197	2.081
Value	$93,012	$0.036
Activator: Copper sulfate, sodium hydrosulfide:		
Pounds	2,584,263	0.938
Value	$487,867	$0.177
Depressant: Aero Depressant 610, Aero Depressant 633, sodium cyanide, sodium sulfite, zinc sulfate:		
Pounds	1,553,862	0.564
Value	$176,841	$0.064
Collector: Aerofloat 25, Aerofloat 31, Aerofloat 130, Aerofloat 208, Aerofloat 238, Aerofloat 242, Aero Promoter 404, Dow Z-200, Minerec, potassium amyl xanthate, potassium ethyl xanthate, Sodium Aerofloat, sodium ethyl xanthate, sodium isopropyl xanthate, Thiocarbanilide:		
Pounds	760,455	0.274
Value	$235,500	$0.085
Frother: Aerofroth 65, Aerofroth 71, Barrett oil, cresylic acid, Dowfroth, methyl isobutyl carbinol, pine oil:		
Pounds	495,397	0.178
Value	$98,955	$0.036
Flocculant: Aerosol, Guar, Separan, Superfloc:		
Pounds	21,219	0.014
Value	$14,960	$0.010
Other:		
Pounds	18,785	0.080
Value	$1,574	$0.007
Total reagents:		
Pounds	10,748,178	3.870
Value	$1,108,709	$0,399

Based on 16 operations accounting for 86 percent of total ore.

Table 33.—Froth flotation of zinc ores in 1970

OPERATING DATA

Plants:		Rod consumption, pounds:	
Number	8	Total	890,964
Capacity ... short tons per day	16,100	Per ton	0.241
Ore treated:		Ball consumption, pounds:	
Short tons	3,751,000	Total	652,349
Zinc ... percent	4.99	Per ton	0.201
Energy used, kilowatt-hours:		Liner consumption, pounds:	
Total ... millions	53.6	Total	105,364
Per ton	14.3	Per ton	0.044
Water used, gallons:			
Total ... millions	1,872.4		
Per ton	500		

CONCENTRATES PRODUCED

Quantity ... short tons	285,601
Zinc ... percent	61.02
Recovery ... do	93

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Lime:		
Pounds	798,165	3.369
Value	$10,613	$0.045
Activator: Copper sulfate:		
Pounds	1,854,761	0.494
Value	$385,790	$0.103
Depressant:		
Pounds	28,248	0.070
Value	$5,085	$0.013
Collector: Aerofloat 211, Dow Z-200, Sodium Aerofloat, sodium ethyl xanthate:		
Pounds	250,072	0.067
Value	$77,683	$0.021
Frother: Aerofroth 65, Dowfroth 250, Dowfroth 1012, pine oil:		
Pounds	220,766	0.059
Value	$64,480	$0.017
Total reagents:		
Pounds	3,152,012	0.840
Value	$543,651	$0.145

Table 34.—Froth flotation of feldspar, mica, and quartz ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	14	Total ... millions	5,558.6
Capacity ... short tons per day	10,000	Per ton	2,350.0
Ore treated ... short tons	2,365,400	Rod consumption, pounds:	
Energy used, kilowatt-hours:		Total	999,710
Total ... millions	44.5	Per ton	0.812
Per ton	18.8	Liner consumption, pounds:	
		Total	124,436
		Per ton	0.108

CONCENTRATES PRODUCED, SHORT TONS

Feldspar	492,768
Mica	33,887
Quartz	785,656
Other	106,000

CONSUMPTION OF FLOTATION REAGENTS [1]

Function and name	Total	Per ton
Modifier: Alum, hydrofluoric acid, lime, sodium hydroxide, sulfuric acid:		
Pounds	8,093,208	3.953
Value	$475,340	$0.232
Depressant:		
Pounds	301,500	0.900
Value	$75,375	$0.225
Collector: Aero Promoter 801, Aero Promoter 825, amines, fatty acids, fuel oil, petroleum sulfonate, other:		
Pounds	3,547,776	1.664
Value	$405,492	$0.190
Frother: Aerofroth 65, pine oil, other:		
Pounds	353,823	0.264
Value	$80,381	$0.060
Flocculant:		
Pounds	26,761	0.059
Value	$11,430	$0.025
Total reagents:		
Pounds	12,323,068	5.779
Value	$1,048,018	$0.491

[1] Based on 13 operations accounting for 90 percent of total ore.

Table 35.—Froth flotation of fluorspar ores in 1970

OPERATING DATA

Plants:		Water used, gallons:	
Number	4	Total ... millions	652.7
Capacity ... short tons per day	1,750	Per ton	1,560
Ore treated:		Ball consumption:	
Short tons	418,500	Total ... pounds	338,799
Fluorspar ... percent	43.21	Per ton	0.810
Energy used, kilowatt-hours:		Liner consumption:	
Total ... millions	26.8	Total ... pounds	108,265
Per ton	64.1	Per ton	0.285

CONCENTRATES PRODUCED

Fluorspar			Lead		Zinc	
Quantity (short tons)	Grade (percent)	Recovery (percent)	Quantity (short tons)	Grade (percent)	Quantity (short tons)	Grade (percent)
160,019	94.23	84	1,568	70.34	17,625	61.32

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Salt, Nalco, soda ash, sodium hydroxide, sodium pyrophosphate, sodium silicate:		
Pounds	6,207,827	14.835
Value	$87,761	$0.210
Activator: Copper sulfate:		
Pounds	365,588	0.946
Value	$91,976	$0.238
Depressant: Aero Depressant 633, Quebracho, sodium cyanide, starch, zinc hydrosulfite:		
Pounds	1,041,121	2.695
Value	$178,857	$0.463
Collector: Aerofloat 31, Aerofloat 211, fatty acids, potassium amyl xanthate, potassium ethyl xanthate, Sodium Aerofloat:		
Pounds	419,652	1.003
Value	$84,635	$0.202
Frother: Methyl isobutyl carbinol, pine oil:		
Pounds	124,376	0.322
Value	$21,075	$0.055
Flocculant:		
Pounds	963	0.030
Value	$1,478	$0.046
Total reagents:		
Pounds	8,159,527	19.498
Value	$465,782	$1.113

Table 36.—Froth flotation of iron ores in 1970

OPERATING DATA

Plants:		Rod consumption, pounds:	
Number	6	Total	14,296,675
Capacity ......short tons per day	55,700	Per ton	0.928
Ore treated:		Ball consumption, pounds:	
Short tons	27,286,100	Total	21,937,656
Iron ......percent	33.7	Per ton	1.426
Energy used, kilowatt-hours:		Liner consumption, pounds:	
Total ......millions	795.7	Total	4,636,630
Per ton	29.2	Per ton	0.174
Water used, gallons:			
Total ......millions	53,450.0		
Per ton	1,960		

CONCENTRATES PRODUCED

Quantity	short tons	11,927,496
Iron	percent	63.9
Recovery	do	83

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Sodium silicate, sulfuric acid:		
Pounds	23,630,257	4.379
Value	$302,784	$0.056
Depressant: Sodium fluoride:		
Pounds	210,518	0.343
Value	$49,817	$0.081
Collector: Aero Promoter 899, amine, Arosurf, fatty acids, fuel oil:		
Pounds	26,672,577	0.978
Value	$1,771,006	$0.065
Frother:		
Pounds	51,811	0.024
Value	$6,995	$0.003
Flocculant: Nalco, polyacrylamide, Superfloc:		
Pounds	205,029	0.016
Value	$204,870	$0.016
Total reagents:		
Pounds	50,770,192	1.861
Value	$2,335,472	$0.086

Table 37.—Froth flotation of limestone-magnesite ores in 1970

OPERATING DATA

Plants:	
Number	4
Capacity ... short tons per day	4,600
Ore treated ... short tons	1,094,400
Concentrate produced ... do	863,621

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier:		
Pounds	888,853	4.441
Value	$30,004	$0.150
Depressant:		
Pounds	993,730	4.965
Value	$35,774	$0.179
Collector: Adogen, fatty acids, fuel oil:		
Pounds	3,171,029	2.898
Value	$212,319	$0.194
Frother: Igepal, pine oil:		
Pounds	59,342	0.219
Value	$14,099	$0.052
Flocculant: Separan:		
Pounds	15,242	0.015
Value	$21,944	$0.021
Total reagents:		
Pounds	5,128,196	4.686
Value	$314,140	$0.287

Table 38.—Froth flotation of phosphate ores in 1970

OPERATING DATA

Plants		Ore treated		Energy used (kilowatt-hours)		Water used (gallons)	
Number	Capacity (short tons per day)	Quantity (short tons)	P_2O_5 (percent)	Total (millions)	Per ton	Total (millions)	Per ton
19	305,900	64,790,900	12.1	529.3	8.2	234,119.1	3,615

CONCENTRATES PRODUCED

Quantity ... short tons	18,559,945
P_2O_5 content ... percent	32.9
Recovery ... do	78.0

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Ammonia, sodium hydroxide, sulfuric acid:		
Pounds	134,346,171	2.150
Value	$1,797,221	$0.029
Collector: Amine, fatty acid, fuel oil, kerosine:		
Pounds	515,594,226	7.958
Value	$10,845,540	$0.167
Frother: Pine oil:		
Pounds	688,683	0.069
Value	$133,462	$0.014
Flocculant:		
Pounds	28,000	0.056
Value	$26,600	$0.053
Total reagents:		
Pounds	650,657,080	10.042
Value	$12,802,823	$0.198

Table 39.—Froth flotation of potash ores in 1970

OPERATING DATA

Plants		Ore treated		Energy used (kilowatt-hours)		Water used (gallons)	
Number	Capacity (short tons per day)	Quantity (short tons)	K_2O (percent)	Total (millions)	Per ton	Total (millions)	Per ton
8	52,200	11,702,000	18.76	184.0	15.7	3,348.5	285

CONCENTRATES PRODUCED

Quantity	short tons	3,271,965
K_2O	percent	57.20
K_2O recovery	do	85

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Ammonia, hydrochloric acid, phosphates, sodium hydroxide:		
Pounds	10,888,518	1.200
Value	$331,570	$0.037
Depressant: Starch, other:		
Pounds	6,220,460	0.641
Value	$400,755	$0.041
Collector: Amine, fuel oil:		
Pounds	5,021,954	0.429
Value	$1,078,699	$0.092
Frother: Barrett oil, methyl isobutyl carbinol, pentasol:		
Pounds	1,670,253	0.143
Value	$186,010	$0.016
Flocculant: Guar, Separan, Superfloc:		
Pounds	646,314	0.063
Value	$385,261	$0.037
Total reagents:		
Pounds	24,447,499	2.089
Value	$2,382,295	$0.204

Table 40.—Froth flotation of anthracite in 1970

OPERATING DATA

Plants:		
Number		4
Capacity	short tons per day	4,000
Raw coal treated	short tons	1,236,000
Clean coal produced	do	355,000

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Collector: Fuel oil, kerosine:		
Pounds	3,505,729	2.836
Value	$64,159	$0.052
Frother: Aerofroth 65, pine oil:		
Pounds	395,019	0.320
Value	$63,382	$0.051
Total reagents:		
Pounds	3,900,748	3.156
Value	$127,541	$0.103

Table 41.—Froth flotation of bituminous coal in 1970

OPERATING DATA

Plants:		
Number		62
Capacity	short tons per day	58,400
Raw coal treated	short tons	11,770,200
Clean coal produced	do	8,063,200

CONSUMPTION OF FLOTATION REAGENTS

Function and name	Total	Per ton
Modifier: Lime, sulfuric acid, other:		
Pounds	2,716,208	2.861
Value	$93,174	$0.098
Collector: Fuel oil, kerosine:		
Pounds	4,265,992	1.657
Value	$82,088	$0.032
Frother: Aerofroth 71, Aerofroth 77, methyl isobutyl carbinol, pine oil, other:		
Pounds	2,168,955	0.192
Value	$368,240	$0.033
Flocculant: Aerofloc, alum, Calgon, Dowall, Nalco, Percol, Polyhall 8-295, Separan, starch, Steinhall, sulfuric acid, Superfloc:		
Pounds	2,204,030	0.209
Value	$1,203,988	$0.114
Total reagents:		
Pounds	11,355,185	0.965
Value	$1,747,490	$0.148

Statistical Summary

By Mary E. Daugherty [1] and Nellie W. Fahrney [1]

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. Further details are contained in the commodity chapters of volume I and the area chapters of volume II.

Mineral production may be measured at any of several stages of extraction and processing. The stage of measurement used in the chapter is normally what is 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 customary in the particular industries producing the respective commodities. No adjustment has been made in dollar values for changes in purchasing power of the dollar.

[1] Statistical assistant, Minerals Yearbook.

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

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total [2]
1966	$15,088	$5,176	$2,703	$22,968
1967	16,195	5,200	2,333	23,729
1968	16,820	5,448	2,703	24,971
1969	17,965	r 5,624	r 3,332	r 26,921
1970	20,153	5,711	3,926	29,790

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	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
MINERAL FUELS								
Asphalt and related bitumens (native): Bituminous limestone and sandstone and gilsonite short tons	1,866,666	$8,136	1,797,219	$8,179	1,918,748	$8,561	1,980,562	$8,879
Carbon dioxide, natural (estimate) thousand cubic feet	1,142,374	165	1,118,027	176	1,194,836	144	1,109,530	191
Coal:								
Bituminous and lignite[2] thousand short tons	552,626	2,555,377	545,245	2,546,340	560,505	2,795,509	602,932	3,772,662
Pennsylvania anthracite do	12,256	96,160	11,461	97,245	10,473	100,769	9,729	105,341
Helium:								
Crude million cubic feet	3,697	42,800	3,788	44,700	3,993	46,843	4,030	47,992
Grade A do	1,015	29,657	1,066	28,355	760	21,599	647	17,405
Natural gas do	18,171,325	2,898,741	r 19,322,493	r 3,168,698	20,698,240	3,455,615	21,920,642	3,745,680
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	187,840	546,927	199,049	571,679	201,784	603,084	206,305	603,024
LP gases do	326,616	632,994	351,262	552,335	378,457	498,927	399,611	672,088
Peat thousand short tons	620	6,768	619	7,230	566	7,055	526	5,986
Petroleum (crude) thousand 42-gallon barrels	3,216,715	9,377,516	3,329,042	9,794,826	3,371,751	10,426,680	3,517,450	11,173,726
Total mineral fuels	XX	16,195,000	XX	16,820,000	XX	17,965,000	XX	20,153,000
NONMETALS (EXCEPT FUELS)								
Abrasive stones[3] short tons	2,701	574	3,141	629	3,311	600	3,134	666
Asbestos do	123,189	11,102	120,690	10,406	125,936	10,648	125,314	10,696
Barite thousand short tons	962	11,604	927	13,706	1,077	15,753	854	12,800
Boron minerals do	892	69,819	963	76,535	1,020	81,261	1,041	86,827
Bromine thousand pounds	349,757	85,391	362,452	86,787	391,883	87,990	349,748	60,560
Calcium-magnesium chloride short tons	608,965	11,983	(4)	(4)	(4)	(4)	632,500	15,225
Cement:								
Portland thousand 376-pound barrels	365,570	1,148,208	388,525	1,227,942	400,883	1,284,600	381,001	1,268,718
Masonry thousand 280-pound barrels	21,700	62,168	23,167	66,259	23,253	69,106	21,275	67,537
Natural and slag thousand 376-pound barrels	94	360	86	332	(4)	(4)	(4)	(4)
Clays thousand short tons	54,664	223,987	57,348	246,938	58,694	264,415	54,853	267,912
Diatomite short tons	(4)	(4)	(4)	(4)	598,482	r 36,485	597,636	32,649
Emery do	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Feldspar long tons	615,397	7,086	667,679	8,265	673,985	8,869	648,276	9,638
Fluorspar short tons	295,643	13,164	252,411	11,656	182,567	8,411	269,221	13,923
Garnet (abrasive) do	20,494	1,849	22,136	1,922	20,458	1,874	18,837	1,936
Gem stones (estimate)	NA	2,430	NA	2,497	NA	2,390	NA	2,396
Gypsum thousand short tons	9,393	34,383	10,018	36,775	9,905	38,354	9,436	35,132
Lime do	17,985	240,216	18,637	249,639	20,209	280,736	19,747	286,155
Magnesium compounds from sea water and brine (except for metals) short tons, MgO equivalent	544,428	41,883	525,210	43,449	r 618,762	r 53,046	707,874	62,434
Mica:								
Scrap short tons	118,503	2,876	125,323	3,014	133,058	2,893	118,843	2,527
Sheet pounds	20,500	(4)	15,000	(4)	(4)	3	--------	--------
Perlite short tons	413,001	3,973	427,574	4,221	471,454	5,100	456,134	4,904
Phosphate rock thousand short tons	39,770	265,947	41,251	250,692	37,725	208,689	38,739	203,218
Potassium salts thousand short tons, K_2O equivalent	3,299	105,313	2,722	75,664	2,804	73,572	2,729	98,123
Pumice thousand short tons	3,446	5,131	3,530	5,570	3,609	5,050	3,134	4,695
Pyrites thousand long tons	861	7,943	872	(4)	(4)	(4)	(4)	(4)
Salt thousand short tons	38,946	251,210	41,274	272,275	44,245	287,680	45,804	303,523
Sand and gravel do	905,899	980,619	917,468	1,020,107	r 937,169	r 1,069,667	943,941	1,115,705
Sodium carbonate (natural) do	1,726	40,539	2,043	42,104	2,513	50,922	2,688	56,320

Sodium sulfate (natural)...do	637	10,710	700	12,729	672	12,427	602	10,932
Stone [5]...do	785,592	1,240,244	819,597	1,317,911	862,895	1,424,694	874,512	1,474,917
Sulfur:								
Frasch process mines...thousand long tons	7,682	251,670	6,645	268,146	6,551	176,659	6,419	151,779
Other mines...long tons	568	3	3,125	46	------	------	------	------
Talc, soapstone, and pyrophyllite...short tons	902,512	6,871	958,262	6,656	1,029,238	7,508	1,027,929	7,773
Tripoli...do	70,984	377	85,534	796	84,673	734	68,105	520
Vermiculite...thousand short tons	255	4,974	290	5,684	310	6,805	285	6,501
Value of items that cannot be disclosed: Aplite, brucite, graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values indicated by footnote [4]	XX	55,734	XX	79,309	XX	r 46,941	XX	34,174
Total nonmetals	XX	5,200,000	XX	5,448,000	XX	r 5,624,000	XX	5,710,815
METALS								
Antimony ore and concentrate short tons, antimony content	892	(6)	856	(6)	938	(6)	1,130	(6)
Bauxite...thousand long tons, dried equivalent	1,654	19,079	1,665	23,752	1,843	25,725	2,082	30,070
Beryllium concentrate...short tons, gross weight	(6)	(6)	168	81	(6)	(6)	(6)	(6)
Copper (recoverable content of ores, etc.)...short tons	954,064	729,401	1,204,621	1,008,195	1,544,579	1,468,400	1,719,657	1,984,484
Gold (recoverable content of ores, etc.)...troy ounces	1,584,187	55,447	1,478,292	[7] 58,038	1,733,176	[7] 71,944	1,743,322	[7] 63,439
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	82,415	817,511	81,934	836,433	89,854	929,293	87,176	941,739
Lead (recoverable content of ores, etc.)...short tons	316,931	88,741	359,156	94,903	509,013	151,635	571,767	178,609
Manganese ore (35 percent or more Mn) short tons, gross weight	12,585	(6)	11,378	(6)	5,630	157	4,737	(6)
Manganiferous ore (5 to 35 percent Mn)...do	289,160	(6)	244,590	(6)	430,637	(6)	368,302	(6)
Mercury...76-pound flasks	23,784	11,639	28,874	15,464	r 29,640	r 14,969	27,303	11,134
Molybdenum (content of concentrate)...thousand pounds	81,596	133,604	93,245	151,000	103,009	173,819	110,381	190,077
Nickel (content of ore and concentrate)...short tons	15,287	(6)	17,294	(6)	17,056	(6)	15,933	(6)
Silver (recoverable content of ores, etc.) thousand troy ounces	32,345	50,135	32,729	70,191	41,906	75,040	45,005	79,696
Tin (content of concentrate)...long tons	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Titanium concentrate, ilmenite...short tons, gross weight	882,414	18,519	960,118	19,484	893,034	18,636	920,964	18,626
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	9,088	20,895	10,704	25,197	r 7,360	r 18,195	8,194	21,890
Uranium (recoverable content U_3O_8)...thousand pounds	20,655	165,239	24,139	182,698	23,748	142,161	24,682	149,464
Vanadium (recoverable in ore and concentrate)...short tons	4,963	21,331	6,483	23,143	5,577	26,334	5,319	34,923
Zinc (recoverable content of ores, etc.)...do	549,413	151,562	529,446	142,950	553,124	161,512	534,136	163,650
Value of items that cannot be disclosed: Cobalt, columbium-tantalum concentrate (1967, 1969), magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), rare-earth metal concentrates, titanium concentrate (rutile 1967–68), zirconium concentrate, and values indicated by footnote 6	XX	50,190	XX	51,030	XX	r 54,180	XX	58,430
Total metals	XX	2,333,000	XX	2,703,000	XX	r 3,332,000	XX	3,926,000
Grand total mineral production	XX	23,729,000	XX	24,971,000	XX	r 26,921,000	XX	29,790,000

r Revised. NA Not available. XX Not applicable.

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

2 Includes small quantity of anthracite mined in States other than Pennsylvania. In 1970 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, millstones (weight not recorded), grinding pebbles, sharpening stones, and tube mill liners.

4 Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."

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

6 Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."

7 Based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968; and Engelhard selling quotations Mar. 20, 1968 through 1970.

Table 3.—Minerals produced in the United States and principal producing States in 1970

Mineral	Principal producing States, in order of quantity	Other producing States
Antimony	Idaho, Alaska, Nevada	Calif., Mont.
Aplite	Va.	
Asbestos	Calif., Vt., Ariz., N.C.	
Asphalt	Tex., Utah, Ala., Mo.	
Barite	Mo., Nev., Ark., Ga	Alaska, Calif., Tenn.
Bauxite	Ark., Ala., Ga	Oreg., Wash.
Beryllium	Utah, S. Dak., Colo., Maine.	
Boron	Calif.	
Bromine	Ark., Mich., Calif.	
Brucite	Nev.	
Calcium-magnesium chloride	Mich., Calif.	
Carbon dioxide	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 and R.I.
Coal	W. Va., Ky., 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	Ariz., Utah, N. Mex., Mont	Calif., Colo., Idaho, Maine, Mich., Mo., Nev., Okla., Oreg., Pa., Tenn., Wash.
Diatomite	Calif., Nev., Wash., Ariz	Oreg.
Emery	N.Y.	
Feldspar	N.C., Calif., Conn., S.C	Ariz., Colo., Ga., Maine, S. Dak., Va.
Fluorspar	Ill., Colo., Utah, Mont	Ky., Nev., N. Mex.
Garnet, abrasive	N.Y., Idaho.	
Gold	S. Dak., Nev., Utah, Ariz	Alaska, Calif., Colo., Idaho, Mont., N. Mex., Oreg., Pa., Tenn., Wash.
Graphite	Tex.	
Gypsum	Mich., Tex., Iowa, Calif	Ariz., Ark., Colo., Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah, Va., 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	Mo., Idaho, Utah, Colo	Ariz., Calif., Ill., Kans., Mont., Nev., N. Mex., N.Y., Okla., Oreg., S. Dak., Va., Wash., Wis.
Lime	Ohio, Pa., Mo., Tex	Ala., Ariz., Ark., Calif., Colo., Conn., Fla., Hawaii, Idaho, Ill., Ind., Iowa, Kans., 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	N.C., Nev., Calif.	
Magnesite	Nev.	
Magnesium Chloride	Tex.	
Magnesium Compounds	Mich., Tex., Calif., N.J	Fla., Miss., Utah.
Manganese ore	N. Mex., Mont.	
Manganiferous ore	Minn., N. Mex., Utah.	
Manganiferous residuum	N.J.	
Marl, greensand	N.J., Md.	
Mercury	Calif., Nev., Alaska, Idaho	Ark., N.Y., Oreg., Tex., Wash.
Mica: Scrap	N.C., Ala., Ga., S.C	Ariz., Colo., Conn., N.H., N. Mex., Pa., S. Dak.
Molybdenum	Colo., Ariz., Utah, N. Mex	Calif., Nev.
Natural gas	Tex., La., Okla., N. Mex	Ala., Alaska, Ariz., Ark., Calif., Colo., 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., Ark., Calif., Colo., Fla., Ill., Kans., Ky., Mich., Miss., Mont., Nebr., N. Dak., Pa., Utah, W. Va., Wyo.
Nickel	Oreg.	
Olivine	Wash., N.C.	

Table 3.—Minerals produced in the United States and principal producing States in 1970—Continued

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

Table 4.—Value of mineral production in the United States and principal minerals produced in 1970

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$323,245	21	1.09	Coal, cement, stone, petroleum.
Alaska	338,271	20	1.14	Petroleum, sand and gravel, natural gas, stone.
Arizona	1,166,767	5	3.92	Copper, molybdenum, sand and gravel, cement.
Arkansas	225,622	27	.76	Petroleum, bromine and bromine compounds, natural gas, bauxite.
California	1,897,136	3	6.37	Petroleum, natural gas, sand and gravel, cement.
Colorado	389,789	18	1.31	Molybdenum, petroleum, coal, sand and gravel.
Connecticut	28,383	45	.10	Stone, sand and gravel, feldspar, lime.
Delaware	1,615	50	.01	Sand and gravel, clays, gem stones.
Florida	300,042	23	1.01	Phosphate rock, stone, cement, sand and gravel.
Georgia	203,225	29	.68	Clays, stone, cement, sand and gravel.
Hawaii	28,965	44	.10	Stone, cement, sand and gravel, pumice.
Idaho	119,748	32	.40	Silver, phosphate rock, lead, zinc.
Illinois	688,697	11	2.31	Coal, petroleum, stone, sand and gravel.
Indiana	255,786	25	.86	Coal, cement, stone, sand and gravel.
Iowa	120,822	31	.40	Cement, stone, sand and gravel, gypsum.
Kansas	586,161	16	1.97	Petroleum, natural gas, natural gas liquids, helium.
Kentucky	847,465	9	2.84	Coal, stone, petroleum, natural gas.
Louisiana	5,102,321	2	17.13	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	23,780	47	.08	Cement, sand and gravel, stone, copper.
Maryland	88,216	37	.30	Stone, cement, sand and gravel, coal.
Massachusetts	50,360	43	.17	Stone, sand and gravel, lime, clays.
Michigan	670,729	12	2.25	Iron ore, cement, copper, sand and gravel.
Minnesota	633,006	13	2.12	Iron ore, sand and gravel, stone, cement.
Mississippi	249,973	26	.84	Petroleum, natural gas, sand and gravel, clays.
Missouri	392,996	17	1.32	Lead, cement, stone, iron ore.
Montana	313,016	22	1.05	Petroleum, copper, sand and gravel, cement.
Nebraska	72,657	39	.24	Petroleum, cement, sand and gravel, stone.
Nevada	186,349	30	.62	Copper, gold, sand and gravel, diatomite.
New Hampshire	8,730	48	.03	Sand and gravel, stone, clays, gem stones.
New Jersey	89,281	36	.30	Stone, sand and gravel, zinc, magnesium compounds.
New Mexico	1,060,358	8	3.56	Petroleum, copper, natural gas, potassium salts.
New York	299,564	24	1.01	Cement, stone, salt, sand and gravel.
North Carolina	98,365	33	.33	Stone, sand and gravel, cement, phosphate rock.
North Dakota	96,047	34	.32	Petroleum, coal, sand and gravel, natural gas.
Ohio	612,166	14	2.05	Coal, stone, lime, sand and gravel.
Oklahoma	1,137,267	6	3.82	Petroleum, natural gas, natural gas liquids, stone.
Oregon	68,101	40	.23	Sand and gravel, stone, cement, nickel.
Pennsylvania	1,095,743	7	3.68	Coal, cement, stone, sand and gravel.
Rhode Island	4,386	49	.01	Sand and gravel, stone, gem stones.
South Carolina	56,365	42	.19	Cement, stone, clays, sand and gravel.
South Dakota	61,576	41	.21	Gold, sand and gravel, stone, cement.
Tennessee	220,465	28	.74	Stone, coal, zinc, cement.
Texas	6,402,462	1	21.49	Petroleum, natural gas, natural gas liquids, cement.
Utah	601,997	15	2.02	Copper, petroleum, coal, molybdenum.
Vermont	27,843	46	.09	Stone, sand and gravel, asbestos, talc.
Virginia	374,321	19	1.26	Coal, stone, cement, sand and gravel.
Washington	90,922	35	.30	Sand and gravel, cement, stone, uranium.
West Virginia	1,285,364	4	4.31	Coal, natural gas, stone, cement.
Wisconsin	87,670	38	.29	Sand and gravel, stone, iron ore, zinc.
Wyoming	705,533	10	2.37	Petroleum, natural gas, sodium salts, uranium.
Total	29,789,668	------	100.00	

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
ALABAMA								
Cement: [2]								
Portland ---- thousand 376-pound barrels	15,364	$46,510	15,514	$48,147	16,527	$51,251	16,053	$51,114
Masonry ---- thousand 280-pound barrels	2,377	6,938	2,523	7,309	2,600	8,520	2,402	7,601
Clays ---- thousand short tons	2,724	7,422	2,793	6,995	3,097	7,083	2,748	8,213
Coal (bituminous) ---- do	15,486	110,696	16,440	115,815	17,456	130,405	20,560	166,308
Iron ore (usable) ---- thousand long tons, gross weight	1,472	8,286	1,151	6,730	1,125	6,435	W	W
Lime ---- thousand short tons	624	7,719	773	8,933	747	9,870	749	10,286
Natural gas ---- million cubic feet	248	31	230	30	180	24	627	87
Petroleum (crude) ---- thousand 42-gallon barrels	7,348	19,500	7,635	20,385	7,701	20,793	7,263	20,627
Sand and gravel ---- thousand short tons	7,229	7,969	8,140	9,130	8,323	9,427	6,725	8,144
Stone ---- do	18,371	33,346	20,643	33,847	19,854	37,512	[3] 19,882	37,166
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, scrap mica, natural gasoline 1969–70, liquefied petroleum gases 1969–70, phosphate rock 1969–70, salt, stone, dimension (1970), talc, and value indicated by symbol W	XX	2,974	XX	2,300	XX	3,416	XX	13,699
Total	XX	251,391	XX	259,621	XX	284,736	XX	323,245
ALASKA								
Antimony ore and concentrate ---- short tons, antimony content	10	W	3	W	12	$13	63	$109
Barite ---- thousand short tons	W	W	91	W	W	W	134	835
Coal (bituminous) ---- do	925	$7,296	750	$4,502	667	4,366	549	4,059
Gold (recoverable content of ores, etc.) ---- troy ounces	22,948	803	21,262	[4] 835	21,227	[4] 881	34,776	[4] 1,265
Lead (recoverable content of ores, etc.) ---- short tons	------	------	W	W	2	1	-------	-------
Natural gas ---- million cubic feet	14,438	3,610	17,343	4,388	50,864	12,665	111,576	27,448
Peat ---- thousand short tons	2	12	------	-------	-------	-------	-------	-------
Petroleum (crude) ---- thousand 42-gallon barrels	29,126	91,164	66,204	186,695	73,953	214,464	83,616	251,684
Sand and gravel ---- thousand short tons	22,370	26,248	18,013	20,366	16,205	18,615	25,825	41,092
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	6	9	4	8	2	4	2	4
Stone ---- thousand short tons	W	W	W	W	1,954	3,902	6,470	10,014
Value of items that cannot be disclosed: Copper (1968), gem stones, liquefied petroleum gases (1969), mercury, platinum-group metals, tin, and values indicated by symbol W	XX	4,924	XX	4,923	XX	2,865	XX	1,761
Total	XX	134,066	XX	221,717	XX	257,776	XX	338,271
ARIZONA								
Clays ---- thousand short tons	[5] 67	[5] $37	77	$347	120	$394	199	$454
Coal (bituminous) ---- do	1	5	---------	---------	---------	---------	132	W
Copper (recoverable content of ores, etc.) ---- short tons	501,741	383,591	627,961	525,566	801,363	761,840	917.918	1,059,277

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
ARIZONA—Continued								
Diatomite short tons	W	W	W	W	725	W	W	W
Fluorspar do	10,000	$280	---	---	---	---	---	---
Gem stones	NA	150	NA	$149	NA	$153	NA	$155
Gold (recoverable content of ores, etc.) troy ounces	80,844	2,830	95,999	[5]3,769	110,878	4,603	109,853	3,998
Gypsum thousand short tons	W	W	W	W	83	424	98	358
Helium, grade A million cubic feet	74	2,066	65	1,600	56	1,126	62	1,186
Iron ore (usable) thousand long tons, gross weight	W	W	16	124	18	136	W	W
Lead (recoverable content of ores, etc.) short tons	4,771	1,336	1,704	450	217	65	285	89
Lime thousand short tons	186	3,142	260	4,561	283	5,074	309	4,523
Mercury 76-pound flasks	W	W	192	103	W	W	---	---
Molybdenum (content of concentrate) thousand pounds	9,261	15,385	12,127	19,207	12,699	20,947	15,672	26,700
Natural gas million cubic feet	1,255	193	881	142	1,136	199	1,101	188
Petroleum (crude) thousand 42-gallon barrels	2,924	8,188	3,370	9,606	2,433	7,056	1,784	5,281
Pumice thousand short tons	1,064	904	1,033	974	910	814	824	627
Sand and gravel do	17,317	17,280	13,981	14,423	r 16,744	r 18,224	17,822	19,804
Silver (recoverable content of ores, etc.) thousand troy ounces	4,588	7,112	4,958	10,633	6,141	10,997	7,330	12,981
Stone thousand short tons	1,910	3,491	3,293	6,239	2,827	5,812	3,511	7,094
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	W	W	1	3	1	2	W	W
Uranium (recoverable content U_3O_8) thousand pounds	83	666	295	1,923	W	W	---	---
Zinc (recoverable content of ores, etc.) do	14,330	3,967	5,441	1,469	9,039	2,639	9,618	2,947
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite 1967), feldspar, scrap mica, perlite, pyrites, vanadium (1967–69), vermiculite (1967–69), and values indicated by symbol W	XX	13,503	XX	16,253	XX	r 18,957	XX	21,105
Total	XX	464,126	XX	617,541	XX	r 859,462	XX	1,166,767
ARKANSAS								
Barite thousand short tons	229	$2,266	166	$3,839	210	$4,616	168	$3,721
Bauxite thousand long tons, dried equivalent	1,571	18,269	1,582	23,058	1,755	24,706	1,869	26,293
Bromine and bromine in compounds thousand pounds	64,450	14,885	95,499	20,790	145,100	28,287	W	W
Clays thousand short tons	941	1,740	919	2,134	992	2,426	1,014	2,902
Coal (bituminous) do	189	1,427	211	1,576	228	1,802	268	2,225
Gem stones	NA	35	NA	30	NA	24	NA	25
Lime thousand short tons	187	2,723	206	3,058	184	2,748	186	2,680
Natural gas million cubic feet	116,522	17,828	156,627	24,456	169,257	26,743	181,351	29,560
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	656	1,780	753	2,192	692	2,049	643	1,824
LP gases do	1,279	3,009	1,435	2,899	1,279	2,098	1,205	2,482
Petroleum (crude) do	21,075	56,902	19,464	53,137	18,049	51,079	18,035	51,760
Sand and gravel thousand short tons	14,239	15,531	12,997	14,643	12,674	14,949	13,301	16,036
Stone do	17,454	23,236	16,322	22,256	16,463	23,134	15,284	22,786
Value of items that cannot be disclosed: Abrasive stones, cement, clays, gypsum, mercury (1967, 1970), soapstone, tripoli, vanadium (1968–70), and values indicated by symbol W	XX	19,822	XX	24,655	XX	23,465	XX	63,331
Total	XX	179,453	XX	198,723	XX	208,126	XX	225,625

CALIFORNIA								
Antimony ore and concentrate .... short tons, antimony content	------	------	------	------	------	------	4	$10
Asbestos .... short tons	77,091	$6,726	75,592	$6,139	75,828	$5,956	78,966	6,332
Barite .... thousand short tons	10	71	W	W	W	W	W	W
Boron minerals .... do	892	[r] 69,819	963	[r] 76,535	1,020	81,261	1,041	86,827
Cement .... thousand 376-pound barrels	42,034	137,961	47,595	151,961	50,610	170,612	49,499	173,126
Clays .... thousand short tons	2,609	6,037	2,755	6,630	2,993	7,443	2,824	6,506
Copper (recoverable content of ores, etc.) .... short tons	788	602	1,182	989	1,129	1,073	2,308	2,663
Feldspar .... long tons	94,769	W	W	W	W	W	W	W
Gem stones	NA	200	NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.) .... troy ounces	40,570	1,420	15,682	[4] 616	7,904	[4] 328	4,999	[4] 182
Gypsum .... thousand short tons	1,241	3,150	1,360	3,603	1,210	3,339	1,132	3,271
Lead (recoverable content of ores, etc.) .... short tons	1,735	486	4,001	1,057	2,518	750	1,772	553
Lime .... thousand short tons	539	8,696	568	9,301	585	9,666	572	9,911
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent	76,592	[r] 6,882	81,622	7,229	76,220	7,143	73,726	7,489
Mercury .... 76-pound flasks	16,385	8,018	21,417	11,470	18,480	9,333	18,593	7,582
Natural gas .... million cubic feet	681,080	202,290	714,893	221,077	677,689	207,440	649,117	208,367
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	14,605	46,620	13,403	42,963	12,954	39,944	11,993	38,478
LP gases .... do	8,730	19,065	8,589	18,749	8,238	17,646	7,051	16,006
Peat .... thousand short tons	30	396	W	W	11	106	10	W
Perlite .... do	W	W	8,806	80	11,419	105	W	W
Petroleum (crude) .... thousand 42-gallon barrels	359,219	829,133	375,496	883,644	375,291	920,060	372,191	945,365
Pumice .... thousand short tons	866	1,357	776	1,312	866	1,229	491	841
Salt .... do	1,732	W	1,901	W	1,895	W	1,656	14,407
Sand and gravel .... do	116,125	139,212	124,655	153,360	124,718	155,883	140,259	174,221
Silver (recoverable content of ores, etc.) .... thousand troy ounces	145	224	598	1,282	492	881	451	799
Stone .... thousand short tons	37,186	55,263	36,125	52,671	38,033	57,757	46,399	66,950
Sulfur ore .... long tons	568	3	3,125	46	------	------	------	------
Talc, soapstone, and pyrophyllite .... short tons	143,466	1,945	165,396	2,075	145,158	2,329	184,660	2,545
Tin (content of concentrate) .... long tons	W	W	------	------	------	------	------	------
Zinc (recoverable content of ores, etc.) .... short tons	441	122	3,525	952	3,327	971	3,514	1,077
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, carbon dioxide, coal (lignite), diatomite, iron ore, lithium minerals, scrap mica (1968), molybdenum, phosphate rock (1968–70), platinum group metals (crude) (1967–68), potassium salts, rare-earth metal concentrates, sodium carbonates and sulfates, tungsten concentrate, wollastonite, and values indicated by symbol W	XX	143,722	XX	150,914	XX	[r] 142,633	XX	123,428
Total	XX	[r] 1,689,420	XX	[r] 1,804,855	XX	[r] 1,844,088	XX	1,897,136
COLORADO								
Beryllium concentrate .... short tons	W	W	W	W	46	W	W	W
Carbon dioxide, natural .... thousand cubic feet	182,701	$31	200,657	$34	175,787	$30	W	W
Clays .... thousand short tons	596	1,274	616	1,222	732	1,619	[5] 637	[5] $1,503
Coal (bituminous) .... do	5,439	25,920	5,558	26,785	5,530	29,121	6,025	35,243
Copper (recoverable content of ores, etc.) .... short tons	3,993	3,053	3,451	2,888	3,598	3,421	3,749	4,326
Feldspar .... long tons	300	2	W	W	358	3	426	3
Gem stones	NA	118	NA	121	NA	122	NA	120
Gold (recoverable content of ores, etc.) .... troy ounces	21,181	741	22,638	[4] 889	25,777	[4] 1,070	37,114	[4] 1,351

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
COLORADO—Continued								
Gypsum ... thousand short tons	77	265	98	354	94	339	W	W
Iron ore (usable) ... thousand long tons, gross weight	W	W	W	W	W	W	W	W
Lead (recoverable content of ores, etc.) ... short tons	21,923	6,138	19,778	5,226	21,767	6,484	21,855	6,827
Lime ... thousand short tons	118	2,028	125	2,375	127	2,449	119	1,613
Manganiferous ore (5 to 35 percent Mn) ... short tons, gross weight	321	3	----	----	----	----	----	----
Molybdenum (content of concentrate) ... thousand pounds	52,040	84,728	61,684	100,296	62,411	105,346	W	W
Natural gas ... million cubic feet	116,857	15,542	121,424	16,392	118,754	17,219	105,804	15,553
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	1,234	3,215	1,289	3,248	1,076	2,798	745	1,937
LP gases ... do	1,703	3,649	1,987	3,338	1,782	2,762	1,542	2,529
Peat ... thousand short tons	22	204	28	250	26	160	34	210
Petroleum (crude) ... thousand 42-gallon barrels	33,905	99,003	31,937	94,215	28,294	88,277	24,723	78,619
Pumice ... thousand short tons	18	105	28	234	42	232	50	268
Pyrites ... thousand long tons	W	W	23	97	24	120	W	W
Sand and gravel ... thousand short tons	21,810	22,904	23,131	26,608	19,877	27,266	22,261	24,190
Silver (recoverable content of ores, etc.) ... thousand troy ounces	1,818	2,817	1,646	3,531	2,599	4,653	2,933	5,194
Stone ... thousand short tons	2,992	5,485	2,471	5,201	2,245	5,079	3,552	8,076
Tin (content of concentrate) ... long tons	31	59	33	64	44	119	W	W
Tungsten concentrate ... short tons, 60-percent WO_3 basis	1,276	3,039	1,893	4,413	1,941	4,440	W	W
Uranium (recoverable content U_3O_8) ... thousand pounds	2,537	20,299	2,706	20,009	2,736	16,935	2,727	15,832
Vanadium (recoverable in ore and concentrate) ... short tons	3,317	14,260	3,492	12,468	W	W	----	----
Zinc (recoverable content of ores, etc.) ... do	52,442	14,519	50,258	13,570	53,715	15,685	56,694	17,370
Value of items that cannot be disclosed: Cement, fluorspar, scrap mica (1967, 1970), perlite, rare-earth metal concentrates (1967–68), salt, and values indicated by symbol W	XX	16,834	XX	15,630	XX	32,745	XX	169,025
Total	XX	346,235	XX	359,458	XX	368,494	XX	389,789
CONNECTICUT								
Clays ... thousand short tons	191	$334	195	$325	197	$341	171	$386
Gem stones	NA	8	NA	8	NA	8	NA	8
Sand and gravel ... thousand short tons	8,320	8,710	8,752	9,321	8,857	10,359	6,765	9,202
Stone ... do	5,097	10,141	6,383	12,729	7,562	15,325	8,338	16,915
Value of items that cannot be disclosed: Feldspar, lime, and scrap mica	XX	1,426	XX	1,493	XX	1,734	XX	1,872
Total	XX	20,619	XX	23,876	XX	27,767	XX	28,383
DELAWARE								
Clays ... thousand short tons	11	$11	12	$12	11	$11	11	$11
Gem stones	NA	1	NA	1	NA	1	NA	1
Sand and gravel ... thousand short tons	1,966	1,846	1,596	1,483	2,257	2,074	1,565	1,603
Stone ... do	210	525	200	500	----	----	----	----
Total	XX	2,383	XX	1,996	XX	2,086	XX	1,615

FLORIDA								
Clays ... thousand short tons	756	$11,574	808	$11,699	907	$13,627	872	$12,661
Lime ... do	155	2,425	125	2,059	182	2,712	167	2,810
Natural gas ... million cubic feet	123	18	108	16	50	8	---	---
Peat ... thousand short tons	22	155	41	277	55	359	46	304
Petroleum (crude) ... thousand 42-gallon barrels	1,568	W	1,474	W	1,731	W	2,999	W
Sand and gravel ... thousand short tons	6,912	6,479	7,765	7,967	14,409	13,988	12,482	12,254
Stone [3] ... do	33,971	38,723	36,692	46,563	42,332	56,611	43,089	61,302
Value of items that cannot be disclosed: Cement, kyanite (1968–70), magnesium compounds, natural gas liquids, phosphate rock, rare-earth metal concentrates, staurolite, stone (dimension limestone 1967–70), titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	250,423	XX	236,042	XX	208,071	XX	210,711
Total	XX	309,797	XX	304,623	XX	295,376	XX	300,042
GEORGIA								
Barite ... thousand short tons	W	W	140	$2,874	124	$3,116	W	W
Clays ... do	4,953	$77,314	5,111	88,632	5,670	98,462	5,684	$110,149
Iron ore (usable) ... thousand long tons, gross weight	267	1,450	192	1,119	241	1,338	243	1,467
Mica: Scrap ... thousand short tons	17	291	W	W	W	W	W	W
Sand and gravel ... do	3,787	4,206	3,803	4,314	3,824	4,709	3,667	4,437
Stone ... do	23,418	49,953	26,903	56,177	27,755	59,451	26,635	59,200
Talc ... short tons	46,150	292	45,600	288	47,790	301	45,900	289
Value of items that cannot be disclosed: Bauxite, cement, feldspar, kyanite, peat, rare-earth metal concentrates (1968–70), titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	19,952	XX	19,686	XX	23,525	XX	27,683
Total	XX	153,458	XX	173,090	XX	190,902	XX	203,225
HAWAII								
Cement ... thousand 376-pound barrels	1,395	$7,360	1,841	$9,254	2,075	$10,544	2,162	$10,334
Clays ... thousand short tons	W	W	3	4	2	9	2	11
Lime ... do	8	265	8	268	9	287	9	338
Pumice ... do	290	562	408	724	403	783	350	933
Sand and gravel ... do	469	1,467	546	1,653	552	1,816	514	1,679
Stone ... do	4,100	7,207	5,211	11,273	6,534	16,059	[3] 6,331	15,538
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	75	XX	49	XX	41	XX	132
Total	XX	16,936	XX	23,225	XX	29,539	XX	28,965
IDAHO								
Antimony ore and concentrate ... short tons, antimony content	823	W	853	W	922	W	993	W
Clays [5] ... thousand short tons	19	$16	12	$14	23	$51	13	$28
Copper (recoverable content of ores, etc.) ... short tons	4,210	3,219	3,525	2,950	3,332	3,168	3,612	4,168
Gem stones	NA	180	NA	200	NA	90	NA	90
Gold (recoverable content of ores, etc.) ... troy ounces	4,838	169	3,227	[4] 127	3,403	[4] 141	3,128	[4] 114
Gypsum ... thousand short tons	---	---	3	13	---	---	---	---

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
IDAHO—Continued								
Iron ore (usable)....thousand long tons, gross weight	W	W	W	W	W	W	W	W
Lead (recoverable content of ores, etc.)....short tons	61,387	17,188	54,790	14,478	65,597	19,541	61,211	19,121
Mercury....76-pound flasks	898	439	W	W	1,012	511	1,038	423
Peat....thousand short tons	2	16	W	W	1	W	W	W
Phosphate rock....do	W	W	3,879	22,721	W	W	W	W
Pumice....do	W	W	135	259	21	62	41	83
Sand and gravel....do	11,246	11,490	8,224	9,133	8,555	7,583	12,953	10,022
Silver (recoverable content of ores, etc.)....thousand troy ounces	17,033	26,402	15,959	34,225	18,930	33,897	19,115	33,849
Stone....thousand short tons	1,986	4,833	2,195	5,209	3,750	6,426	4,240	6,368
Tungsten concentrate....short tons, 60-percent WO_3 basis	68	175	W	W	27	63	W	W
Zinc (recoverable content of ores, etc.)....short tons	56,528	15,650	57,248	15,457	55,900	16,323	41,052	12,578
Value of items that cannot be disclosed: Cement, clays, (fire clay and kaolin), abrasive garnet, lime, perlite, stone (dimension 1970), vanadium, and values indicated by symbol W	XX	29,631	XX	9,467	XX	30,453	XX	32,904
Total	XX	109,408	XX	114,253	XX	118,309	XX	119,748
ILLINOIS								
Cement:								
Portland....thousand 376-pound barrels	9,069	$30,186	9,372	$32,475	8,720	$29,996	7,946	$25,252
Masonry....thousand 280-pound barrels	591	1,851	602	2,097	603	2,137	508	1,874
Clays [5]....thousand short tons	1,881	3,799	2,327	4,813	1,863	4,321	1,676	3,862
Coal (bituminous)....do	65,133	252,975	62,441	250,685	64,722	279,712	65,119	320,705
Fluorspar....short tons	210,207	9,859	188,325	9,134	88,480	4,676	148,208	8,637
Lead (recoverable content of ores, etc.)....do	2,384	668	1,467	388	791	236	1,532	479
Natural gas....million cubic feet	5,144	602	4,380	552	3,800	536	4,850	761
Peat....thousand short tons	50	697	62	867	67	958	63	711
Petroleum (crude)....thousand 42-gallon barrels	60,115	181,581	56,391	173,120	50,724	161,302	43,747	141,994
Sand and gravel....thousand short tons	38,801	44,175	45,609	52,943	44,138	56,688	43,926	60,155
Stone....do	48,458	66,757	55,858	80,188	54,857	81,318	55,776	86,502
Zinc (recoverable content of ores, etc.)....short tons	20,416	5,652	18,182	4,909	13,765	4,019	16,797	5,146
Value of items that cannot be disclosed: Clay (fuller's earth), gem stones, lime, natural gas liquids, and tripoli	XX	37,999	XX	35,372	XX	33,916	XX	32,619
Total	XX	636,801	XX	647,543	XX	659,815	XX	688,697
INDIANA								
Abrasive stones....short tons	5	$16	5	$16	5	$17	W	W
Cement [2]....thousand 376-pound barrels	15,924	53,123	14,774	48,096	14,497	45,264	12,432	$41,810
Clays....thousand short tons	1,489	2,126	1,550	2,355	1,483	2,264	1,335	2,139
Coal (bituminous)....do	18,772	73,419	18,486	71,680	20,086	82,902	22,263	102,371
Natural gas....million cubic feet	198	46	234	55	171	40	153	36
Peat....thousand short tons	43	441	39	557	38	515	W	W
Petroleum (crude)....thousand 42-gallon barrels	10,081	30,041	8,692	26,511	7,841	25,013	7,487	23,958

Sand and gravel ---- thousand short tons	26,265	25,588	25,774	26,160	26,218	27,438	23,476	25,796
Stone ---- do	26,977	46,725	26,307	46,790	25,559	45,400	25,818	45,215
Value of items that cannot be disclosed: Cement (masonry), gypsum, lime, and values indicated by symbol W	XX	13,396	XX	13,166	XX	13,018	XX	14,461
Total	XX	244,921	XX	235,386	XX	241,871	XX	255,786
IOWA								
Cement:								
Portland ---- thousand 376-pound barrels	13,712	$45,394	13,900	$47,275	14,084	$47,265	12,744	$45,432
Masonry ---- thousand 280-pound barrels	612	1,853	624	1,986	606	1,912	520	1,758
Clays ---- thousand short tons	1,208	1,643	1,264	1,747	1,199	1,660	1,181	1,823
Coal (bituminous) ---- do	883	3,227	876	3,289	903	3,392	987	4,059
Gypsum ---- do	1,219	5,186	1,351	5,838	1,169	5,274	1,136	4,223
Sand and gravel ---- do	17,734	16,564	16,332	15,192	18,391	17,867	21,058	20,642
Stone ---- do	26,133	37,912	26,150	40,397	26,233	40,895	25,305	41,119
Value of items that cannot be disclosed: Gem stones, lime, and peat	XX	1,443	XX	1,573	XX	1,665	XX	1,766
Total	XX	113,222	XX	117,297	XX	119,930	XX	120,822
KANSAS								
Cement: [2]								
Portland ---- thousand 376-pound barrels	8,833	$25,545	9,680	$29,898	9,764	$29,365	9,197	$28,177
Masonry ---- thousand 280-pound barrels	350	1,000	383	1,177	348	1,023	328	1,029
Clays ---- thousand short tons	935	1,339	932	1,433	[5] 797	[5] 1,070	[5] 713	[5] 946
Coal (bituminous) ---- do	1,136	5,294	1,268	6,526	1,313	7,108	1,627	9,102
Helium:								
Crude ---- million cubic feet	2,720	32,554	2,750	33,600	2,669	32,667	2,609	32,777
Grade A ---- do	225	5,364	292	7,300	330	7,578	354	8,137
Lead (recoverable content of ores, etc.) ---- short tons	1,031	289	1,227	324	395	118	80	25
Lime ---- thousand short tons	--------	--------	W	W	7	W	6	W
Natural gas ---- million cubic feet	871,971	116,844	835,555	115,307	883,156	122,759	899,955	125,994
Natural gas liquids:								
Natural gasoline ---- thousand 42-gallon barrels	4,623	10,703	4,824	10,977	4,855	11,848	6,549	14,617
LP gases ---- do	15,835	31,923	15,748	25,827	19,574	26,229	20,814	30,597
Petroleum (crude) ---- do	99,200	297,600	94,505	285,405	88,716	283,891	84,853	277,469
Pumice ---- thousand short tons	W	W	11	10	W	W	--------	--------
Salt [6] ---- do	1,069	14,686	1,128	15,520	1,270	17,090	1,230	18,206
Sand and gravel ---- do	12,066	8,650	12,427	10,559	12,029	10,061	12,968	12,351
Stone ---- do	13,551	17,806	14,372	20,650	15,828	22,645	15,161	22,406
Zinc (recoverable content of ores, etc.) ---- short tons	4,765	1,319	3,012	813	1,900	555	1,186	364
Value of items that cannot be disclosed: Natural cement, clays (fire 1969–70), gypsum, salt (brine), and values indicated by symbol W	XX	3,152	XX	3,311	XX	3,808	XX	3,964
Total	XX	574,068	XX	r 568,637	XX	r 577,815	XX	586,161
KENTUCKY								
Clays [5] ---- thousand short tons	1,195	$2,066	1,219	$1,952	1,232	$2,076	1,020	$1,793
Coal (bituminous) ---- do	100,294	396,883	101,156	395,039	109,049	450,950	125,305	711,163
Fluorspar ---- short tons	32,952	1,686	17,050	878	W	W	W	W
Lead (recoverable content of ores, etc.) ---- do	845	237	W	W	--------	--------	--------	--------

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
KENTUCKY—Continued								
Natural gas ____ million cubic feet	89,168	21,400	89,024	22,256	81,304	20,407	77,892	19,161
Petroleum (crude) ____ thousand 42-gallon barrels	15,535	45,052	14,036	41,125	12,924	40,194	11,575	36,461
Sand and gravel ____ thousand short tons	7,981	7,859	7,478	8,081	8,364	9,628	8,760	10,474
Silver (recoverable content of ores, etc.) ____ thousand troy ounces	1	1	----	----	----	----	----	----
Stone ____ thousand short tons	24,812	35,481	30,105	43,266	[3] 30,158	[3] 44,644	29,310	45,358
Zinc (recoverable content of ores, etc.) ____ short tons	6,317	1,749	W	W	W	W	4,189	1,283
Value of items that cannot be disclosed: Native asphalt (1967–68), cement, ball clay, natural gas liquids, stone (quartzite, 1969), and values indicated by symbol W	XX	23,291	XX	22,266	XX	23,149	XX	21,772
Total	XX	535,705	XX	534,863	XX	591,048	XX	847,465
LOUISIANA								
Clays ____ thousand short tons	995	$1,260	863	$1,163	1,078	$2,943	1,080	$1,575
Lime ____ do	758	9,891	781	10,159	822	10,750	1,025	12,811
Natural gas ____ million cubic feet	5,716,857	1,057,619	6,416,015	1,212,627	7,227,826	1,387,743	7,788,276	1,503,137
Natural gas liquids:								
Natural gasoline and cycle products ____ thousand 42-gallon barrels	41,777	130,212	49,928	156,903	53,565	171,434	56,526	174,632
LP gases ____ do	43,921	92,234	57,165	91,464	71,867	96,302	80,385	138,262
Petroleum (crude) ____ do	774,527	2,419,823	817,426	2,570,641	844,603	2,791,269	906,907	3,061,558
Salt ____ thousand short tons	9,585	48,483	10,908	53,854	12,435	61,102	13,584	64,854
Sand and gravel ____ do	20,312	27,442	20,411	26,504	18,131	21,895	18,155	22,363
Stone [3] ____ do	7,599	11,174	9,387	11,785	9,237	11,892	9,059	11,660
Sulfur (Frasch process) ____ thousand long tons	4,233	139,739	4,074	162,664	3,999	108,299	3,618	89,489
Value of items that cannot be disclosed: Cement, gypsum, and stone (crushed miscellaneous)	XX	23,873	XX	23,246	XX	21,697	XX	21,980
Total	XX	3,961,750	XX	4,321,010	XX	4,685,326	XX	5,102,321
MAINE								
Clays ____ thousand short tons	42	$54	[5] 42	[5] $65	[5] 42	[5] $56	[5] 41	[5] $55
Copper ____ short tons	----	----	W	W	W	W	2,703	3,120
Gem stones	NA	35	NA	35	NA	35	NA	35
Sand and gravel ____ thousand short tons	11,627	5,368	11,866	5,978	11,275	6,026	12,971	6,888
Silver ____ thousand troy ounces	----	----	W	W	W	W	63	112
Stone ____ thousand short tons	1,159	2,999	1,187	3,205	1,101	3,798	W	W
Zinc ____ short tons	----	----	W	W	W	W	9,114	2,792
Value of items that cannot be disclosed: Beryllium (1969–70), cement, fire clay (1968–70), copper (1968–69), feldspar, peat, silver (1968–69), zinc (1968–69), and values indicated by symbol W	XX	6,426	XX	8,527	XX	10,273	XX	10,778
Total	XX	14,882	XX	17,810	XX	20,188	XX	23,780

MARYLAND								
Clays ---- thousand short tons	998	$1,462	[5] 1,078	[5] $1,252	[5] 1,152	[5] $1,369	[5] 1,129	[5] $1,433
Coal (bituminous) ---- do	1,305	4,548	1,447	5,318	1,368	5,261	1,615	8,083
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ---- thousand short tons	W	W	W	W	W	W	W	W
Natural gas ---- million cubic feet	621	159	864	221	978	248	813	202
Peat ---- thousand short tons	W	W	6	94	4	78	4	47
Sand and gravel ---- do	12,868	17,724	11,719	17,157	14,230	21,226	12,951	20,434
Stone ---- do	14,479	28,581	13,344	26,606	15,067	30,504	16,015	32,783
Value of items that cannot be disclosed: Cement, clays (ball clay 1968–70, fire clay 1968–70), diatomite 1969, greensand marl, potassium salts, talc and soapstone, and values indicated by symbol W	XX	20,342	XX	21,193	XX	24,794	XX	25,231
Total	XX	72,819	XX	71,844	XX	83,483	XX	88,216
MASSACHUSETTS								
Clays ---- thousand short tons	W	W	257	$314	332	$624	284	$582
Gem stones	NA	$2	NA	2	NA	2	NA	2
Lime ---- thousand short tons	195	3,044	198	3,380	199	3,718	W	W
Sand and gravel ---- do	17,881	19,504	17,799	20,106	19,456	22,950	17,925	22,244
Stone ---- do	6,203	17,724	6,917	19,501	7,847	22,521	8,136	24,349
Value of items that cannot be disclosed: Nonmetals and value indicated by symbol W	XX	338	XX	37	XX	28	XX	3,183
Total	XX	40,612	XX	43,340	XX	49,843	XX	50,360
MICHIGAN								
Cement:								
Portland ---- thousand 376-pound barrels	29,645	$94,515	31,375	$99,158	30,373	$98,425	29,813	$101,019
Masonry ---- thousand 280-pound barrels	1,995	5,296	2,006	5,527	1,904	5,473	1,519	5,253
Clays ---- thousand short tons	2,466	2,636	2,599	2,906	2,667	3,037	2,480	2,887
Copper (recoverable content of ores, etc.) ---- short tons	58,458	44,692	74,805	62,607	75,226	71,516	67,543	77,945
Gypsum ---- thousand short tons	1,422	5,085	1,405	5,196	1,327	5,384	1,312	5,061
Iron ore (usable) ---- thousand long tons, gross weight	14,130	162,610	12,699	148,890	14,058	169,756	13,100	168,958
Lime ---- thousand short tons	1,787	21,582	1,630	19,870	1,589	20,372	1,538	21,355
Magnesium compounds from sea water and brine (except for metal) short tons, MgO equivalent	309,446	26,388	266,406	25,087	r 321,191	r 30,343	411,911	38,050
Natural gas ---- million cubic feet	33,589	8,296	40,480	10,160	36,163	9,294	38,851	10,373
Natural gas liquids:								
Natural gasoline ---- thousand 42-gallon barrels	1,139	3,491	1,066	3,177	921	2,481	599	1,611
LP gases ---- do	1,414	3,444	1,384	3,432	1,197	2,561	1,176	2,764
Peat ---- thousand short tons	237	2,292	238	2,919	186	2,724	167	1,896
Petroleum (crude) ---- thousand 42-gallon barrels	13,664	39,455	12,974	38,287	12,213	37,494	11,693	36,246
Salt ---- thousand short tons	4,789	42,389	4,893	44,481	4,819	45,961	4,899	49,963
Sand and gravel ---- do	52,310	49,616	56,663	54,979	58,092	58,968	53,092	54,646
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	302	468	473	1,014	1,009	1,807	892	1,579
Stone ---- thousand short tons	36,432	39,910	37,279	41,092	39,186	43,572	41,687	49,501
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine, and potassium salts and values indicated by symbol W	XX	58,039	XX	58,293	XX	58,818	XX	41,622
Total	XX	610,204	XX	627,075	XX	r 667,986	XX	670,729

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
MINNESOTA								
Clays [5] ..... thousand short tons	228	$342	240	$359	275	$412	227	$335
Iron ore (usable) ..... thousand long tons, gross weight	49,457	468,623	51,275	508,814	56,957	570,446	54,791	571,488
Manganiferous ore (5 to 35 percent Mn) ..... short tons, gross weight	236,753	W	191,846	W	381,491	W	321,436	W
Peat ..... thousand short tons	14	257	6	96	12	249	13	335
Sand and gravel ..... do	41,212	33,132	44,674	36,414	48,121	40,191	46,851	38,802
Stone ..... do	4,160	11,442	4,427	13,045	5,035	14,253	4,579	[3] 7,000
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay, gem stones, lime, and values indicated by symbol W	XX	9,530	XX	8,699	XX	10,085	XX	15,046
Total	XX	523,326	XX	567,427	XX	635,636	XX	633,006
MISSISSIPPI								
Clays ..... thousand short tons	1,654	$7,852	1,693	$9,075	1,703	$8,660	1,553	$8,062
Natural gas ..... million cubic feet	139,497	24,133	135,051	22,601	131,234	23,097	126,031	23,190
Natural gas liquids:								
Natural gasoline and cycle products ..... thousand 42-gallon barrels	427	1,167	459	1,277	565	1,572	544	1,465
LP gases ..... do	424	1,085	518	958	538	799	428	964
Petroleum (crude) ..... do	57,147	155,726	58,708	164,396	64,283	187,514	65,119	194,706
Sand and gravel ..... thousand short tons	14,039	15,485	11,980	12,669	11,484	12,263	10,859	11,950
Stone ..... do	1,879	2,055	747	833	W	W	W	W
Value of items that cannot be disclosed: Cement, iron ore (1967), lime, magnesium compounds, stone, and values indicated by symbol W	XX	r 9,055	XX	9,146	XX	9,279	XX	9,636
Total	XX	r 216,558	XX	220,955	XX	243,184	XX	249,973
MISSOURI								
Barite ..... thousand short tons	332	$4,444	284	$4,102	304	$4,220	230	$3,555
Cement:								
Portland ..... thousand 376-pound barrels	15,044	52,119	20,081	71,206	21,325	74,368	21,224	64,261
Masonry ..... thousand 280-pound barrels	372	1,172	405	1,312	427	1,319	402	1,234
Clays ..... thousand short tons	2,305	6,220	2,433	6,158	[5] 2,251	[5] 6,405	2,128	6,480
Coal (bituminous) ..... do	3,696	15,573	3,205	13,460	3,301	14,283	4,447	19,526
Copper (recoverable content of ores, etc.) ..... short tons	3,215	2,458	5,494	4,598	12,664	12,039	12,134	14,003
Iron ore (usable) ..... thousand long tons, gross weight	1,871	26,673	1,648	23,585	2,622	35,826	2,612	38,100
Lead (recoverable content of ores, etc.) ..... short tons	152,649	42,742	212,611	56,180	355,452	105,889	421,764	131,751
Lime ..... thousand short tons	W	W	W	W	W	W	W	W
Natural gas ..... million cubic feet	121	30	107	14	126	17	87	21
Petroleum (crude) ..... thousand 42-gallon barrels	W	W	W	W	67	W	66	W
Sand and gravel ..... thousand short tons	9,716	12,556	10,649	14,204	10,940	14,574	12,446	15,379
Silver (recoverable content of ores, etc.) ..... thousand troy ounces	226	351	341	731	1,442	2,582	1,817	3,218
Stone ..... thousand short tons	36,585	53,953	38,988	58,743	41,977	63,251	39,726	[3] 57,285
Zinc (recoverable content of ores, etc.) ..... short tons	7,430	2,057	12,301	3,321	41,099	12,001	50,721	15,540
Value of items that cannot be disclosed: Native asphalt, and values indicated by symbol W	XX	16,662	XX	18,624	XX	20,458	XX	22,643
Total	XX	237,010	XX	276,238	XX	367,232	XX	392,996

MONTANA								
Clays [5] thousand short tons	46	$50	30	$34	34	$63	41	$71
Coal (bituminous and lignite) do	371	996	519	1,214	1,030	2,199	3,447	6,394
Copper (recoverable content of ores, etc.) short tons	65,483	50,063	69,480	58,151	103,314	98,219	120,412	138,955
Gem stones	NA	109	NA	109	NA	109	NA	109
Gold (recoverable content of ores, etc.) troy ounces	9,786	343	13,385	[4] 525	24,189	[4] 1,004	22,456	[4] 817
Iron ore (usable) thousand long tons, gross weight	10	81	12	W	13	W	14	W
Lead (recoverable content of ores, etc.) short tons	898	251	1,870	494	1,753	522	996	311
Lime thousand short tons	143	1,765	179	2,005	255	2,737	208	W
Manganese ore (35 percent or more Mn) short tons, gross weight	W	W	4,649	213	775	26	512	W
Manganiferous ore (5 to 35 percent Mn) do	2,763	16	2,063	22	------	------	------	------
Natural gas million cubic feet	25,866	2,173	19,313	1,757	41,229	4,205	42,705	4,399
Petroleum (crude) thousand 42-gallon barrels	34,959	87,543	48,460	124,488	43,954	118,359	37,879	105,403
Pumice thousand short tons	------	------	93	327	134	102	------	------
Sand and gravel do	12,339	10,655	8,762	7,754	16,595	14,383	19,275	20,249
Silver (recoverable content of ores, etc.) thousand troy ounces	2,066	3,203	2,133	4,574	3,429	6,141	4,304	7,622
Stone thousand short tons	4,782	6,037	3,314	4,878	7,667	10,579	6,501	6,896
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	W	W	W	W	W	W	9	23
Zinc (recoverable content of ores, etc.) short tons	3,341	925	3,778	1,020	6,143	1,794	1,457	446
Value of items that cannot be disclosed: Antimony (1967, 1970), cement, clays (bentonite), fluorspar, gypsum, natural gas liquids, peat, phosphate rock, talc, vermiculite, and values indicated by symbol W	XX	22,314	XX	20,566	XX	22,189	XX	21,321
Total	XX	186,524	XX	228,131	XX	282,631	XX	313,016
NEBRASKA								
Clays thousand short tons	126	$142	148	$206	149	$223	90	$147
Gem stones	NA	5	NA	4	NA	5	NA	5
Lime thousand short tons	W	W	28	W	35	W	27	W
Natural gas million cubic feet	8,453	1,454	8,129	1,423	6,989	1,209	5,991	1,024
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	186	578	153	456	128	387	W	W
LP gases do	494	1,223	451	911	408	738	365	858
Petroleum (crude) do	13,373	36,775	13,183	36,781	12,106	36,075	11,451	35,384
Sand and gravel thousand short tons	11,739	10,878	12,742	12,946	12,758	13,592	12,232	12,974
Stone do	4,846	7,483	4,416	7,435	4,665	9,494	4,265	7,378
Value of items that cannot be disclosed: Cement, pumice, and values indicated by symbol W	XX	12,330	XX	14,446	XX	16,307	XX	14,887
Total	XX	70,868	XX	74,608	XX	78,030	XX	72,657
NEVADA								
Antimony ore and concentrate short tons, antimony content	53	$35	------	------	W	W	W	W
Barite thousand short tons	154	923	216	$1,511	320	$2,275	192	$1,455
Copper (recoverable content of ores, etc.) short tons	50,771	38,815	77,213	64,623	104,924	99,749	106,688	123,118
Gem stones	NA	100	NA	100	NA	100	NA	100
Gold (recoverable content of ores, etc.) troy ounces	434,993	15,225	317,382	[4] 12,460	456,294	[4] 18,941	480,144	[4] 17,472
Gypsum thousand short tons	409	1,412	552	1,534	521	1,550	451	1,457
Iron ore (usable) thousand long tons, gross weight	641	2,858	569	2,917	W	W	575	W
Lead (recoverable content of ores, etc.) short tons	1,500	420	863	228	1,420	423	364	114

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
NEVADA—Continued								
Mercury ... 76-pound flasks	4,703	2,301	4,780	2,560	8,165	4,124	4,916	2,005
Perlite ... short tons	10,712	94	9,315	79	8,998	77	8,470	73
Petroleum (crude) ... thousand 42-gallon barrels	279	W	271	W	223	W	149	W
Pumice ... thousand short tons	105	236	62	144	83	188	80	191
Sand and gravel ... do	10,166	8,644	7,812	10,442	8,447	10,834	8,574	9,819
Silver (recoverable content of ores, etc.) ... thousand troy ounces	566	877	645	1,384	884	1,583	718	1,271
Stone ... thousand short tons	1,375	2,145	1,325	2,041	1,494	2,433	1,860	2,722
Talc and soapstone ... short tons	2,096	17	3,029	38	6,434	81	W	W
Tungsten ore and concentrate ... short tons, 60-percent WO_3 basis	W	W	25	58	34	69	122	306
Zinc (recoverable content of ores, etc.) ... short tons	3,035	840	2,104	568	941	275	127	39
Value of items that cannot be disclosed: Brucite, cement, clays, diatomite, fluorspar, lime, lithium minerals, magnesite, molybdenum, peat (1967), pyrites (1969), salt, and values indicated by symbol W	XX	15,941	XX	19,354	XX	r 25,594	XX	26,207
Total	XX	90,883	XX	120,041	XX	r 168,296	XX	186,349
NEW HAMPSHIRE								
Clays ... thousand short tons	42	$42	41	$41	44	$40	40	$32
Mica, sheet ... pounds	16,000	W	---	---	---	---	---	---
Peat ... thousand short tons	(7)	(7)	---	---	---	---	---	---
Sand and gravel ... do	8,449	5,137	7,742	5,698	6,310	5,149	6,529	4,753
Stone ... do	473	2,887	383	3,377	320	2,888	W	W
Value of items that cannot be disclosed: Feldspar, gem stones, mica (scrap 1969–70) and values indicated by symbol W	XX	51	XX	50	XX	43	XX	3,945
Total	XX	8,117	XX	9,166	XX	8,120	XX	8,730
NEW JERSEY								
Clays ... thousand short tons	437	$1,189	373	$1,008	327	$1,123	262	$990
Gem stones	NA	10	NA	10	NA	10	NA	10
Peat ... thousand short tons	43	542	56	621	46	551	45	557
Sand and gravel ... do	18,626	29,975	20,306	33,570	20,325	33,977	16,732	31,571
Stone ... do	12,611	28,253	13,151	30,343	15,162	34,034	[3] 15,160	[3] 40,567
Zinc (recoverable content of ores, etc.)[8] ... short tons	26,041	7,031	25,668	6,930	25,076	7,322	28,683	8,788
Value of items that cannot be disclosed: Iron ore (1967), lime, magnesium compounds, manganiferous residuum, greensand marl, stone, dimension (1970) and titanium concentrate	XX	5,747	XX	4,984	XX	r 6,122	XX	6,798
Total	XX	72,747	XX	77,466	XX	r 83,139	XX	89,281
NEW MEXICO								
Carbon dioxide, natural ... thousand cubic feet	771,516	$57	749,364	$52	902,186	$69	W	W
Clays ... thousand short tons	46	74	66	89	70	89	67	$91
Coal (bituminous) ... do	3,463	12,641	3,429	13,507	4,471	16,376	7,361	21,249
Copper (recoverable content of ores, etc.) ... short tons	75,008	57,345	90,769	75,968	119,956	114,040	166,278	191,885

Feldspar……long tons	---------	---------	98	W	W	W	---------	---------
Gem stones	NA	60	NA	59	NA	60	NA	60
Gold (recoverable content of ores, etc.)……troy ounces	5,188	182	6,630	[4] 260	8,952	[4] 372	8,719	[4] 317
Gypsum……thousand short tons	155	588	146	549	141	526	W	W
Helium:								
Crude……million cubic feet	---------	---------	---------	---------	---------	---------	1	18
Grade A……do	71	2,492	39	1,355	13	260	(7)	6
Iron ore (usable)……thousand long tons, gross weight	W	W	17	113	W	W	W	W
Lead (recoverable content of ores, etc.)……short tons	1,827	512	1,363	360	2,368	705	3,550	1,109
Lime……thousand short tons	17	243	27	377	37	W	37	W
Manganese ore (35 percent or more Mn)……short tons, gross weight	W	W	6,729	W	4,855	131	4,225	W
Manganiferous ore (5 to 35 percent Mn)……do	49,323	348	50,681	379	49,146	340	46,166	W
Natural gas……million cubic feet	1,067,510	138,776	1,164,182	156,000	1,138,133	155,924	1,138,980	162,874
Natural gas liquids:								
Natural gasoline and cycle products……thousand 42-gallon barrels	8,050	20,730	8,868	23,104	9,053	24,388	9,606	25,548
LP gases……do	21,647	40,003	23,802	34,989	24,920	30,402	25,999	37,179
Peat……thousand short tons	---------	---------	(7)	4	(7)	4	(7)	7
Perlite……do	346,586	3,424	365,481	3,706	397,987	4,493	382,456	4,321
Petroleum (crude)……thousand 42-gallon barrels	126,144	368,340	128,550	378,708	129,227	404,441	128,184	410,320
Potassium salts……thousand short tons, K_2O equivalent	2,883	91,098	2,289	63,406	2,327	62,034	2,390	85,877
Pumice……thousand short tons	220	639	243	527	226	415	203	442
Salt……do	82	1,036	W	W	W	W	W	W
Sand and gravel……do	14,672	14,336	12,262	12,396	8,574	10,422	10,666	10,516
Silver (recoverable content of ores, etc.)……thousand troy ounces	157	244	225	482	466	834	782	1,385
Stone……thousand short tons	1,391	2,408	2,226	3,527	2,826	3,286	[8] 3,100	[8] 4,030
Uranium (recoverable content U_3O_8)……thousand pounds	11,202	89,615	12,282	95,144	11,811	69,887	11,574	69,970
Vanadium (recoverable in ore and concentrate)……short tons	W	W	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.)……do	21,380	5,919	18,686	5,045	24,308	7,098	16,601	5,086
Value of items that cannot be disclosed: Beryllium (1969), cement, fluorspar (1967–70), mica scrap, molybdenum, stone (other dimension 1970), tin (1969), and values indicated by symbol W	XX	23,001	XX	23,669	XX	29,150	XX	28,068
Total	XX	874,106	XX	893,775	XX	935,746	XX	1,060,358
NEW YORK								
Clays……thousand short tons	1,506	$1,814	1,675	$1,790	1,623	$1,783	1,707	$1,897
Gem stones	NA	10	NA	10	NA	10	NA	10
Gypsum……thousand short tons	570	3,118	570	2,925	492	2,945	425	2,737
Lead (recoverable content of ores, etc.)……short tons	1,653	463	1,396	369	1,686	502	1,280	400
Lime……thousand short tons	1,139	10,570	1,086	10,154	1,055	10,224	W	W
Mercury……76-pound flasks	---------	---------	---------	---------	[r] 280	[r] 141	28	11
Natural gas……million cubic feet	3,837	1,201	4,632	1,390	4,861	1,458	3,358	1,017
Peat……thousand short tons	23	232	15	153	14	178	15	145
Petroleum (crude)……thousand 42-gallon barrels	1,972	9,026	1,532	7,093	1,256	5,683	1,194	5,397
Salt……thousand short tons	5,320	41,568	5,218	42,488	5,582	45,561	5,990	47,254
Sand and gravel……do	43,500	44,499	43,439	45,812	39,806	42,518	35,537	38,839
Silver (recoverable content of ores, etc.)……thousand troy ounces	31	48	28	59	32	57	24	42
Stone……thousand short tons	33,389	56,615	35,441	63,510	37,561	66,839	37,616	68,118
Zinc (recoverable content of ores, etc.)……short tons	70,555	19,534	66,194	17,872	58,728	17,149	58,577	17,947
Value of items that cannot be disclosed: Cement, abrasive garnet, iron ore, talc, titanium concentrate, wollastonite, and values indicated by symbol W	XX	110,620	XX	106,011	XX	107,432	XX	115,750
Total	XX	299,318	XX	299,636	XX	[r] 302,480	XX	299,564

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
NORTH CAROLINA								
Clays [5] ... thousand short tons	2,977	$2,012	3,310	$2,148	3,342	$2,610	3,318	$3,102
Feldspar ... long tons	265,690	3,113	316,862	4,340	338,149	4,615	345,186	5,173
Gem stones	NA	25	NA	20	NA	20	NA	20
Mica:								
Scrap ... thousand short tons	70	1,751	69	1,640	67	1,513	64	1,457
Sheet ... pounds	4,500	W	15,000	W	W	3	----	----
Sand and gravel ... thousand short tons	10,014	9,962	10,771	11,178	10,562	11,437	12,772	13,277
Stone ... do	24,507	41,488	24,543	42,429	26,812	47,829	30,363	54,121
Talc and pyrophyllite ... short tons	109,393	513	100,030	520	105,728	586	92,639	544
Value of items that cannot be disclosed: Asbestos, barite (1967-68), cement, clay (kaolin), iron ore (1969–70), lithium minerals, olivine, phosphate rock, tungsten (1970), and values indicated by symbol W	XX	18,230	XX	20,544	XX	21,843	XX	20,671
Total	XX	77,094	XX	82,819	XX	90,456	XX	98,365
NORTH DAKOTA								
Clays ... thousand short tons	W	W	W	W	W	W	W	W
Coal (lignite) ... do	4,156	$7,967	4,487	$7,986	4,704	$8,696	5,639	$11,009
Gem stones	NA	1	NA	1	NA	1	NA	1
Natural gas ... million cubic feet	40,462	6,636	41,023	6,769	33,587	5,441	34,889	5,722
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	554	1,443	558	1,479	508	1,346	504	1,376
LP gases ... do	2,111	3,901	2,156	3,622	1,951	2,868	1,840	2,944
Petroleum (crude) ... do	25,315	65,818	25,040	66,106	22,703	63,568	21,998	67,107
Sand and gravel ... thousand short tons	8,822	9,118	10,839	10,159	7,039	7,274	8,090	6,336
Stone ... do	596	1,092	165	326	72	99	103	126
Value of items that cannot be disclosed: Lime, molybdenum (1967), peat (1968), (1970), salt, uranium (1968), and values indicated by symbol W	XX	1,562	XX	1,588	XX	1,755	XX	1,426
Total	XX	97,538	XX	98,036	XX	91,048	XX	96,047
OHIO								
Cement:								
Portland ... thousand 376-pound barrels	14,726	$46,860	15,222	$49,814	15,100	$50,071	11,752	$39,997
Masonry ... thousand 280-pound barrels	946	2,730	1,063	3,155	1,123	3,527	867	3,116
Clays ... thousand short tons	4,670	15,185	4,750	15,216	4,587	11,693	3,920	10,100
Coal (bituminous) ... do	46,014	176,921	48,323	191,427	51,242	210,082	55,351	262,390
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ... thousand short tons	3,636	48,817	3,701	49,367	4,159	60,975	3,951	61,197
Natural gas ... million cubic feet	41,315	9,957	42,673	10,540	49,793	12,837	52,113	14,123
Peat ... thousand short tons	7	100	7	94	11	116	6	95
Petroleum (crude) ... thousand 42-gallon barrels	9,924	31,427	11,204	35,722	10,972	36,098	9,864	32,914
Salt ... thousand short tons	5,407	39,549	5,713	43,172	5,844	43,519	5,329	47,498
Sand and gravel ... do	43,196	52,888	46,734	57,671	r 50,029	r 64,552	42,069	57,506

Stone ... do	45,458	72,534	[3] 48,054	[3] 78,772	51,792	86,570	47,244	81,506
Value of items that cannot be disclosed: Abrasive stone, gypsum, stone (dimension limestone and dolomite 1968)	XX	1,917	XX	1,945	XX	1,815	XX	1,721
Total	XX	498,888	XX	536,898	XX	[r] 581,858	XX	612,166
OKLAHOMA								
Clays [5] ... thousand short tons	744	$869	726	$967	802	$1,182	769	$1,120
Coal (bituminous) ... do	823	4,703	1,089	6,401	1,838	10,662	2,427	15,211
Gypsum ... do	804	2,266	931	2,565	980	3,912	874	2,616
Helium:								
Grade A ... million cubic feet	309	9,835	309	8,700	221	7,717	149	5,214
Crude ... do	---	---	---	---	133	1,123	245	1,935
Lead (recoverable content of ores, etc.) ... short tons	2,727	764	2,387	631	605	180	797	249
Natural gas ... million cubic feet	1,412,952	202,052	1,390,884	197,506	1,523,715	233,128	1,594,943	248,811
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	13,545	35,846	13,905	38,829	14,621	38,931	14,813	39,933
LP gases ... do	23,944	49,276	25,497	39,520	27,304	34,403	28,029	52,975
Petroleum (crude) ... thousand 42-gallon barrels	230,749	676,095	223,623	668,202	224,729	701,155	223,574	712,419
Salt ... thousand short tons	10	76	7	44	9	51	13	78
Sand and gravel ... do	4,540	5,280	5,041	6,288	5,262	7,156	5,675	7,258
Stone ... do	16,355	18,932	17,290	21,950	18,799	23,650	18,177	23,701
Zinc (recoverable content of ores, etc.) ... short tons	10,670	2,954	6,921	1,869	2,744	801	2,650	812
Value of items that cannot be disclosed: Cement, clay (bentonite), copper, lime, pumice, silver, and tripoli	XX	23,178	XX	23,360	XX	26,758	XX	24,935
Total	XX	1,032,126	XX	1,016,832	XX	1,090,809	XX	1,137,267
OREGON								
Clays [5] ... thousand short tons	295	$295	213	$284	215	$321	134	$180
Diatomite ... short tons	108	2	120	W	85	W	500	5
Gem stones	NA	750	NA	750	NA	750	NA	750
Gold (recoverable content of ores, etc.) ... troy ounces	186	7	23	[4] 1	875	[4] 36	256	[4] 9
Lead ... short tons	---	---	---	---	(7)	(7)	(7)	(7)
Lime ... thousand short tons	99	2,059	120	2,407	115	2,337	96	1,777
Mercury ... 76-pound flasks	943	461	938	502	43	22	274	112
Nickel (content of ore and concentrate) ... short tons	15,287	W	17,294	W	17,056	W	15,933	W
Peat ... thousand short tons	W	W	(7)	11	---	---	---	---
Perlite ... do	(7)	(7)	---	---	---	---	---	---
Pumice ... do	834	1,195	725	977	875	1,139	1,061	1,252
Sand and gravel ... do	19,630	25,250	18,260	21,457	15,740	20,491	17,532	25,978
Silver (recoverable content of ores, etc.) ... thousand troy ounces	(7)	(7)	(7)	1	5	9	4	6
Stone ... thousand short tons	13,201	20,256	14,312	21,168	11,662	18,897	13,439	20,948
Talc and soapstone ... short tons	W	W	3	1	W	W	W	W
Value of items that cannot be disclosed: Bauxite (1970), cement, clay (fire clay 1967–70), copper (1968–70), and values indicated by symbol W	XX	16,285	XX	16,890	XX	16,162	XX	17,084
Total	XX	66,560	XX	64,449	XX	60,164	XX	68,101

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
PENNSYLVANIA								
Cement:								
Portland ... thousand 376-pound barrels	40,197	$114,592	43,018	$123,176	44,893	$126,941	40,909	$121,100
Masonry ... thousand 280-pound barrels	2,929	7,948	3,151	8,706	3,085	8,504	2,804	8,324
Clays [5] ... thousand short tons	2,994	16,703	3,034	17,679	2,727	19,637	2,665	15,845
Coal:								
Anthracite ... do	12,256	96,160	11,461	97,245	10,473	100,770	9,729	105,341
Bituminous ... do	79,412	419,345	76,200	408,982	78,631	461,579	80,491	585,057
Copper (recoverable content of ores, etc.) ... short tons	4,401	3,365	4,850	4,059	3,382	3,215	2,539	2,930
Gem stones	NA	4	NA	4	NA	4	NA	4
Lime ... thousand short tons	1,719	24,715	1,702	24,272	2,008	28,952	1,887	29,279
Mica, scrap ... do	W	W	W	W	W	W	1	60
Natural gas ... million cubic feet	89,966	25,280	87,987	24,460	79,134	21,841	76,841	21,439
Natural gas liquids:								
Natural gasoline ... thousand 42-gallon barrels	28	77	27	73	22	61	19	50
LP gases ... do	42	114	37	95	35	78	34	87
Peat ... thousand short tons	40	437	36	385	35	407	44	517
Petroleum (crude) ... thousand 42-gallon barrels	4,387	19,701	4,160	18,698	4,448	20,086	4,093	18,500
Sand and gravel ... thousand short tons	17,479	29,614	18,101	31,076	18,105	31,451	18,504	33,915
Stone ... do	60,155	103,157	62,812	108,151	66,992	117,726	66,241	120,187
Zinc (recoverable content of ores, etc.) [8] ... short tons	35,067	9,468	30,382	8,203	33,035	9,646	29,554	9,055
Value of items that cannot be disclosed: Clays (kaolin), cobalt, gold, iron ore, scrap mica, pyrites, pyrophyllite, silver, tripoli, and values indicated by symbol W	XX	27,718	XX	28,780	XX	25,470	XX	24,053
Total	XX	898,398	XX	904,044	XX	976,368	XX	1,095,743
RHODE ISLAND								
Sand and gravel ... thousand short tons	2,334	$2,416	2,291	$2,546	2,480	$3,015	2,387	$2,913
Stone ... do	481	1,618	W	W	W	1,417	W	W
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	1	XX	1,676	XX	1	XX	1,473
Total	XX	4,035	XX	4,222	XX	4,433	XX	4,386
SOUTH CAROLINA								
Clays ... thousand short tons	1,733	$8,048	1,936	$8,923	2,444	$10,911	1,974	$9,878
Sand and gravel ... do	5,248	7,178	5,662	8,074	5,692	8,229	5,864	7,766
Stone ... do	[3] 8,310	[3] 12,366	8,942	13,717	8,846	13,506	9,710	[3] 14,734
Value of items that cannot be disclosed: Cement, feldspar, kyanite, scrap mica, peat, pyrites, stone (dimension granite (1967–70), and vermiculite	XX	20,682	XX	21,144	XX	23,218	XX	23,987
Total	XX	48,274	XX	51,858	XX	55,864	XX	56,365

SOUTH DAKOTA								
Beryllium concentrate ____ short tons, gross weight	W	W	75	$35	46	$23	W	W
Cement:								
Portland ____ thousand 376-pound barrels	1,406	$4,815	1,826	6,228	1,556	5,715	W	W
Masonry ____ thousand 280-pound barrels	54	178	54	180	49	181	W	W
Clays ____ thousand short tons	199	799	226	1,119	187	1,171	165	$946
Coal (lignite) ____ do	5	27	----	----	----	----	----	----
Feldspar ____ long tons	61,411	420	39,077	264	29,434	194	17,211	114
Gem stones	NA	30	NA	34	NA	36	NA	35
Gold (recoverable content of ores, etc.) ____ troy ounces	601,785	21,062	593,052	[4] 23,283	593,146	[4] 24,621	578,716	[4] 21,059
Gypsum ____ thousand short tons	12	49	16	65	11	46	15	61
Lead (recoverable content of ores, etc.) ____ short tons	----	----	----	----	1	(7)	3	1
Mica (scrap) ____ thousand short tons	W	W	W	W	(7)	20	(7)	34
Petroleum (crude) ____ thousand 42-gallon barrels	211	502	187	401	158	362	160	374
Sand and gravel ____ thousand short tons	13,463	13,737	11,558	11,578	11,158	10,807	16,556	16,656
Silver (recoverable content of ores, etc.) ____ thousand troy ounces	121	188	138	295	124	223	120	212
Stone ____ thousand short tons	1,866	9,694	1,860	9,687	2,092	10,839	1,979	13,375
Zinc (recoverable content of ores, etc.) ____ short tons	----	----	----	----	----	----	1	(7)
Value of items that cannot be disclosed: Columbium-tantalum concentrates (1967–69), lime, molybdenum (1967), tin (1969), uranium, vanadium (1967, 1970), and values indicated by symbol W	XX	1,117	XX	917	XX	683	XX	8,709
Total	XX	52,618	XX	54,086	XX	54,921	XX	61,576
TENNESSEE								
Barite ____ thousand short tons	15	$235	21	$362	16	$295	19	$286
Cement:								
Portland ____ thousand 376-pound barrels	8,062	25,548	8,488	27,691	9,159	29,403	8,878	29,832
Masonry ____ thousand 280-pound barrels	1,092	2,992	1,370	3,836	1,331	3,587	969	2,749
Clays ____ thousand short tons	1,574	5,152	[5] 1,562	[5] 5,772	[5] 1,719	[5] 7,064	[5] 1,401	[5] 7,123
Coal (bituminous) ____ do	6,832	26,974	8,148	29,647	8,082	30,682	8,237	40,372
Copper (recoverable content of ores, etc.) ____ short tons	14,600	11,162	14,196	11,881	15,353	14,596	15,535	17,928
Gold (recoverable content of ores, etc.) ____ troy ounces	181	6	140	[4] 5	126	[4] 5	124	[4] 5
Lead (recoverable content of ores, etc.) ____ short tons	----	----	----	----	----	----	----	----
Natural gas ____ million cubic feet	58	11	48	9	57	11	64	13
Petroleum (crude) ____ thousand 42-gallon barrels	7	W	6	W	32	W	309	W
Phosphate rock ____ thousand short tons	2,992	22,571	3,149	23,628	W	W	W	W
Sand and gravel ____ do	7,975	10,679	7,344	11,140	6,175	9,709	6,715	10,639
Silver (recoverable content of ores, etc.) ____ thousand troy ounces	130	202	90	192	79	141	95	168
Stone [3] ____ thousand short tons	31,463	41,958	32,083	43,854	33,265	46,192	35,374	50,013
Zinc (recoverable content of ores, etc.) ____ short tons	113,065	31,303	124,039	33,491	124,532	36,363	118,260	36,233
Value of items that cannot be disclosed: Clay (fuller's earth) 1969, lime, pyrites, stone (crushed sandstone 1968), dimension sandstone 1967), and values indicated by symbol W	XX	10,779	XX	9,826	XX	27,402	XX	25,104
Total	XX	189,572	XX	201,334	XX	205,450	XX	220,465

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
TEXAS								
Cement:								
Portland ... thousand 376-pound barrels	31,944	$99,329	34,499	$107,532	36,037	$117,989	33,967	$122,960
Masonry ... thousand 280-pound barrels	888	2,847	1,059	3,371	1,110	3,873	1,007	3,769
Clays ... thousand short tons	4,497	8,081	4,687	8,860	4,407	8,664	4,148	9,587
Gem stones	NA	150	NA	150	NA	150	NA	150
Gypsum ... thousand short tons	984	3,419	1,039	3,616	1,314	4,398	1,220	4,252
Helium:								
Crude ... million cubic feet	978	10,246	1,039	11,100	1,190	13,053	1,175	13,262
Grade A ... do	336	9,900	362	9,400	141	4,917	82	2,862
Lime ... thousand short tons	1,564	20,713	1,564	21,154	1,633	22,107	1,673	24,427
Natural gas ... million cubic feet	7,188,900	948,935	7,495,414	1,011,881	7,853,199	1,075,888	8,357,716	1,203,511
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	95,991	277,105	97,075	269,182	96,628	289,042	97,511	284,871
LP gases ... do	177,367	320,326	189,162	278,068	194,599	237,411	204,177	334,850
Petroleum (crude) ... do	1,119,962	3,375,565	1,133,380	3,450,707	1,151,775	3,696,328	1,249,697	4,104,005
Salt ... thousand short tons	8,344	36,435	8,534	42,663	9,261	43,012	10,184	45,000
Sand and gravel ... do	31,398	39,170	31,843	41,546	29,972	39,756	31,438	46,362
Stone ... do	49,424	61,577	48,480	58,006	46,638	64,986	45,557	64,422
Sulfur (Frasch process) ... thousand long tons	3,448	111,931	2,571	105,482	2,552	68,360	2,801	62,290
Talc and soapstone ... short tons	90,836	356	125,880	517	163,812	668	171,420	878
Value of items that cannot be disclosed: Native asphalt, bromine, coal (lignite), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, perlite (1967), pumice, sodium sulfate, uranium, and vermiculite (1967–68)	XX	80,286	XX	82,596	XX	79,368	XX	75,004
Total	XX	5,406,371	XX	5,505,831	XX	5,769,970	XX	6,402,462
UTAH								
Carbon dioxide, natural ... thousand cubic feet	65,664	$5	57,747	$4	64,839	$5	60,754	$4
Clays [5] ... thousand short tons	114	288	160	476	179	1,286	189	1,237
Coal (bituminous) ... do	4,175	24,281	4,316	24,893	4,657	29,396	4,733	34,472
Copper (recoverable content of ores, etc.) ... short tons	168,609	128,905	228,245	191,027	296,699	282,066	295,738	341,282
Fluorspar ... do	W	W	8,762	213	6,667	207	19,214	595
Gem stones	NA	80	NA	83	NA	85	NA	85
Gold (recoverable content of ores, etc.) ... troy ounces	288,350	10,092	334,419	[4] 13,129	433,385	[4] 17,990	408,029	[4] 14,848
Iron ore (usable) ... thousand long tons, gross weight	1,708	11,916	1,764	11,281	1,921	12,552	1,990	13,837
Lead (recoverable content of ores, etc.) ... short tons	53,813	15,068	45,205	11,945	41,332	12,313	45,377	14,175
Lime ... thousand short tons	169	3,182	174	3,439	191	3,947	186	3,756
Manganiferous ore (5 to 35 percent Mn) ... short tons	-------	-------	-------	-------	-------	-------	700	W
Natural gas ... million cubic feet	48,965	6,463	46,151	7,292	46,733	7,197	42,781	6,460
Petroleum (crude) ... thousand 42-gallon barrels	24,048	63,221	23,504	62,826	23,295	65,320	23,370	65,603
Pumice ... thousand short tons	W	W	8	19	10	21	W	18
Salt ... do	403	3,525	405	3,756	481	4,439	366	3,638
Sand and gravel ... do	9,412	8,631	10,293	9,364	19,151	16,042	12,010	10,439
Silver (recoverable content of ores, etc.) ... thousand troy ounces	4,875	7,556	5,121	10,982	5,954	10,661	6,030	10,678

Stone ... thousand short tons	1,831	4,108	1,953	4,312	2,582	4,434	1,650	4,320
Tungsten concentrates ... short tons, 60-percent WO_3 basis	---------	---------	W	W	3	6	W	W
Uranium (recoverable content U_3O_8) ... thousand pounds	1,287	10,300	1,712	13,175	1,140	6,824	1,635	10,023
Vanadium (recoverable in ore and concentrate) ... short tons	471	2,024	563	2,010	W	W	257	W
Zinc (recoverable content of ores, etc.) ... do	34,251	9,483	33,153	8,951	34,902	10,191	34,688	10,628
Value of items that cannot be disclosed: Asphalt (gilsonite), cement, clays (fire clay 1967, kaolin (1967–68), gypsum, magnesium compounds, molybdenum, natural gas liquids, perlite (1967, 1969–70), phosphate rock, potassium salts, pyrites (1967–68), and values indicated by symbol W	XX	45,349	XX	44,774	XX	57,507	XX	55,899
Total	XX	354,477	XX	423,951	XX	542,489	XX	601,997
VERMONT								
Lime ... short tons	W	W	W	W	1,500	$25	---------	---------
Peat ... thousand short tons	(7)	$4	W	W	(7)	4	(7)	$6
Sand and gravel ... do	3,718	2,178	3,587	$2,806	3,336	3,028	4,046	4,122
Stone ... do	2,761	20,520	2,536	21,401	2,151	19,810	1,514	19,088
Value of items that cannot be disclosed: Asbestos, clays, gem stones, lime, talc, and values indicated by symbol W	XX	4,566	XX	4,508	XX	4,892	XX	4,627
Total	XX	27,268	XX	28,715	XX	27,759	XX	27,843
VIRGINIA								
Clays ... thousand short tons	1,382	$1,623	1,462	$1,714	1,677	$1,504	1,633	$1,672
Coal (bituminous) ... do	36,721	171,183	36,966	178,946	35,555	192,802	35,016	246,181
Gem stones	NA	7	NA	7	NA	7	NA	7
Lead (recoverable content of ores, etc.) ... short tons	3,430	960	3,573	944	3,358	1,000	3,356	1,048
Lime ... thousand short tons	829	10,345	919	11,138	1,072	13,653	1,046	14,090
Natural gas ... million cubic feet	3,818	1,149	3,389	1,013	2,846	845	2,805	864
Petroleum (crude) ... thousand 42-gallon barrels	3	W	3	W	1	W	1	W
Sand and gravel ... thousand short tons	9,863	12,494	10,859	13,644	12,140	15,954	11,126	15,229
Soapstone ... short tons	W	W	3,928	10	4,600	12	3,760	9
Stone ... thousand short tons	31,324	52,470	31,217	53,533	33,461	58,713	35,415	60,477
Zinc (recoverable content of ores, etc.) [8] ... short tons	18,846	5,088	19,257	5,199	18,704	5,462	18,063	5,534
Value of items that cannot be disclosed: Aplite, cement, feldspar, gypsum, iron ore (pigment materials 1967–69), kyanite, salt, titanium concentrate, and values indicated by symbol W	XX	28,366	XX	29,515	XX	27,575	XX	29,210
Total	XX	283,685	XX	295,663	XX	317,527	XX	374,321
WASHINGTON								
Barite ... thousand short tons	(7)	$1	---------	---------	---------	---------	---------	---------
Cement:								
Portland ... thousand 376-pound barrels	5,614	20,581	6,328	$23,030	6,356	$22,724	6,495	$24,832
Masonry ... thousand 280-pound barrels	65	200	56	175	58	204	41	158
Clays [5] ... thousand short tons	139	203	255	253	230	434	240	436
Coal (bituminous) ... do	59	517	178	823	58	480	37	470
Copper (recoverable content of ores, etc.) ... short tons	21	16	22	18	18	17	9	11
Gem stones	NA	75	NA	100	NA	150	NA	150
Lead (recoverable content of ores, etc.) ... short tons	2,762	773	5,655	1,494	8,649	2,577	6,784	2,119

See footnotes at end of table.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
WASHINGTON—Continued								
Peat ... thousand short tons	41	181	40	159	33	134	17	71
Sand and gravel ... do	28,164	27,520	31,432	27,839	34,245	31,046	25,089	27,902
Stone ... do	14,454	19,099	14,331	16,690	15,742	21,069	13,701	19,100
Talc and soapstone ... short tons	4,916	26	W	W	4,228	W	W	W
Zinc (recoverable content of ores, etc.) ... do	21,540	5,964	13,884	3,749	9,738	2,843	11,956	3,663
Value of items that cannot be disclosed: Bauxite (1970), carbon dioxide (1967), clays (fire clay, bentonite, diatomite, gold, gypsum (1967–69), lime, magnesite (1967–68), mercury (1968), olivine, pumice, silver, tungsten (1967), uranium (1970), and values indicated by symbol W	XX	6,911	XX	7,095	XX	6,948	XX	12,010
Total	XX	82,067	XX	81,425	XX	88,626	XX	90,922
WEST VIRGINIA								
Clays [5] ... thousand short tons	245	$254	193	$219	247	$348	191	$238
Coal (bituminous) ... do	153,749	800,683	145,921	775,720	141,011	807,811	144,072	1,142,245
Lime ... do	217	3,099	207	2,848	269	3,648	262	3,757
Natural gas ... million cubic feet	211,460	50,962	236,971	62,086	231,759	62,575	242,052	61,583
Petroleum (crude) ... thousand 42-gallon barrels	3,561	14,244	3,312	13,149	3,104	11,888	3,124	11,871
Salt ... thousand short tons	1,127	5,137	1,308	4,971	1,309	4,978	1,190	5,171
Sand and gravel ... do	5,827	12,167	5,657	11,900	r 5,021	r 11,475	4,396	11,473
Stone [3] ... do	9,445	16,447	9,011	16,789	9,031	15,801	9,740	16,722
Value of items that cannot be disclosed: Calcium-magnesium chloride (1967), cement, clay (fire clay), gem stones, natural gas liquids, and stone (dimension sandstone)	XX	34,865	XX	30,026	XX	28,715	XX	32,304
Total	XX	937,858	XX	917,708	XX	r 947,239	XX	1,285,364
WISCONSIN								
Clays ... thousand short tons	89	$112	17	$34	12	$24	8	$14
Iron ore (usable) ... thousand long tons, gross weight	-----	-----	-----	-----	36	W	806	W
Lead (recoverable content of ores, etc.) ... short tons	1,596	447	1,126	298	1,102	328	761	238
Lime ... thousand short tons	212	3,414	224	3,620	244	4,080	247	4,503
Peat ... do	2	W	2	153	2	155	2	W
Sand and gravel ... do	42,542	32,955	39,807	30,903	42,815	35,414	41,103	35,107
Stone ... do	17,122	24,863	17,000	25,223	18,954	27,571	17,577	25,167
Zinc (recoverable content of ores, etc.) ... short tons	28,953	8,016	25,711	6,942	22,901	6,687	20,634	6,322
Value of items that cannot be disclosed: Abrasive stones, cement, gem stones, and values indicated by symbol W	XX	9,805	XX	4,522	XX	5,533	XX	16,319
Total	XX	79,612	XX	71,695	XX	79,792	XX	87,670

WYOMING

Clays — thousand short tons	1,495	$14,313	1,828	$17,275	1,992	$18,970	1,950	$18,829
Coal (bituminous) — do	3,588	11,876	3,829	12,117	4,602	15,443	7,222	24,423
Gem stones	NA	125	NA	127	NA	129	NA	130
Gypsum — thousand short tons	W	W	W	W	W	W	216	868
Iron ore (usable) — thousand long tons, gross weight	1,854	19,186	1,967	19,452	2,048	20,751	W	W
Lime — thousand short tons	W	W	28	W	27	W	22	W
Natural gas — million cubic feet	240,074	35,051	248,481	36,278	303,517	44,617	338,520	49,762
Natural gas liquids:								
Natural gasoline — thousand 42-gallon barrels	2,361	6,447	2,331	6,501	2,523	7,051	2,597	7,085
LP gases — do	4,139	7,648	3,917	7,090	4,428	7,085	4,556	7,472
Petroleum (crude) — do	136,312	351,685	144,250	380,589	154,945	433,846	160,345	469,811
Sand and gravel — thousand short tons	8,181	8,253	9,350	8,973	7,568	7,288	9,447	9,298
Stone — do	1,246	2,375	1,434	2,754	1,584	3,012	1,266	2,758
Uranium (recoverable content U_3O_8) — thousand pounds	4,655	37,243	5,928	44,343	6,716	40,318	6,346	38,768
Value of items that cannot be disclosed: Cement, copper (1969), feldspar (1967–68 and 70), gold (1969), gypsum, phosphate rock, pumice (1967), silver (1969), sodium carbonates and sulfates, vanadium (1967), vermiculite (1967), and values indicated by symbol W	XX	36,494	XX	40,691	XX	48,933	XX	76,329
Total	XX	530,696	XX	576,190	XX	647,443	XX	705,533

[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 stone, included with "Value of items that cannot be disclosed."
[4] Based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968; and Engelhard selling quotations Mar. 20, 1968 through 1970.
[5] Excludes certain clays, included with "Value of items that cannot be disclosed."
[6] Excludes salt in brine, included with "Value of items that cannot be disclosed."
[7] Less than ½ unit.
[8] 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.

Table 6.—Mineral production[1] in the Canal Zone and islands administered by the United States[2]

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
American Samoa:								
Pumice ... thousand short tons	28	$24	21	$51	2	$5	2	$6
Sand and gravel ... do	7	7	20	19	7	7	26	25
Stone ... do	28	50	53	79	54	108	49	69
Total	XX	81	XX	149	XX	120	XX	100
Canal Zone:								
Sand and gravel ... thousand short tons	56	94	55	77	60	97	60	97
Stone (crushed) ... do	100	245	106	290	74	231	85	265
Total	XX	339	XX	367	XX	328	XX	362
Guam: Stone ... thousand short tons	511	820	560	998	654	1,399	626	1,289
Virgin Islands: Stone (crushed) ... do	183	851	366	1,555	411	1,682	514	2,226
Wake: Stone (crushed) ... do	31	150	41	132	9	45	4	18

XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Production data for Wake furnished by U.S. Department of Transportation, Federal Aviation Administration; Guam, by the Government of Guam; American Samoa, by the Government of American Samoa.

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

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
Cement ... thousand 376-pound barrels	8,447	$27,397	8,923	$27,577	8,943	$27,920	9,460	$29,515
Clays ... thousand short tons	291	244	512	481	438	454	429	486
Lime ... do	35	1,106	39	1,187	41	1,505	41	W
Salt ... do	12	195	32	395	32	395	32	395
Sand and gravel ... do	14,101	21,633	16,146	24,723	9,432	23,296	e 9,432	e 23,296
Stone ... do	7,269	12,795	7,367	13,580	6,985	13,550	7,296	13,947
Total	XX	63,370	XX	67,943	XX	67,120	XX	[2] 67,639

e Estimate. 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	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude ---- short tons	344,414	$172,137	408,452	$214,780
Scrap ---- do	86,255	33,827	57,159	20,945
Plates, sheets, bars, etc ---- do	135,707	99,596	137,675	106,913
Castings and forgings ---- do	4,360	10,473	3,438	9,068
Antimony: Metals and alloys, crude ---- do	207	216	544	634
Bauxite, including bauxite concentrates thousand long tons	r 5	456	3	245
Aluminum sulfate ---- short tons	12,274	367	17,726	578
Other aluminum compounds ---- do	1,038,680	85,850	1,134,707	92,633
Beryllium ---- pounds	28,951	630	41,353	1,021
Bismuth: Metals and alloys ---- do	447,931	1,515	910,275	2,332
Cadmium ---- thousand pounds	1,085	3,254	373	997
Chrome:				
Ore and concentrates:				
Exports ---- thousand short tons	49	1,915	41	2,582
Reexports ---- do	150	5,806	73	2,572
Ferrochrome ---- do	25	5,679	28	8,259
Cobalt ---- thousand pounds	3,257	5,951	2,699	5,798
Columbium metals, alloys and other forms do	41	601	46	562
Copper:				
Ore, concentrate, composition metal and unrefined (copper content) ---- short tons	5,517	5,113	69,343	65,869
Refined copper and semimanufactures ---- short tons	236,914	303,386	249,217	370,388
Other copper manufactures ---- do	4,602	6,160	6,057	8,568
Copper sulfate or blue vitriol ---- short tons	3,127	2,385	2,485	1,543
Copper base alloys ---- do	94,803	111,048	127,593	138,327
Ferroalloys:				
Ferrosilicon ---- do	6,487	1,666	44,694	11,887
Ferrophosphorous ---- do	37,351	912	33,106	1,199
Gold:				
Ore and base bullion ---- troy ounces	58,867	2,434	106,117	3,903
Bullion, refined ---- do	279,434	9,853	968,108	33,887
Iron ore ---- thousand long tons	5,160	62,310	5,492	67,898
Iron and steel:				
Pig iron ---- short tons	43,961	2,647	309,746	18,339
Iron and steel products (major):				
Semimanufactures ---- do	r 4,809,469	r 641,559	6,584,610	846,518
Manufactured steel mill products ---- do	705,579	322,826	767,140	381,695
Iron and steel scrap: Ferrous scrap, including rerolling materials ---- thousand short tons	r 9,177	r 302,707	10,364	447,369
Lead:				
Pigs, bars, anodes ---- short tons	4,968	3,913	7,747	4,757
Scrap ---- do	2,340	505	4,214	1,056
Magnesium: Metal and alloys and semimanufactured forms, n.e.c ---- short tons	27,372	17,961	35,732	22,542
Manganese:				
Ore and concentrate ---- do	r 19,796	r 1,589	20,294	2,461
Ferromanganese ---- do	1,759	483	21,747	4,356
Mercury:				
Exports ---- 76-pound flasks	507	294	4,653	2,133
Reexports ---- do	108	57	50	19
Molybdenum:				
Ore and concentrates (molybdenum content) thousand pounds	r 57,575	99,055	55,737	95,246
Metals and alloys, crude and scrap do	21	70	671	802
Wire ---- do	61	1,083	107	1,252
Semifabricated forms, n.e.c ---- do	229	682	133	643
Powder ---- do	r 44	r 168	329	528
Ferromolybdenum ---- do	1,455	2,381	2,014	3,088
Nickel:				
Alloys and scrap (including monel metal), ingots, bars, sheets, etc ---- short tons	29,240	64,420	26,007	64,830
Catalysts ---- do	3,592	7,531	2,524	6,451
Nickel-chrome electric resistance wire ---- do	746	3,630	870	5,642
Semifabricated forms, n.e.c ---- do	1,180	6,487	2,055	9,001
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap troy ounces	223,569	30,356	270,584	32,978
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap) troy ounces	277,495	16,355	143,182	10,034
Platinum group manufactures, except jewelry ----	NA	4,310	NA	5,727
Rare-earths: Cerium ore, metal, alloys and lighter flints pounds	103,169	351	77,523	275

See footnotes at end of table.

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

Mineral	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
METALS—Continued				
Silver:				
Ore, concentrates, waste and sweepings thousand troy ounces	30,952	53,334	10,375	18,102
Bullion, refined do	57,957	103,386	17,239	31,037
Tantalum:				
Ore, metal, and other forms thousand pounds	209	2,652	762	3,884
Powder do	100	2,952	139	4,367
Tin:				
Ingots, pigs, bars, etc:				
Exports long tons	2,362	8,459	4,009	15,222
Reexports do	541	1,927	443	1,701
Tin scrap and other tin-bearing material except tin-plate scrap long tons	5,369	4,825	2,756	2,466
Titanium:				
Ore and concentrate short tons	1,424	183	1,100	297
Sponge (including iodide titanium and scrap) do	2,802	1,936	2,892	2,583
Intermediate mill shapes and mill products, n.e.c do	1,773	9,206	1,740	10,435
Dioxide and pigments do	24,507	7,510	26,183	7,944
Tungsten ore and concentrates:				
Exports thousand pounds	r 7,151	19,829	19,470	61,131
Reexports do	---------	---------	188	341
Vanadium ore and concentrate, pentoxide, etc. (vanadium content) thousand pounds	516	1,300	1,946	5,808
Zinc:				
Slabs, pigs, or blocks short tons	9,298	2,612	288	114
Sheets, plates, strips, or other forms, n.e.c do	2,714	1,746	1,412	1,173
Scrap (zinc content) do	1,989	716	3,112	1,049
Semifabricated forms, n.e.c do	28,810	6,321	25,528	5,635
Zirconium:				
Ore and concentrate do	2,698	295	4,380	591
Metals and alloys and other forms pounds	443,462	5,911	600,035	6,284
NONMETALS				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder thousand carats	8,122	21,599	7,258	18,711
Crushing bort do	45	265	33	154
Industrial diamonds do	345	1,634	339	1,838
Diamond grinding wheels do	699	r 3,560	614	3,117
Other natural and artificial, metallic abrasives and products	NA	r 43,596	NA	40,518
Asbestos, unmanufactured:				
Exports short tons	34,522	4,626	38,235	5,340
Reexports do	1,651	353	8,350	1,656
Boron: Boric acid, borates, crude and refined do	233,650	24,004	233,200	25,680
Cement thousand 376-pound barrels	589	3,189	847	5,211
Clays:				
Kaolin or china clay short tons	477,674	14,789	816,284	27,294
Fire clay do	162,557	2,621	167,308	3,464
Other clays do	r 930,237	r 28,256	1,071,087	35,358
Fluorspar do	3,605	213	14,952	1,145
Graphite do	5,655	682	5,783	701
Gypsum:				
Crude, crushed or calcined thousand short tons	40	2,003	41	1,915
Manufactures, n.e.c	NA	1,443	NA	1,560
Kyanite and allied minerals short tons	19,696	1,353	24,024	1,622
Lime do	51,006	1,153	53,876	1,391
Mica sheet, waste and scrap and ground pounds	11,810,008	1,274	17,459,607	1,422
Mica, manufactured	638,830	1,834	1,260,780	3,310
Mineral-earth pigments: Iron oxide, natural and manufactured short tons	3,992	1,439	4,565	1,621
Nitrogen compounds (major) thousand short tons	r 4,009	r 184,098	3,421	150,735
Phosphate rock do	11,369	87,418	11,738	89,898
Phosphatic fertilizers (superphosphates) do	847	33,922	774	28,645
Pigments and compounds (lead and zinc):				
Lead pigments short tons	1,688	686	1,516	649
Zinc pigments do	4,865	1,641	7,867	2,866
Potash:				
Fertilizer do	1,232,636	33,061	966,410	28,490
Chemical do	26,620	4,712	80,377	8,450
Quartz, natural, quartzite, cryolite and chiolite do	794	165	671	108

See footnotes at end of table.

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

Mineral	1969		1970	
	Quantity	Value (thousands)	Quantity	Value (thousands)
NONMETALS—Continued				
Salt:				
Crude and refined ---- thousand short tons	716	4,486	423	3,657
Shipments to noncontiguous Territories do	14	1,200	16	969
Sodium and sodium compounds:				
Sodium sulfate ---- do	91	2,644	55	1,668
Sodium carbonate ---- do	324	10,326	336	12,007
Stone:				
Dolomite, block ---- do	93	1,809	77	1,454
Limestone, crushed, ground, broken do	1,382	3,189	1,755	3,459
Marble and other building and monumental thousand cubic feet	NA	863	NA	877
Stone, crushed, ground, broken -- thousand short tons	284	3,569	388	3,288
Manufactures of stone	NA	793	NA	1,318
Sulfur:				
Crude ---- thousand long tons	r 1,549	r 57,449	1,429	33,096
Crushed, ground, flowers of ---- do	r 2	r 334	4	955
Talc, crude and ground ---- short tons	69,022	3,713	104,946	5,738
MINERAL FUELS				
Carbon black ---- thousand pounds	196,203	22,915	192,636	24,505
Coal:				
Anthracite ---- thousand short tons	627	8,420	789	11,215
Bituminous ---- do	56,234	585,452	70,908	950,232
Briquets ---- do	73	3,952	69	3,736
Coke ---- do	1,629	38,510	2,514	78,885
Petroleum:				
Crude ---- thousand barrels	1,436	3,694	4,991	17,225
Gasoline ---- do	r 1,874	r 14,475	1,049	10,362
Jet ---- do	r 326	r 1,323	63	228
Naphtha ---- do	r 3,224	r 24,638	2,052	19,249
Kerosine ---- do	r 151	r 1,312	118	973
Distillate oil ---- do	r 2,403	r 8,849	1,631	5,555
Residual oil ---- do	r 16,766	r 34,005	19,801	45,734
Lubricating oil ---- do	r 16,089	r 186,814	15,712	189,374
Asphalt ---- do	r 413	r 3,615	399	4,668
Liquefied petroleum gases ---- do	r 12,781	r 34,297	9,932	31,674
Wax ---- do	r 1,616	32,724	1,783	40,862
Coke ---- do	r 23,028	74,176	30,515	97,654
Petrochemical feedstocks ---- do	r 3,829	18,170	3,754	19,856
Miscellaneous ---- do	r 908	18,651	1,061	21,331
Total	XX	r 4,412,016	XX	5,455,967

r Revised. NA Not available. XX Not applicable.

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

Mineral	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
METALS				
Aluminum:				
Metal ... short tons	468,236	$214,845	350,060	$164,227
Scrap ... do	28,850	11,003	36,779	12,979
Plates, sheets, bars, etc ... do	r 57,168	r 38,437	78,660	53,836
Aluminum oxide (alumina) ... do	1,912,474	106,333	2,554,807	152,537
Antimony:				
Ore (antimony content) ... do	12,098	5,248	13,820	12,733
Needle or liquated ... do	62	51	18	54
Metal ... do	980	888	1,290	3,493
Oxide ... do	4,715	3,852	4,256	10,023
Arsenic: White (As_2O_3 content) ... do	18,171	2,064	18,763	2,089
Bauxite: Crude ... thousand long tons	r 12,160	r 165,639	12,620	156,362
Beryllium ore ... short tons	6,422	2,648	4,942	1,912
Bismuth ... pounds	r 894,804	r 3,712	997,924	5,636
Boron carbide ... do	422,133	883	52,652	166
Cadmium:				
Metal ... thousand pounds	1,078	3,166	2,492	7,800
Flue dust (cadmium content) ... do	1,115	1,495	1,111	2,438
Calcium:				
Metal ... pounds	r 662,200	r 619	164,769	141
Chloride ... short tons	9,226	350	8,280	359
Chromate:				
Ore and concentrates (Cr_2O_3 content) thousand short tons	506	20,030	647	31,805
Ferrochrome ... do	r 37	r 12,394	26	9,620
Metal ... do	1	r 2,072	2	3,052
Cobalt:				
Metal ... thousand pounds	12,037	21,725	11,873	26,020
Oxide (gross weight) ... do	1,175	2,023	710	1,394
Salts and compounds (gross weight) thousand pounds	131	67	157	92
Columbium ore ... do	4,161	2,681	5,719	4,345
Copper: (copper content):				
Ore and concentrates ... short tons	3,588	3,274	64,540	77,367
Regulus, black, coarse ... do	6	17	247	346
Unrefined, black, blister ... do	241,712	233,265	224,289	245,778
Refined in ingots, etc ... do	131,171	132,573	132,143	146,093
Old and scrap ... do	r 5,692	r 5,183	2,308	2,044
Ferroalloys: Ferrosilicon (silicon content) do	16,944	4,577	10,060	4,117
Gold:				
Ore and base bullion ... troy ounces	236,738	9,064	286,988	9,992
Bullion ... do	5,624,649	227,842	6,365,380	227,472
Iron ore ... thousand long tons	r 40,732	r 402,178	44,876	479,380
Iron and steel:				
Pig iron ... short tons	r 404,888	r 18,445	249,241	13,729
Iron and steel products (major):				
Iron products ... do	35,012	9,604	28,609	9,886
Steel products ... do	13,983,804	1,758,171	13,809,116	2,362,493
Scrap ... do	311,350	r 12,571	279,586	10,609
Tinplate ... do	23,849	917	21,707	591
Lead:				
Ore, flue dust, matte (lead content) do	115,286	22,697	42,606	8,360
Base bullion (lead content) ... do	1,993	699	1,177	448
Pigs and bars (lead content) ... do	278,873	72,104	244,623	73,397
Reclaimed scrap, etc. (lead content) do	6,682	1,513	2,981	798
Sheets, pipe and shot ... do	518	174	513	241
Magnesium:				
Metallic and scrap ... do	3,515	1,913	2,948	1,566
Alloys (magnesium content) ... do	467	1,175	122	300
Sheets, tubing, ribbons, wire, other forms (magnesium content) ... short tons	r 334	r 1,168	225	637
Manganese:				
Ore (35 percent or more manganese) (manganese content) ... short tons	r 979,708	r 39,136	846,706	34,263
Ferromanganese (manganese content) do	r 239,144	r 32,281	226,979	31,563
Mercury:				
Compounds ... pounds	r 13,510	r 16	196	3
Metal ... 76-pound flasks	31,924	15,207	21,972	9,101
Minor metals: Selenium and salts ... pounds	r 564,266	r 3,380	461,974	4,329
Nickel:				
Pigs, ingots, shot, cathodes ... short tons	r 99,656	r 209,476	117,371	302,821
Scrap ... do	r 3,184	r 8,077	2,149	4,485
Oxide ... do	4,013	6,524	6,423	12,611

See footnotes at end of table.

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

Mineral	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
METALS—Continued				
Platinum group:				
Unwrought:				
Grains and nuggets (platinum) troy ounces	67,560	9,741	28,937	3,828
Sponge (platinum) do	272,794	33,665	346,069	39,585
Sweepings, waste and scrap troy ounces	127,053	5,422	64,096	6,578
Iridium do	5,938	1,027	8,459	1,239
Palladium do	249,389	[r] 10,410	270,134	9,896
Rhodium do	38,077	8,615	38,626	7,541
Ruthenium do	7,566	391	20,816	984
Other platinum group metals do	11,602	1,696	9,242	495
Semimanufactured:				
Platinum do	58,249	8,018	124,867	16,323
Palladium do	[r] 382,783	14,280	503,822	17,532
Rhodium do	3,387	444	4,986	428
Other platinum group metals do	1,453	190	3,036	442
Radium: Radioactive substitutes	NA	4,697	NA	3,472
Rare-earths: Ferrocerium and other cerium alloys pounds	17,328	91	9,373	54
Silver:				
Ore and base bullion thousand troy ounces	32,332	48,115	29,246	45,040
Bullion do	39,544	71,247	29,569	52,637
Tantalum ore thousand pounds	975	3,196	1,046	3,231
Tin:				
Ore (tin content) long tons	-----------	-----------	4,667	13,987
Blocks, pigs, grains, etc do	54,950	185,037	50,554	187,662
Dross, skimmings, scrap, residues and tin alloys, n.s.p.f long tons	948	1,052	776	275
Tin foil, powder, flitters, etc	NA	3,458	NA	4,311
Titanium:				
Ilmenite [1] short tons	[r] 398,903	[r] 9,453	261,683	6,812
Rutile do	204,907	16,207	243,269	19,813
Metal pounds	13,211,214	[r] 11,735	14,190,209	13,480
Ferrotitanium do	1,103,148	259	146,300	48
Compounds and mixtures do	[r] 107,157,550	[r] 19,410	121,000,983	22,566
Tungsten: (tungsten content):				
Ore and concentrates thousand pounds	1,503	3,445	1,284	3,176
Metal do	[r] 33	[r] 65	35	173
Other alloys do	[r] 30	[r] 552	190	1,560
Zinc:				
Ore (zinc content) short tons	565,234	79,242	450,770	67,164
Blocks, pigs, slabs do	[r] 324,758	[r] 84,617	260,132	73,695
Sheets do	[r] 840	[r] 380	692	419
Old, dross, skimmings do	2,486	322	1,915	284
Dust do	8,251	2,652	9,359	3,161
Manufactures	NA	[r] 489	NA	1,276
Zirconium: Ore, including zirconium sand do	95,414	3,858	94,759	3,704
NONMETALS				
Abrasives: Diamonds (industrial) thousand carats	14,076	52,821	13,365	49,037
Asbestos short tons	694,558	76,422	649,402	75,146
Barite:				
Crude and ground do	616,573	5,783	707,028	6,360
Witherite do	459	22	182	35
Chemicals do	[r] 6,952	[r] 1,154	7,238	1,173
Cement thousand 376-pound barrels	9,687	24,376	13,812	34,176
Clays:				
Raw short tons	76,698	1,541	81,393	1,610
Manufactured do	5,190	209	5,147	192
Cryolite do	20,406	4,251	21,377	4,666
Feldspar: Crude long tons	46	7	225	23
Fluorspar short tons	1,149,546	32,818	1,092,318	32,758
Gem stones:				
Diamonds thousand carats	4,690	504,647	4,275	424,897
Emeralds do	309	9,175	326	7,715
Other	NA	52,871	NA	53,431
Graphite short tons	[r] 58,459	2,419	66,449	3,027
Gypsum:				
Crude, ground, calcined thousand short tons	5,860	12,481	6,130	13,829
Manufactures	NA	[r] 2,121	NA	2,684
Iodine, crude thousand pounds	5,705	5,753	5,905	6,819
Kyanite short tons	2,088	88	1,179	56

See footnotes at end of table.

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

Mineral	1969		1970	
	Quantity	Value (thousands)	Quantity	Value (thousands)
NONMETALS—Continued				
Lime:				
Hydrated short tons	39,270	$542	34,158	$479
Other do	144,471	1,911	167,432	1,946
Magnesium compounds:				
Crude magnesite do	r 18	r (2)	21	(2)
Lump, ground, caustic calcined magnesia short tons	15,238	983	11,476	702
Refractory magnesia, dead-burned, fused magnesite, dead-burned dolomite short tons	r 97,335	6,481	128,193	9,032
Compounds do	48,719	1,251	39,876	1,336
Mica:				
Uncut sheet and punch thousand pounds	1,601	1,695	875	966
Scrap do	3,078	74	6,048	136
Manufactures do	5,520	3,060	4,530	2,549
Mineral-earth pigments, Iron oxide pigments:				
Natural short tons	2,736	225	2,115	155
Synthetic do	22,555	4,390	24,138	5,264
Ocher, crude and refined do	87	6	62	4
Siennas, crude and refined do	1,341	146	1,051	115
Umber, crude and refined do	6,240	235	4,883	171
Vandyke brown do	472	42	435	50
Nitrogen compounds (major), including urea thousand short tons	r 1,803	r 88,733	2,495	119,176
Phosphate, crude do	140	3,554	136	3,790
Phosphatic fertilizers do	83	3,976	110	5,679
Pigments and salts:				
Lead pigments and compounds short tons	32,473	7,984	22,591	5,845
Zinc pigments and compounds do	23,518	4,476	20,766	4,106
Potash do	r 3,978,422	r 67,094	4,418,064	101,337
Pumice:				
Crude or unmanufactured do	8,424	r 60	10,639	74
Wholly or partly manufactured do	375,861	819	354,681	902
Manufactures, n.s.p.f	NA	61	NA	29
Quartz crystal (Brazillian pebble) pounds	1,291,003	477	975,679	421
Salt thousand short tons	3,302	11,990	3,536	13,329
Sand and gravel:				
Glass sand do	43	194	64	262
Other sand and gravel do	r 855	1,253	815	1,338
Sodium sulfate do	286	4,808	269	4,753
Stone and whiting	NA	r 30,548	NA	35,674
Strontium: Mineral short tons	27,803	595	37,254	827
Sulfur and pyrites:				
Sulfur ore and other forms n.e.s. thousand long tons	r 1,675	57,222	1,537	34,149
Pyrites do	99	322	197	662
Talc: Unmanufactured short tons	20,358	749	29,988	1,294
MINERAL FUELS				
Carbon black:				
Acetylene pounds	7,097,186	1,220	5,876,221	1,103
Gas black and carbon black do	1,129,280	165	168,997	39
Coal:				
Bituminous, slack, culm, lignite short tons	r 108,904	1,081	36,441	457
Briquets do	1,351	18	3,208	93
Coke do	173,052	3,354	152,879	3,531
Peat:				
Fertilizer grade do	297,364	13,631	281,429	13,398
Poultry and stable grade do	2,633	121	1,782	104
Petroleum:				
Crude oil thousand barrels	r 514,114	1,120,191	483,293	1,048,746
Gasoline do	22,709	87,203	24,320	101,658
Special naphtha do	3,191	8,233	2,111	5,193
Kerosine do	965	2,567	1,451	4,614
Distillate fuel oil do	78,275	223,867	79,510	218,653
Residual fuel oil do	461,611	987,848	557,845	1,227,259
Military jet fuel do	5,134	15,813	7,060	21,745
Commercial jet fuel do	40,405	124,447	44,992	163,771
Liquefied gases do	12,651	20,373	21,419	39,625
Asphalt do	4,761	10,284	6,201	13,394
Unfinished oil do	r 38,766	87,798	39,261	110,323
Lubricants do	163	1,535	224	2,110
Wax do	158	799	117	591
Petrochemical feed stocks do	40	106	5,195	13,766
Total	XX	r 8,304,493	XX	9,435,163

r Revised. NA Not available. XX Not applicable.

1 Includes titanium slag averaging about 70 percent TiO_2. For detail see Titanium Chapter, table 9.

2 Less than ½ unit.

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

Mineral	1969			1970 [p]		
	World [r] [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
MINERAL FUELS						
Carbon black ---thousand pounds--	5,703,294	2,963,261	52	5,878,769	2,931,153	50
Coal:						
Bituminous	[2] 2,134,471	555,493	26	[2] 2,218,464	596,970	27
Lignite	837,472	5,012	1	867,984	5,963	1
Pennsylvania anthracite	199,020	10,473	5	201,622	9,729	5
Coke (excluding breeze):						
Gashouse [3]	29,857	---	NA	27,619	---	---
Oven and beehive	366,210	64,757	18	382,510	66,525	17
Natural gas (marketable) million cubic feet--	34,325,102	20,698,240	60	37,820,609	21,920,642	58
Peat	203,536	572	(4)	217,471	517	(4)
Petroleum (crude) thousand barrels--	15,214,038	3,371,752	22	16,689,617	3,517,450	21
NONMETALS						
Asbestos	3,640	126	3	3,826	125	3
Barite	4,235	1,077	25	4,221	854	20
Cement thousand 376-pound barrels--	3,179,863	[5] 416,652	13	3,350,142	[5] 406,721	12
China clay	13,847	[6] 4,739	34	14,390	[6] 4,926	34
Corundum	7	---	---	8	---	---
Diamonds -------thousand carats--	40,863	---	---	42,355	---	---
Diatomite	1,785	598	34	1,783	598	34
Feldspar ------thousand long tons--	2,345	674	29	2,298	648	28
Fluorspar	4,229	183	4	4,600	269	6
Graphite	424	W	NA	417	W	NA
Gypsum	56,481	9,905	18	55,581	9,436	17
Lime (sold or used by producers)	99,067	[5] 20,250	20	105,829	[5] 19,788	19
Magnesite	12,670	W	NA	13,847	W	NA
Mica (including scrap) thousand pounds--	351,655	266,115	76	347,426	238,000	69
Nitrogen, agricultural [7]	31,649	[5] 7,869	25	33,730	[5] 8,413	25
Phosphate rock	90,062	37,725	42	93,858	38,739	41
Potash (K_2O equivalent)	18,810	2,804	15	20,443	2,729	13
Pumice [8]	16,279	3,609	22	16,036	3,134	20
Pyrites -------thousand long tons--	20,599	W	NA	21,810	W	NA
Salt	148,789	[5] 44,277	30	156,365	[5] 45,836	29
Strontium [8]	31	---	---	39	---	---
Sulfur, elemental thousand long tons--	20,771	8,560	41	21,748	8,531	39
Talc, pyrophyllite, and soapstone	5,137	1,029	20	5,306	1,028	19
Vermiculite [8]	466	310	67	432	285	66
METALS, MINE BASIS						
Antimony (content of ore and concentrate) ----------short tons--	73,044	938	1	73,152	1,130	2
Arsenic, white [8]	56	W	NA	56	W	NA
Bauxite -------thousand long tons--	51,803	[9] 1,843	4	57,072	2,082	4
Beryllium concentrate --short tons--	8,834	W	NA	8,197	W	NA
Bismuth --------thousand pounds--	8,460	W	NA	8,918	W	NA
Cadmium ----------------do----	38,653	[10] 12,646	33	35,245	[10] 9,465	27
Chromite	5,896	---	---	6,527	---	---
Cobalt (contained)	22	W	NA	26	W	NA
Columbium-tantalum concentrates [8] thousand pounds--	34,557	W	NA	43,898	W	NA
Copper (content of ore and concentrate)	6,213	[11] 1,545	25	6,527	[11] 1,720	26
Gold -------thousand troy ounces--	46,526	1,733	4	47,356	1,743	4
Iron ore ------thousand long tons--	707,183	[12] 88,328	12	754,299	[12] 89,760	12
Lead (content of ore and concentrate)	3,569	[11] 509	14	3,751	[11] 572	15
Manganese ore (35 percent or more Mn)	19,196	6	(4)	20,390	5	(4)
Mercury thousand 76-pound flasks--	290	30	10	284	27	10
Molybdenum (content of ore and concentrate) --thousand pounds--	142,639	99,807	70	163,648	111,352	68
Nickel (content of ore and concentrate)	533	16	3	685	15	2
Platinum groups (Pt., Pd., etc.) thousand troy ounces--	3,431	22	(4)	4,216	17	(4)
Silver ----------------------do----	290,469	41,906	14	301,740	45,006	15
Tin (content of ore and concentrate) -------------long tons--	224,079	W	NA	226,569	W	NA
Titanium concentrates:						
Ilmenite [8]	3,542	931	26	3,942	868	22
Rutile [8]	437	---	NA	460	---	NA

See footnotes at end of table.

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

Mineral	1969			1970 p		
	World r 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, MINE BASIS—Continued						
Tungsten concentrate (contained tungsten) short tons	35,375	3,452	10	37,009	4,053	11
Vanadium (content of ore and concentrate) [8] short tons	14,830	5,577	38	16,448	5,319	32
Zinc (content of ore and concentrate)	5,892	553	9	6,061	534	9
METALS, SMELTER BASIS						
Aluminum	9,932	3,793	38	10,655	3,976	37
Copper	6,622	[13] 1,585	24	6,877	[13] 1,641	24
Iron, pig (including ferroalloys)	456,577	97,632	21	479,151	94,808	20
Lead	3,561	[14] 639	18	3,637	667	18
Magnesium short tons	221,748	99,887	45	243,250	112,007	46
Selenium [8] thousand pounds	2,789	1,247	45	2,392	1,005	42
Steel ingots and castings	632,010	[15] 41,262	22	652,735	[15] 131,514	20
Tellurium [8] thousand pounds	395	234	59	357	158	44
Tin [16] long tons	223,426	345	(4)	222,296	NA	NA
Uranium oxide (U_3O_8) [8] short tons	23,056	12,281	53	23,707	12,768	54
Zinc	5,472	1,041	19	5,407	878	16

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. The 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 mainland 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: 1968, 1,233,951; 1969, 1,547,494.

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 Mineral Industries

By Forrest T. Moyer [1]

Injury experience in the mineral-extracting and mineral processing industries worsened during 1970. The frequency and severity rates for all injuries retrogressed 5 and 7 percent, respectively, from the 1969 data. Overall operating activity, as measured by man-hours worked, was 2 percent higher than that of 1969.

The fatality-frequency rate of 0.30 per million man-hours for all mineral-extracting and mineral-processing industries in 1970 was 11 percent higher than in 1969, primarily because of the sharply worsened fatality experience in the coal and the oil and gas industries. The total of 34,515 nonfatal injuries in 1970 was 2,275 more than occurred during the proceeding year, and the frequency rate of 17.88 increased 5 percent over that of 1969.

The injury-severity rate increased 7 percent to 2,593 days lost per million man-hours of worktime for all injuries, compared with 2,431 in 1969. There were 573 work fatalities reported for 1970, 63 more than in the previous year. Four major disasters (a single accident which results in the death of five or more persons) claimed 55 lives in the mineral industries during 1970. In the coal industry, a dust explosion at the Finley Coal Co. bituminous coal mine in Kentucky killed 38 men. In the oil and gas industries, a premature detonation of experimental explosives at the research department site of Pan American Petroleum Corp. in Oklahoma claimed the lives of five company employees (in addition, four employees from other industries were killed), an oil well blowout at a drilling department site of Sturm Drilling Co. in Texas killed five men, and the rupturing of a liquid-full vessel at the base of a fractionator tower at the Point Breeze refinery, Atlantic Richfield Co., in Pennsylvania killed seven men. No major disasters were reported in the mineral industries during 1969.

The safety records of the separate mineral industries varied, as summarized in the later text and detailed in the tables of this chapter.

Mine Safety Legislation and Regulations.—Under the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91–173) of December 30, 1969, mandatory health and safety standards for underground workings of coal mines were developed and published in the Federal Register throughout 1970. Regulations prescribing the requirements for coal operators to notify and report injuries and accidents to the Bureau of Mines became effective December 31, 1970. These regulations expanded and continued the mandatory reporting requirements that had been in effect since 1942. As required by the Act, standards for surface mines and surface work areas of underground mines were developed and published as proposed rulemaking near the end of the year.[2] All activities of the Federal government in the field of coal mine health and safety were expanded sharply during 1970 and this acceleration was at its highest rate at the close of the year.

The Act established coal workers' pneumoconiosis (black lung) as a compensable occupational disease and part B of title IV of the act provided for monthly benefit payments to coal miners totally disabled due to pneumoconiosis and to widows of coal miners who died from the disease. By

[1] Supervisory survey statistician, Office of Accident Analysis, Office of Deputy Director for Health and Safety.

[2] Department of the Interior. Towards Improved Health and Safety for America's Coal Miners, 1970 Annual Report of the Secretary of the Interior. December 1970, 79 pp.

December 31, 1970 more than 247,000 claims for compensation had been filed, and by April 30, 1971, the total had reached 286,000.[3] Of the claims completed by April 30, 1971, 120,000 were allowances (68,000 miners and 52,000 widows) and 125,000 were denials (96,000 miners and 29,000 widows). By April 30, 1971, total cumulative Federal disbursements since enactment of the program were over $273 million, and monthly recurring payments were over $21 million.

As prescribed by the Federal Metal and Nonmetallic Mine Safety Act (Public Law 89–577) of September 16, 1966, the mandatory and advisory health and safety standards became effective on July 31, 1970, 1 year after their first publication in the Federal Register. Through 1970, the health and safety activities of the Federal government in this area were increased.[4]

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 mineral-producing and mineral-processing establishments in the United States. Data concerning officeworkers are excluded except for the oil and gas industry, for which such data are not separable.

The coverage of all industries is complete except for oil and gas, in which coverage varies from year to year, particularly with respect to small companies. All injury rates were calculated from unrounded data and in some instances, the rates cannot be reproduced from the 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.

MINERALS

METAL MINES AND MILLS

Fatality experience in 1970 in the metal mining and milling industry was slightly better, but the nonfatal injury record was moderately worse than that of 1969. The total of 65 fatal injuries was three less than that of 1969, and the fatality rate of 0.39 in 1970 was 9 percent better than that of the preceding year. Owing largely to the improved record of fatal injuries, the severity rate of 3,514 for all injuries in 1970 was 7 percent better from that of 1969. However, the total of 4,165 nonfatal injuries was 434 higher than in 1969 and the frequency rate of 25.21 in 1970 was 7 percent worse than in 1969.

Fatality experience at copper mines and mills was better but the nonfatal injury record worsened in 1970. Owing largely to the better fatality record, the severity rate for all injuries declined. Although the number of fatal injuries at gold-silver mines and mills was the same in both 1970 and 1969, the fatality frequency rate decreased slightly in 1970. However, the number of nonfatal injuries was higher and the frequency rate for these injuries worsened in 1970. The severity rate for all injuries at gold-silver operations was improved in 1970. All general measures of safety performance at iron mines and mills compared unfavorably with the corresponding data for 1969. At lead-zinc mines and mills, the number and the frequency rate of fatal injuries were unchanged from 1969, but the nonfatal injury record worsened slightly in 1970. The severity rate for all injuries at these operations was virtually unchanged in 1970. The general measures of injury experience in the uranium industry were sharply better than in 1969. Similarly, there was moderate improvement in the safety record in 1970 at miscellaneous metal (bauxite, mercury, titanium, etc.) operations. The detailed injury experience and worktime for the metal mining industries are given for mines in table 1 and for mills in table 2.

NONFERROUS SMELTING AND REFINING INDUSTRY

All general measures of injury experience were better at nonferrous smelting, reduc-

[3] Committee on Education and Labor, House of Representatives. Black Lung Benefits Program, First Annual Report on Part B of Title IV of the Federal Coal Mine Health and Safety Act of 1969. June 1971, 34 pp.

[4] Department of the Interior. Administration of the Federal Metal and Nonmetallic Mine Safety Act, 1970 Annual Report of the Secretary of the Interior. January 1971, 60 pp.

ing, and refining plants in 1970. The eight fatal injuries in 1970, seven less than in 1969, occurred at a frequency rate of 0.06, compared with 0.12 in 1969. The total of 1,530 nonfatal injuries, 36 less than in 1969, resulted in a rate of occurrence of 12.28 in 1970, slightly better than in 1969. Similarly, the severity rate of 1,036 for all injuries was an improvement compared with 1,293 in 1969. Injury experience and worktime data by industry groups are detailed in table 3.

NONMETAL MINES AND MILLS

The injury experience in the nonmetallic mineral mining industry (all nonmetals except stone and sand and gravel) generally worsened in 1970. The total of 26 fatal injuries was one less than that of 1969, but, with the reduction in total man-hours worked, the frequency rate was slightly higher than in 1969. For nonfatal injuries, increases were noted for all general measures of injury experience. In 1970 the severity rate of 2,855 for all injuries was moderately worse than that of 1969.

All general measures of injury experience were better in 1970 in the phosphate rock and sulfur industries. There have been no work fatalities at sulfur operations since 1967. On the other hand, these general measures worsened markedly in 1970 at miscellaneous nonmetal (barite, boron minerals, feldspar, fluorite, magnesite, mica, talc, etc.) operations. In clay-shale mines and mills, there was general improvement except for a slightly higher frequency rate for nonfatal injuries. In both the gypsum and salt industries, fatality experience worsened in 1970, but the nonfatal injury record was improved over that of 1969. At potash operations, the fatality record was better than that of 1969 but the nonfatal injury experience worsened in 1970. Detailed injury and worktime statistics by industry groups are listed for mines in table 4 and for mills in table 5.

STONE QUARRIES AND MILLS

In 1970 the fatality experience was improved, but the nonfatal injury record worsened at stone operations. Fatalities totaled 43 in 1970, 10 less than in 1969, and the resulting frequency rate of 0.23 was an 18 percent improvement. In 1970 the total of nonfatal injuries was 3,575, an increase of 186, and the frequency rate for these injuries increased to 19.53, compared with 18.12 in 1969.

In 1970 each of the general measures of safety performance were better only at marble operations. Conversely, the safety record in the sandstone and traprock industries worsened in each of the general measures. In the cement, lime, and limestone industries, fatality experience was improved in 1970 but the record for nonfatal injuries worsened from the corresponding data for 1969. In the slate and miscellaneous stone (gneiss, quartz, schist, etc.) industries, the fatality record was worse, but nonfatal injury experience was better in 1970. In the granite industry, the fatality record in 1970 was unchanged from that of 1969 and, for nonfatal injuries, both the number and rate of occurrence were slightly higher. Detailed statistics on the stone quarrying industry are presented in table 6.

SAND AND GRAVEL OPERATIONS

The 28 fatal injuries at sand and gravel plants, three less than in 1969, resulted in an improved fatality frequency rate. For nonfatal injuries, the total count of 1,910 was slightly less than in 1969, but the frequency rate for these injuries was slightly higher at 20.51, primarily due to the reduced worktime. The severity rate of 2,849 for all injuries in 1970 represented an improvement of 6 percent. Statistical data are given in table 7.

SLAG (IRON-BLAST-FURNACE) OPERATIONS

In 1970, fatality experience at slag plants was one work-death, compared with three in 1969 and, as a result, the injury-severity rate for all injuries of 2,072 was reduced by approximately two-thirds from that of 1969. However, nonfatal injury experience in 1970 worsened to a total of 72, and the frequency rate for all injuries (fatal and nonfatal) of 20.27 was markedly higher than that of 1969. Data for 1966–70 are listed in table 8.

MINERAL FUELS

COAL MINES

In 1970, fatality experience worsened appreciably in the coal mining industry, when 260 work fatalities occurred at a frequency rate of 1.02 per million man-hours. In 1969, when both the total number and frequency rate of fatalities were the lowest in statistical history, 203 fatal injuries had a rate of occurrence of 0.85. The retrogression in fatality experience resulted principally from a major disaster in a bituminous coal mine in Kentucky on December 30, 1970. A coal dust explosion, initiated by use of nonpermissible explosives and blasting procedures, in the underground workings of the Nos. 15 and 16 mines, Finley Coal Co., Hyden, Ky., claimed the lives of 38 men. There were no major disasters in coal mines during 1969. Owing primarily to the worsened fatality record in 1970, the severity rate for all injuries increased sharply to 7,963 days lost or charged per million man-hours. The total of 10,575 nonfatal injuries was 658 higher than that of 1969, but, owing to the increased worktime, the frequency rate was 41.53 for these injuries in 1970 compared with 41.76 in the preceding year. The detailed injury experience and worktime for the coal mining industries are listed in table 9.

In bituminous coal and lignite mines, 255 fatal injuries occurred in 1970 at a frequency of 1.04 per million man-hours, respectively, 34 and 24 percent worse than the record low data of 190 fatalities at a rate of 0.84 in 1969. The retrogression in fatality experience in 1970 resulted largely from the mine explosion disaster in December. Owing primarily to the adverse record of fatal injuries, the severity rate of 8,128 for all injuries was 12 percent worse than that of 1969. The fatality experience in 1970 worsened at both underground and surface mines and was better only at mechanical cleaning plants. For nonfatal injuries, the total of 10,090 in 1970 was 665 higher than that of the preceding year. However, because of the increased worktime, the frequency rate of 41.33 for nonfatal injuries in 1970 was slightly better than that of 41.44 in 1969.

In anthracite mines, all general measures of injury experience improved in 1970. The fatality record was sharply better and the total of five fatal injuries occurred at a frequency of 0.47 per million man-hours, compared with 13 deaths at a rate of 1.29 in 1969. The severity rate of 4,123 for all injuries in 1970 showed a similar marked improvement and was less than one-half the 1969 total of 9,090. Nonfatal injuries totaled 485 and had a rate of occurrence of 46.24 in 1970, slightly better than the corresponding data for 1969.

OIL AND NATURAL GAS OPERATIONS

The general measures of injury experience in the oil and gas industries during 1970 were appreciably worse than those of 1969. The frequency rates of 0.14 for fatal and 10.27 for nonfatal injuries, compared unfavorably with the respective rates of 0.10 and 9.61 in 1969. Similarly, the severity rate of 1,281 for all injuries was 30 percent worse than that of 983 in 1969. There were three major disasters (described earlier) with a total loss of 17 lives in 1970, whereas in 1969, no major disasters were reported. Injury and worktime statistics are given in table 10.

COKE OPERATIONS

Fatality experience in the coal-coking industry was sharply better than in 1969, but the nonfatal injury record was moderately worse in 1970. The total of eight fatal injuries, seven less than in 1969, resulted in a fatality frequency rate of 0.20, compared with 0.39 for the preceding year. The number of nonfatal injuries was higher in 1970, and the frequency rate of 6.57 was worse than that of 6.00 in 1969. The severity rate of 1,562 for all injuries was appreciably better than that of 2,533 in 1969, owing primarly to the improved fatality experience. Statistical data are listed in table 11.

PEAT

The safety record of the peat industry in 1970 worsened to a total of 14 nonfatal injuries at a frequency rate of 18.36 per million man-hours. These injuries were more severe than in 1969 and the injury-severity rate worsened to 587 in 1970. There were no fatalities in 1970 or 1969. Data for 1966–70 are given in table 12.

NATIVE ASPHALT

This industry group comprising gilsonite and asphaltic-stone operations has been combined with other mineral industry groups, beginning with the data for 1970. Injury experience and worktime statistics for 1970 for gilsonite operations have been included with the "Miscellaneous nonmetal" group of the nonmetal mining and milling industry and for asphaltic-stone operations have been included in the "Limestone" and "Miscellaneous stone" groups of the stone quarrying and milling industry. The injury experience and worktime data on native asphalt operations during 1966–69 are listed in table 13.

Table 1.—Worktime and injury experience at metal 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
Copper:								
1966	16,278	317	5,164	41,323	23	976	24.18	4,856
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 p	17,100	327	5,578	44,697	13	1,015	22.95	2,727
Gold-silver (lode-placer):								
1966	3,847	236	907	7,254	10	305	43.42	9,846
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 p	3,700	242	882	7,074	8	360	51.88	8,978
Iron:								
1966	14,056	277	3,898	31,360	13	553	18.05	3,526
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 p	10,900	295	3,229	25,888	8	535	21.05	2,799
Lead-zinc:								
1966	8,692	261	2,273	18,212	15	1,096	61.00	8,108
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 p	7,500	266	1,986	15,904	16	1,075	68.73	8,873
Uranium:								
1966	3,604	204	735	5,945	7	210	36.50	8,845
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 p	3,900	209	809	6,682	8	175	27.09	8,261
Miscellaneous:								
1966	3,443	281	967	7,762	7	295	38.91	7,555
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 p	3,200	292	940	7,536	4	290	39.28	4,988
Total: [1]								
1966	49,920	279	13,944	111,857	75	3,435	31.38	5,736
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 p	46,200	290	13,423	107,781	57	3,450	32.55	4,563

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 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	Non-fatal	Frequency	Severity
Copper:								
1966	5,369	344	1,847	14,765	--------	75	5.08	394
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 p	6,500	351	2,273	18,193	2	230	12.81	1,696
Gold-silver (lode-placer):								
1966	406	287	117	934	1	31	34.26	8,479
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 p	300	298	86	686	--------	10	16.04	181
Iron:								
1966	6,293	299	1,881	15,090	3	117	7.95	1,615
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 p	6,600	334	2,209	17,691	4	160	9.38	1,657
Lead-zinc:								
1966	1,449	268	389	3,104	--------	77	24.81	2,290
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 p	1,300	282	353	2,828	--------	75	26.52	959
Uranium:								
1966	1,420	297	422	3,398	--------	69	20.31	1,291
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 p	1,600	314	511	4,270	--------	65	15.46	613
Miscellaneous:								
1966	5,238	325	1,710	13,760	3	206	15.19	2,192
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 p	5,300	325	1,712	13,704	2	165	12.33	1,674
Total: [1]								
1966	20,175	315	6,357	51,050	7	575	11.40	1,563
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 p	21,500	332	7,144	57,372	8	710	12.55	1,544

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

Table 3.—Worktime and injury experience at primary nonferrous reduction and refinery plants 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
Copper:								
1966	10,411	335	3,486	27,779	5	362	13.21	1,673
1967	10,750	226	2,434	19,471	2	260	13.46	1,219
1968	10,293	291	2,993	23,909	1	338	14.18	991
1969	11,708	332	3,892	31,031	4	470	15.28	1,627
1970 p	11,700	340	3,997	31,979	5	555	17.51	2,109
Lead:								
1966	2,508	317	795	6,360	3	105	16.98	3,392
1967	2,031	289	587	4,679	--------	110	23.51	1,546
1968	2,366	293	693	5,543	1	126	22.91	2,434
1969	2,610	343	894	7,152	2	196	27.68	2,668
1970 p	2,600	338	895	7,158	1	120	16.90	2,096
Zinc:								
1966	7,086	330	2,337	18,432	1	338	18.39	895
1967	7,280	316	2,304	18,426	5	289	15.96	2,493
1968	6,715	334	2,246	17,972	--------	335	18.64	742
1969	6,501	357	2,319	18,555	6	386	21.13	2,675
1970 p	5,900	359	2,116	16,928	--------	360	21.33	697
Aluminum:								
1966	18,372	348	6,393	50,986	--------	228	4.47	368
1967	20,508	347	7,107	56,854	1	245	4.33	439
1968	20,059	346	6,937	55,805	2	324	5.84	468
1969	22,193	352	7,805	62,455	3	467	7.53	660
1970 p	22,300	352	7,841	62,728	--------	415	6.58	320
Miscellaneous:								
1966	2,024	351	711	5,699	--------	34	5.97	763
1967	2,477	307	761	6,081	1	33	5.59	1,093
1968	2,096	344	720	5,783	--------	32	5.53	421
1969	2,232	346	773	6,155	--------	47	7.64	254
1970 p	2,100	350	737	5,899	2	80	14.24	2,529
Total: [1]								
1966	40,401	340	13,722	109,257	9	1,067	9.85	985
1967	43,046	307	13,194	105,511	9	937	8.97	1,029
1968	41,529	327	13,590	109,012	4	1,155	10.63	725
1969	45,244	347	15,683	125,348	15	1,566	12.61	1,293
1970 p	44,700	349	15,587	124,692	8	1,530	12.34	1,036

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

Table 4.—Worktime and injury experience at nonmetal (except stone) 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
Clay-shale:								
1966	5,776	219	1,266	10,316	2	281	27.43	2,147
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 p	4,300	213	917	7,446	2	155	20.82	2,271
Gypsum:								
1966	935	244	228	1,848	--------	23	12.45	3,743
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 p	900	251	232	1,874	2	15	8.01	7,043
Phosphate rock:								
1966	3,183	302	960	7,791	5	161	21.31	4,329
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 p	2,100	283	603	4,877	2	35	7.59	2,757
Potash:								
1966	1,934	357	690	5,516	4	209	38.61	5,663
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 p	1,300	342	460	3,684	2	150	41.54	5,046
Salt:								
1966	1,809	279	504	4,104	2	90	22.42	4,371
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 p	1,800	279	494	3,985	5	120	31.87	8,262
Sulfur:								
1966	1,491	360	537	4,632	--------	54	11.66	1,985
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 p [1]	1,700	314	541	4,328	--------	55	13.17	311
Miscellaneous:								
1966	3,599	234	841	6,796	3	240	35.76	3,810
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 p	3,200	247	794	6,405	3	255	40.13	5,460
Total: [2]								
1966	18,727	268	5,027	41,003	16	1,058	26.19	3,586
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 p [1]	15,400	262	4,042	32,598	16	785	24.57	4,030

p Preliminary.
[1] Includes data on gilsonite operations for the first time; in prior years, these data were included in the native asphalt industry.
[2] Data may not add to totals shown because of independent rounding.

Table 5.—Worktime and injury experience at nonmetal (except stone) mills 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
Clay-shale:								
1966	15,603	270	4,214	34,028	3	1,020	30.06	2,101
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 p	12,300	275	3,376	27,058	4	895	33.26	2,053
Gypsum:								
1966	2,589	269	696	5,557	1	21	3.96	1,721
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 p	1,500	270	405	3,292	---	10	3.04	80
Phosphate rock:								
1966	1,948	335	653	5,237	3	60	12.03	3,821
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 p	1,900	333	634	5,074	1	15	3.35	1,507
Potash:								
1966	1,030	360	371	2,967	---	47	15.84	2,028
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 p	700	313	228	1,827	---	30	15.32	571
Salt:								
1966	3,814	292	1,112	8,898	2	162	18.43	1,787
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 p	3,400	285	977	7,865	1	230	29.62	1,258
Sulfur:								
1966	2	300	1	5	---	---	---	---
1967	1	250	(1)	2	---	1	500.00	12,500
1968	---	---	---	---	---	---	---	---
1969	---	---	---	---	---	---	---	---
1970 p	---	---	---	---	---	---	---	---
Miscellaneous:								
1966	7,015	286	2,006	16,118	2	254	15.88	1,541
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 p [2]	6,700	298	2,006	16,121	4	460	28.66	3,854
Total: [3]								
1966	32,001	283	9,052	72,810	11	1,564	21.63	2,030
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 p [2]	26,600	287	7,625	61,237	10	1,640	26.94	2,229

p Preliminary.
[1] Less than 500.
[2] Includes data on gilsonite operations for the first time; in prior years, these data were included in the native asphalt industry.
[3] Data may not add to totals shown because of independent rounding.

Table 6.—Worktime and injury experience at stone quarries and mills 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
Cement: [1]								
1966	22,611	326	7,381	59,044	6	359	6.18	1,245
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 p	21,400	321	6,888	55,280	4	390	7.13	911
Granite:								
1966	8,141	246	2,005	16,756	2	412	24.71	3,069
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 p	7,300	248	1,809	15,724	5	405	25.95	3,077
Lime: [1]								
1966	7,467	299	2,236	18,039	6	345	19.46	3,269
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 p	7,300	305	2,244	18,152	1	365	20.27	929
Limestone:								
1966	30,380	245	7,434	63,422	30	1,542	24.79	4,385
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 p [2]	30,600	248	7,589	65,883	24	1,635	25.20	3,360
Marble:								
1966	2,953	255	753	6,178	1	213	34.64	2,523
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 p	2,200	250	553	4,580	--------	130	28.38	1,438
Sandstone:								
1966	5,447	240	1,308	10,895	3	314	29.10	2,739
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 p	4,500	239	1,071	8,875	4	285	32.56	3,761
Slate:								
1966	1,376	266	366	2,975	1	79	26.89	2,762
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 p	1,100	257	283	2,268	1	45	20.28	5,251
Traprock:								
1966	5,562	221	1,231	10,263	1	241	23.58	1,975
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 p	4,300	239	1,036	8,628	3	240	27.93	2,758
Miscellaneous:								
1966	1,889	211	398	3,216	1	78	24.56	2,528
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 p [2]	1,900	233	446	3,635	1	80	22.56	2,285
Total: [3]								
1966	85,826	269	23,113	190,787	51	3,583	19.05	2,852
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 p [2]	80,800	271	21,919	183,026	43	3,575	19.77	2,300

p Preliminary.
[1] Includes burning or calcining and other mill operations.
[2] Includes data on asphaltic stone operations for the first time; in prior years, these data were included in the native asphalt industry.
[3] Data may not add to totals shown because of independent rounding.

Table 7.—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: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1966	55,344	225	12,459	104,971	35	2,098	20.32	2,901
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 p	49,400	218	10,787	93,117	28	1,910	20.81	2,849

p Preliminary.

Table 8.—Worktime and injury experience at slag (iron-blast-furnace) plants in the United States

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
1966	1,472	277	407	3,332	--------	44	13.20	709
1967	1,721	255	439	3,539	3	53	15.82	5,762
1968	1,724	263	454	3,697	1	57	15.69	2,454
1969	1,610	271	442	3,573	3	49	14.55	6,061
1970	1,647	268	441	3,602	1	72	20.27	2,072

Table 9.—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: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Bituminous coal and lignite mines:								
1966	135,952	213	28,928	230,087	227	9,617	42.78	7,900
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 p	134,100	229	30,760	244,146	255	10,090	42.37	8,128
Anthracite mines:								
1966	9,292	203	1,883	13,672	6	829	61.07	4,477
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 p	6,000	240	1,447	10,533	5	485	46.71	4,123
Total: [1]								
1966	145,244	212	30,811	243,759	233	10,446	43.81	7,708
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 p	140,100	230	32,207	254,678	260	10,575	42.55	7,963

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

Table 10.—Worktime and injury experience of the oil industry (all activities) and the natural gas industry (excluding distribution activities) in the United States

Year	Average men working daily	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
1966	451,747	954,527	103	8,724	9.25	1,050
1967	445,562	938,946	88	8,776	9.44	981
1968	466,652	986,952	102	9,069	9.29	985
1969	449,606	939,385	95	9,023	9.71	983
1970	462,468	972,278	134	9,989	10.41	1,281

Table 11.—Worktime and injury experience at coke ovens 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: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Slot ovens:								
1966	13,745	363	4,983	39,909	3	155	3.96	658
1967	13,409	360	4,821	38,583	5	201	5.34	963
1968	12,877	361	4,645	37,167	7	184	5.14	1,876
1969	13,418	356	4,779	38,169	15	216	6.05	2,542
1970	13,795	355	4,891	39,194	8	256	6.74	1,575
Beehive ovens:								
1966	471	236	111	821	--------	36	43.82	1,048
1967	292	179	52	374	4	25	77.61	67,561
1968	216	233	50	378	--------	20	52.85	1,855
1969	199	226	45	351	--------	15	42.74	1,598
1970	202	231	47	360	--------	4	11.11	156
Total: [1]								
1966	14,216	358	5,094	40,730	3	191	4.76	666
1967	13,701	356	4,873	38,956	9	226	6.03	1,602
1968	13,093	359	4,696	37,546	7	204	5.62	1,875
1969	13,617	354	4,824	38,520	15	231	6.39	2,533
1970	13,997	353	4,937	39,554	8	260	6.78	1,562

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

Table 12.—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: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
1966	523	184	96	804	--------	10	12.44	373
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

Table 13.—Worktime and injury experience in the native-asphalt industry (bituminous limestone, bituminous sandstone, and gilsonite mines and mills) in the United States [1]

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
1966	368	270	99	806	1	28	35.98	7,872
1967	393	255	100	821	--------	33	40.21	2,985
1968	399	259	103	837	--------	23	27.49	672
1969	445	262	117	949	--------	36	37.93	733

[1] Beginning in 1970, data on asphaltic stone and gilsonite operations, which comprised the native asphalt industry, have been separated and included, respectively, in the limestone and miscellaneous stone subdivisions of the stone industry and the miscellaneous nonmetal subdivision of the nonmetal industry.

Abrasive Materials

By Robert G. Clarke [1]

Industries that consume large volumes of abrasive materials, and in particular the automotive industry, experienced a general reduction of activity in 1970. Consequently, the quantity and value of output of most abrasive materials, both natural and artificial, declined.

Domestic production of natural abrasive materials in 1970 was less by about 17 percent in tonnage and 3 percent in total value when compared with 1969. However, the trends in individual instances were not consistent. For example, special silica stone products and garnet decreased in quantity but increased in value, whereas, emery and tripoli decreased more in value than in quantity.

Artificial abrasives manufactured in 1970 include fused aluminum oxide, silicon carbide, and metallic abrasives. Production of aluminum oxide decreased 10 percent in quantity and 12 percent in value from 1969. Silicon carbide production increased 4 percent in quantity and less that ½ percent in value, but the yearend stocks of silicon carbide increased considerably. The tonnage and value of metallic abrasives decreased by 10 percent and 2 percent, respectively. Shipments of manufactured abrasive products—grinding wheels, coated abrasives, and abrasive grain—each declined about 10 percent. Diamond products as a whole followed the general decline, but the product mix of synthetic and natural diamonds was not segregated.

Foreign Trade.—Imports of abrasive materials were the lowest in value since 1965, but exports and reexports attained a record high in 1970. Net imports, the excess of imports over exports and reexports, was only $4 million, the lowest dollar value since World War II. The chief factor in the decline of imports and the increase of exports has been the rapid growth in diamond manufacture in the United States.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient abrasive statistics in the United States

Kind	1966	1967	1968	1969	1970
Natural abrasives (domestic) sold or used by producers:					
Tripoli ---------------short tons--	66,163	70,984	85,534	84,673	68,105
Value------------thousands--	$328	$377	$796	$734	$520
Special silica-stone products [1] short tons--	3,806	2,701	3,141	3,311	3,134
Value------------thousands--	$515	$574	$629	$600	$666
Garnet---------------short tons--	21,952	20,494	22,136	20,458	18,837
Value------------thousands--	$2,092	$1,849	$1,922	$1,874	$1,936
Emery---------------short tons--	11,102	W	W	W	W
Value------------thousands--	$210	W	W	W	W
Artificial abrasives [2]--------short tons--	607,508	552,812	567,814	608,622	561,107
Value---------------thousands--	$82,794	$80,405	$86,316	$92,589	$85,772
Foreign trade (natural and artificial abrasives):					
Exports (value)-------thousands--	$51,753	$50,896	$60,266	$70,654	$64,338
Reexports (value)----------do----	$13,143	$17,239	$19,807	$20,373	$28,085
Imports for consumption (value) do----	$110,650	$100,427	$103,150	$100,371	$96,467

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	1969 Quantity	1969 Value	1970 Quantity	1970 Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semi-precious stones, including diamond dust and powder—carats	8,122	$21,599	7,258	$18,711
Crushing bort—do	45	265	33	154
Industrial diamond—do	345	1,634	339	1,838
Emery, natural corundum, and other natural abrasives, n.e.c.—pounds	r 31,772	2,832	33,375	3,403
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide)—do	34,004	6,775	35,949	6,869
Silicon carbide, crude or in grains—do	12,556	2,487	12,883	2,319
Carbide, abrasives, n.e.c—do	3,026	5,434	4,730	7,332
Grinding and polishing wheels and stones:				
Diamond—carats	699	r 3,560	614	3,117
Pulpstones—pounds	2,460	692	2,315	690
Hand polishing stones, whetstones, oilstones, hones, and similar stones—do	915	1,227	905	1,229
Wheels and stones, n.e.c—do	4,774	7,633	4,247	7,549
Abrasive paper and cloth, coated with natural or artificial abrasive materials—reams	300	r 8,489	334	8,240
Coated abrasives, n.e.c	NA	2,307	NA	2,887
Metallic abrasives—pounds	62,146	5,720	(1)	(1)
Total	XX	r 70,654	XX	64,338

r Revised. NA Not available. XX Not applicable.
[1] No longer separately classified.

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

(Thousands)

Kind	1969 Quantity	1969 Value	1970 Quantity	1970 Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semi-precious stones, including diamond dust and powder—carats	148	$391	378	$920
Crushing bort—do	350	2,238	364	2,326
Industrial diamond—do	2,704	17,503	3,837	24,604
Emery, natural corundum, and other natural abrasives, n.e.c.—pounds	200	42	751	112
MANUFACTURED ABRASIVES				
Carbide abrasives, n.e.c—pounds	20	79	24	37
Grinding and polishing wheels and stones:				
Diamond—carats	1	3	3	50
Pulpstones—pounds	------	------	22	3
Wheels and stones, n.e.c—do	6	11	11	12
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)	2	(1)	(1)
Coated abrasives, n.e.c	NA	72	NA	18
Metallic abrasives—pounds	91	32	(2)	(2)
Total	XX	20,373	XX	28,085

NA Not available. XX Not applicable.
[1] Less than ½ unit.
[2] No longer separately classified.

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

(Thousands)

Kind	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Burrstones in blocks, rough short tons	(1)	(1)	(1)	(1)
Emery, flint, rottenstone, and tripoli, crude or crushed do	21	r $767	14	$437
Silicon carbide, crude do	109	14,648	107	15,356
Aluminum oxide, crude artificial do	169	21,086	161	20,412
Other crude artificial abrasives do	(1)	7	1	123
Abrasives, ground, grains, pulverized or refined:				
Silicon carbide short tons	2	711	2	684
Aluminum oxide do	5	r 1,418	7	2,007
Emery, corundum, flint, garnet, and other, including artificial abrasives short tons	2	r 467	1	288
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasive	(2)	6,255	(2)	5,682
Hones, whetstones, oilstones, and polishing stones number	285	67	296	77
Abrasive wheels and millstones:				
Burrstones, manufactured or bound up into millstones short tons	(1)	6	------	------
Solid natural stone wheels number	4	16	12	11
Diamond do	72	488	65	616
Other	(2)	1,105	(2)	1,181
Articles not especially provided for:				
Emery or garnet	(2)	13	(2)	19
Natural corundum or artificial abrasive materials	(2)	206	(2)	241
Other	(2)	88	(2)	66
Diamonds:				
Diamond dies number	10	200	11	230
Crushing bort carats	357	918	363	994
Other industrial diamond do	4,731	r 29,799	4,752	27,374
Miners' diamond do	783	4,363	1,131	5,669
Dust and powder do	r 8,206	r 17,743	7,119	15,000
Total	XX	r 100,371	XX	96,467

r Revised.
1 Less than ½ unit.
2 Quantity not reported.

TRIPOLI

Tripoli from Arkansas and Oklahoma, amorphous or soft silica from Illinois, and rottenstone from Pennsylvania are all fine-grained, porous silica materials of essentially similar composition and uses such that they are discussed without distinction as a group. The output declined 13 percent in quantity and 17 percent in value in 1970. Abrasive use in 1970 declined to 68 percent of the total, and filler use increased to 30 percent, compared with 70 percent and 20 percent, respectively, in 1969.

Tripoli producers in 1970 were Malvern Minerals Co., Garland County, Ark., Hercules Minerals Co., Polk County, Ark., and Industrial Minerals, Inc., Polk County, Ark.; Illinois Minerals Co., and Tammsco, Inc., both in Alexander County, Ill.; The Carborundum Co., Newton County, Mo., and Ottawa County, Okla.; and Keystone Filler & Manufacturing Co. and Penn Paint & Filler Co., both in Lycoming County, Pa.

Prices quoted in Engineering and Mining Journal, December 1970, for tripoli and amorphous silica were as follows:

Tripoli, paper bags, 40-ton carloads, f.o.b. Elco, Ill., air-floated, through 200 mesh, cents per pound	1¼
Silica, amorphous, 50-lb paper bags, carloads, dollars per short ton:	
90–95 percent through 200 mesh	25
96–99 percent through 200 mesh	27
90–95 percent through 325 mesh	29
96–98 percent through 325 mesh	29
98–99.4 percent through 325 mesh	30
99.5 percent through 325 mesh	42
99.9 percent through 400 mesh	63
99 percent below 15 microns	69
99 percent below 10 microns	89

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

Kind		1966	1967	1968	1969	1970
Abrasives	short tons	45,785	44,961	52,837	50,337	41,703
Value	thousands	$1,880	$1,916	$2,201	$2,013	$1,583
Filler	short tons	10,581	11,240	13,418	14,352	18,093
Value	thousands	$285	$354	$388	$413	$545
Other	short tons	4,491	4,797	5,203	5,487	1,134
Value	thousands	$133	$143	$149	$157	$28
Total	short tons	60,857	60,998	71,458	70,176	60,930
Value [3]	thousands	$2,298	$2,413	$2,737	$2,584	$2,156

[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 that were produced in 1970 included oilstones from Arkansas, whetstone from Indiana, grinding pebbles from Minnesota and Wisconsin, grindstones from Ohio, and tube mill liners from Minnesota. Although the total tonnage of silica stone products declined by 5 percent, the value increased by 11 percent in 1970, chiefly due to an increase in the value of oilstones, which have significantly higher unit value.

In 1970, novaculite for oilstones was produced by Arkansas Abrasive 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.

In June 1970 Lowe's, Inc., Cassopolis, Mich., acquired Tamms Industries Co., Tamms, Illinois, Amorphous Silica Div. The mining and processing operation will continue to be located at Tamms, which is one of the few locations in the world where this type of silica is found. Lowe's, Inc., mines and processes clay and silica for use in agricultural, consumer, industrial, and pet products.

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

Year	Short tons	Value (thousands)
1966	3,806	$515
1967	2,701	574
1968	3,141	629
1969	3,311	600
1970	3,134	666

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

NATURAL SILICATE ABRASIVES

Garnet.—Domestic production of natural garnet declined by 8 percent in quantity but increased 3 percent in value in 1970. There were four producers, two in New York State and two in Idaho. Barton Mines Corp., the largest producer, mined from a large deposit of garnetiferous, metamorphosed, igneous rock in Warren County, N.Y., and processed the garnet for use in coated abrasives, for metal lapping, and for grinding and polishing optical lenses and plate glass. Interpace Corp., the principal wollastonite producer in the United States, recovered garnet as a byproduct in the processing of wollastonite ore in Essex County, N.Y. The two Idaho producers, Idaho Garnet Abrasive Co. and Emerald Creek Garnet Milling Co., produce garnet from placer deposits in Benewah County, Idaho. Both the Idaho and the Essex County, N.Y., materials were mostly used as sand-blast abrasive, but a portion was also used for miscellaneous abrasives, nonskid paints, and water filtration.

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

Year	Short tons	Value (thousands)
1966	21,952	$2,092
1967	20,494	1,849
1968	22,136	1,922
1969	20,458	1,874
1970	18,837	1,936

NATURAL ALUMINA ABRASIVES

Corundum.—Abrasive-grade natural corundum has not been mined in the United States for more than half a century, and for many years the entire quantity used by domestic industry was imported from Southern Rhodesia. In 1968 economic sanctions by the United Nations halted imports from that country. In 1969 the office of Emergency Preparedness (OEP) dropped corundum from the list of strategic and critical materials for stockpiling. Congressional approval was obtained early in 1970 for the sale of 1,964 short tons remaining in Government inventory by the Stockpile Disposal Division of the General Services Administration (GSA).

Emery.—Domestic production of emery in 1970 was by one producer in the United States, De Luca Emery Mine, Inc., near Peekskill in Westchester County, N.Y. Production data of quantity and value were withheld to avoid disclosing individual company confidential data. Di Rubbo American Emery Ore Co. ceased its operations in Westchester County mainly because of water problems. Emery was used for miscellaneous abrasive purposes such as antiskid aggregate in floors, stair treads, and pavements.

Table 8.—Natural corundum: World production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
India	359	592	[e] 610
South Africa, Republic of	282	252	272
U.S.S.R. [e]	6,600	6,600	7,200
Total	7,241	7,444	8,082

[e] Estimate. [p] Preliminary.

[1] In addition to the countries listed, Malawi reported an insignificant production (25 pounds in 1970), and Southern Rhodesia may have continued production at a significant level (several thousand tons) but available information is insufficient to make reliable estimates of output.

INDUSTRIAL DIAMOND

In 1970 imports of industrial diamond declined 5 percent in number of carats and almost 7 percent in value from the figures of 1969. Although shipments of industrial diamond from Ireland were less by almost 8 percent in quantity and 4 percent in value, Ireland increased its share slightly to about one-third of the total value. Domestic production of synthetic diamond in 1970 was estimated at 13 million carats, unchanged from 1969. Secondary production (salvage from used diamond tools and diamond-containing wastes) was estimated to be unchanged at 3 million carats.

A conference was held in New York City, on June 16, 1970, of a Government-Industry Working Group on Industrial Diamond, to solicit industry views and recommendations for disposal of 17.9 million carats of crushing bort and stones that were in excess of stockpile objectives. The quantity had been determined by OEP and a disposal plan was proposed by the Property Management and Disposal Service of GSA. Owing to differing views among the participants, additional time was required and no action had been taken by yearend. The stockpile objectives on December 3, 1970, were at 20.0 million carats for industrial diamond stones and 23.7 million carats for crushing bort.

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

(Thousand carats and thousand dollars)

Year	Quantity	Value
1968	13,686	$60,302
1969	14,076	52,821
1970	13,365	49,037

WORLD REVIEW

Angola.—The production of diamond by Companhia de Diamantes de Angola (DIAMANG) during 1970 exceeded that of 1969. DIAMANG's concession covers over 80 percent of the total area of Angola; but, according to the terms of its contract, it must release all but 50,000 square kilometers of its concession in 1971. DIAMANG has 14 geologists from Anglo-American Exploration exploring to find and retain the best areas in its present concession. Three of the four new firms granted concessions in Western Angola in 1969 began exploratory work in 1970.

Australia.—Stellar Mining Co. found a large kimberlite intrusion in the Kimberley district of Western Australia. Gems have been recovered here in the past.[2]

Botswana.—Work continued on schedule at the De Beers Orapa diamond mine. The Orapa pipe, covering 276 acres, is claimed to be the world's second largest. Daily output will be 7,250 metric tons of kimberlite to produce 2 million carats per year of which 90 percent will be of industrial quality.[3]

Brazil.—Mineração Tejucana S.A. increased its dredging capabilities in the Tocos section of the valley of the Jequitinhonha River, Minas Gerais, and will also install a dredge in the Capao Comprido section.[4]

Central African Republic.—Total diamond production for 1969 was 535,317 carats, down 12 percent from that of 1968, and was estimated at 50 percent industrial diamonds. Production in 1970 fell 10 percent in volume to 482,446 carats, from the 1969 level. The Government passed a law in 1970 forbidding anyone but native-born citizens from prospecting for diamonds or other precious stones.

Congo (Kinshasa).—Congolese officials expressed concern during the year regarding the GSA recommendation to Congress to dispose of 22.8 million carats of U.S. surplus industrial diamond holdings. Action by the U.S. Congress was postponed to 1971.

India.—The National Mineral Development Corporation of India continued development of the Vajrakarur mine in the Anantapur district in South India. The kimberlite deposit is expected to yield 57,000 carats per year in 4 years, compared with the present 24,000 carats per year.[5]

Ireland.—The world's newest and largest factory for the manufacture of industrial diamond was opened on the Shannon Industrial Estate on May 4, 1970, by Ultra High Pressure Units (Ireland) Limited.

Ivory Coast.—The output of all diamonds in 1970, both gem and industrial, was reported at 212,808 carats, compared with 202,413 carats in 1969. Normally 60 percent of the diamond yield is considered to be industrial diamond grade. One company, Société Anonyme de Recherches et d'Exploitations Minières en Côte d'Ivoire (SAREMCI) accounted for more than 80 percent of the total output of three active producers.

Lesotho.—Production for 1970 of gem diamonds was 3,502 carats and of industrial diamonds, 13,038 carats. The Lesotho National Development Corp. negotiated with Newmont Mining Corp. and Lonhro Ltd. for prospecting and development at the Kao kimberlite pipe. Altogether, six new ventures for all of Lesotho were under consideration. The Lesotho Department of Mines is hopeful that diamond output will expand manyfold.

Liberia.—For the fiscal year, 1969–70, the Bureau of Natural Resources and Surveys of Liberia reported diamond production of 825,959 carats, of which more than 25 percent were estimated to be industrial diamonds.

Sierra Leone.—Total diamond exports for 1970 were 1,955,011 carats, which were estimated to be 85 percent gem stones and 15 percent industrial material. A new company was formed to mine diamonds, called The National Diamond Mining Company (Sierra Leone) Limited, of which capital ownership was 51 percent by the Government and 49 percent by Sierra Leone Selection Trust Limited. Diamond is Sierra Leone's most important resource and accounts for about two-thirds of its exports, about 20 percent of its revenue, and the employment of more than 50,000 people.

South Africa, Republic of.—An exploratory shaft is being sunk at the Finsch Diamond Mine at Lime Acres, 100 miles west of Kimberley, to explore the rich diamond pipe at depth. The shaft, 16 feet in diameter, will reach a depth of 1,250 feet and is being sunk by the Gold Fields Cementation Mining Co. The Finsch pipe is 1,500 feet in diameter, is the second richest in South Africa, and the first Diamond pipe to be opened since the Premier Mine in 1903.[6] The biggest source of diamonds remains the Kimberley area where mining started over 100 years ago. New finds and improved recovery techniques have extend-

[2] Mining and Minerals Engineering (London). V. 6, No. 12, December 1970, p. 53.

[3] South African Mining and Engineering Journal. V. 81, No. 4044, pt. 2, Aug. 7, 1970, pp. 510–515.

[4] Skillings Mining Review. V. 59, No. 33, Aug. 15, 1970, p. 131.

[5] Journal of Mines, Metals & Fuels, V. 18, No. 10, October 1970, p. 382.

[6] The South African Mining and Engineering Journal. V. 81, No. 4032, pt. 1, May 15, 1971, pp. 995–997.

ed the outlook for diamond mining in South Africa.

Spain.—Interest has been shwon in diamond mining as a byproduct of prospecting for platinum in Malaga Province. Examination of samples for heavy minerals disclosed the presence of diamonds. The Spanish Government controlled Instituto Nacional de Industria joined a cooperative exploration program with two Canadian companies, Noranda Exploration Ltd. and Plour Management Ltd. to evaluate diamond potential covering 70,000 acres of the Province.[7]

TECHNOLOGY

Discrepancies in diamond abrasive sizing caused by the variables of sieve, sieving device, sieving time, sieve load, and humidity will be minimized by the adoption of standards sponsored by the Industrial Diamond Association and the Diamond Wheel Manufacturers' Institute. The standards were presented previously to the American National Standards Institute.[8] When natural diamond is crushed, the particles may be separated by shape, arbitrarily into four divisions—blocky, more elongated, neither too blocky nor too flat, and perfect needles or flats—and each shape is allocated a number. Early synthetic diamond was small and friable and did not fit into the scheme.[9] However, the latest high-pressure systems such as at Shannon, Ireland[10] and at Worthington, Ohio,[11] control the crystal growth to produce relatively large crystals that are strong and have well-defined edges and corners.

Plunge-grinding without damage to the wheel or to the material being ground, particularly tungsten carbide, glass, ceramics, exotic alloys, and laminates of aluminum and boron carbide, can be done at low speeds, 800 to 1,000 surface feet per minute with diamond wheels applied at high pressure. The wheels are made with high-strength bonds, and the grinding machine must be designed for high wheel pressures.[12]

A great number of patents were granted for improvements in making diamond abrasive products and modifications in the machines that apply them. The following patents are of interest in the making of diamonds: U.S. 3,499,732 (A Method for Making Diamond), March 10, 1970, to D. R. Garrett. This describes a method by which a dense, compacted mass of diamond-forming material is converted by use of energy generated by detonation of a high explosive charge; and, U.S. 3,536,447, (A method of Preparing Synthetic Diamond Crystals, Oct. 27, 1970, to M. Wakatsuki, T. Aoki, S. Takasu, and N. Wakamutu. This describes a method in which a new catalyst for use in ultrahigh-pressure, high-temperature production of synthetic diamond consists of an alloy of silicon with either copper, gold, or silver.

A synthetic carbonado that compared favorably with natural carbonado was made from diamond powder at a pressure of about 65 kilobars and a tempertature of 2,500°.[13]

The largest known manufactured industrial diamond in the world was shown at Provo, Utah, by Dr. Hall of Megadiamond Corp. It was made by the synthetic carbonado method.[14]

Two systems provide for standardization of dimensions of drill rods, core barrels, and drilling tools for mining and exploration: (1) The metric system and (2) the inch system. A comparison of the systems and a correlation have been made of design principles, manufacturing methods, and applications of diamond bits.[15]

The National Technical Information Service, Springfield, Va., has reprinted (available as a hard copy or microfiche) under NTIS No. PB 192 860, Industrial Diamond, A Materials Survey, by Henry P. Chandler (BuMines Info Circ 8200, 1964).

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[7] World Mining. V. 6, No. 3, March 1970, p. 51.

[8] Connors, E. J. A New Method for Checking Diamond Abrasive Size. Abrasive Eng., v. 16, No. 2, February 1970, pp. 18–20.

[9] Raal F. A., Dr. De Beers SDA—A Superior Diamond Abrasive. Ind. Diamond Rev., v. 30, No. 361, December 1970, pp. 478–482.

[10] Industrial Diamond Review. World's Largest Diamond Manufacturing Plant Inaugurated. V. 30, No. 356, July 1970, pp. 252–255.

[11] Tuzzeo, J. J. Tailored Diamond Increases Blade Life. Stone, v. 90, No. 9, September 1970, pp. 5–7.

[12] Abrasive Engineering. Diamond Slow-Down. V. 16, No. 8, August 1970, p. 18.

[13] Hall, H. Tracy. Sintered Diamond: A Synthetic Carbonado. Sci., V. 169, No. 48, Aug. 28, 1970, pp. 868–869.

[14] The Mining Record. 20-Carat Synthetic Diamond. V. 81, No. 39, Sept. 30, 1970, p. 3.

[15] Marx, Claus. Drilling With Diamond Bits. Min. Mag., v. 122, No. 2, February 1970, pp. 106–115.

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

(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			
	1969		1970		1969		1970		1969		1970		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	------	------	(1)	$2	(1)	$2	26	$182	29	$120	43	$188	------	------	------	------
Belgium-Luxembourg	43	$89	101	201	571	2,941	988	4,309	18	76	33	70	52	$110	236	$410
Brazil	------	------	------	------	11	153	5	89	(1)	10	(1)	5	------	------	------	------
British West Africa	------	------	------	------	1	7	11	89	------	------	------	------	------	------	------	------
Canada	12	51	(1)	2	94	562	91	470	31	171	33	134	425	330	347	264
Central African Republic	11	30	4	8	43	951	49	484	8	15	1	1	------	------	2	4
Congo	25	52	32	66	91	225	93	199	------	------	------	------	23	56	1	1
France	------	------	------	------	2	33	5	178	(1)	(1)	3	17	(1)	9	2	3
Germany, West	------	------	------	------	11	246	6	70	5	246	------	------	37	63	24	36
Ghana	------	------	12	30	259	1,015	81	503	3	21	1	3	------	------	------	------
Ireland	19	55	16	45	18	53	60	205	536	2,786	794	4,112	6,169	14,089	5,344	11,901
Israel	2	8	6	11	42	460	16	154	2	8	(1)	1	4	9	65	118
Japan	(1)	(1)	1	5	109	1,321	97	2,002	2	10	1	2	498	1,099	291	639
Netherlands	138	307	20	41	747	3,652	649	3,178	2	6	2	5	63	129	66	151
Sierra Leone	------	------	------	------	5	18	3	9	------	------	------	------	------	------	1	2
South Africa, Republic of	45	200	138	523	1,385	9,252	1,479	9,633	124	636	98	505	211	434	77	175
Switzerland	------	------	------	------	24	197	10	16	------	------	------	------	56	107	36	60
United Kingdom	36	70	33	60	802	3,758	810	3,908	16	225	57	262	615	1,192	590	1,171
Venezuela	------	------	------	------	21	293	97	667	------	------	8	59	------	------	------	------
Western Africa n.e.c.	26	53	------	------	442	4,393	171	987	5	27	------	------	44	105	9	20
Other	(1)	3	------	------	53	265	5	42	2	6	57	305	8	11	28	45
Total	357	918	363	994	4,731	29,797	4,752	27,374	783	4,363	1,131	5,669	8,205	17,743	7,119	15,000

[1] Less than ½ unit.

Table 11.—Natural diamond: World production, by country [1]
(Thousand carats)

Country [2]	1968 Gem	1968 Industrial	1968 Total	1969 Gem	1969 Industrial	1969 Total	1970 [p] Gem	1970 [p] Industrial	1970 [p] Total
Africa:									
Angola	1,316	351	1,667	1,617	404	2,021	1,917	479	2,396
Central African Republic	305	304	609	268	267	535	241	241	482
Congo (Kinshasa)	551	11,353	11,904	491	13,625	14,116	1,750	12,336	14,086
Ghana	245	2,202	2,447	239	2,152	2,391	252	2,271	2,523
Guinea [e]	21	49	70	22	50	72	22	52	[3] 74
Ivory Coast	77	110	187	81	121	202	85	128	213
Lesotho	2	10	12	5	24	29	4	13	17
Liberia [4]	537	212	749	562	184	746	[5] 620	[5] 206	[5] 826
Sierra Leone	560	962	1,522	736	1,253	1,989	[5] 723	[5] 1,232	[5] 1,955
South Africa, Republic of:									
Premier mine	608	1,824	2,432	631	1,891	2,522	669	2,008	[6] 2,677
Other DeBeers Co.[7]	[r] 2,313	1,892	4,205	2,457	2,010	4,467	[e] 2,511	[e] 2,054	[e] 4,565
Other	478	318	796	524	350	874	[e] 522	[e] 348	[e] 870
Total, Republic of South Africa	[r] 3,399	4,034	7,433	3,612	4,251	7,863	3,702	4,410	8,112
South-West Africa	1,636	86	1,722	1,923	101	2,024	[e] 2,100	[e] 100	[e] 2,200
Tanzania	356	346	702	394	383	777	359	349	708
Other areas:									
Brazil [e]	160	160	320	160	160	320	160	160	320
Guyana	28	38	66	21	31	52	24	37	61
India	7	2	9	10	2	12	[e] 10	[e] 2	[e] 12
Indonesia [e]	14	6	20	14	6	20	14	6	20
U.S.S.R.[e]	1,400	5,600	7,000	1,500	6,000	7,500	1,600	6,250	7,850
Venezuela	60	54	114	118	76	194	129	371	500
World total	[r] 10,674	25,879	36,553	11,773	29,090	40,863	13,712	28,643	42,355

[e] Estimate. [p] Preliminary. [r] Revised.

[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 the case of all countries except Angola, Congo (Kinshasa), Lesotho (1969 only), Liberia, and Venezuela, where sources list both total output and the detail. The estimated distribution of the total in the case of a number of countries is conjectural, based on unofficial sources of varying reliability.

[2] In addition to the countries listed, Botswana also produces diamond, but output statistics are regarded as confidential by the producer, and there is insufficient general information to prepare reliable estimates.

[3] Government of Guinea estimate.

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

[5] Exports.

[6] Officially reported production of nonalluvial stones from Transvaal; the Premier mine is the only major source of such stones in the Transvaal.

[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.

ARTIFICIAL ABRASIVES

Crude fused aluminum oxide abrasive material was produced in the United States and Canada in 1970 by six firms. The Carborundum Co., Norton Co., and General Abrasive Co., Inc., Division of U.S. Industries, Inc., each operated plants in both countries. Pyrominerals, Ltd.; Simonds Canada Abrasive Co., Ltd.; and The Exolon Co., had operations only in Canada. Of the combined output, 168,593 tons was regular grade, and 26,671 tons was white, high-purity material. Output was at 54 percent of rated plant capacity. About 9 percent of the total output of fused aluminum oxide, domestic and Canadian, was used in nonabrasive applications, principally in the manufacture of refractories.

Pyrominerals Ltd., 80 percent-controlled by American Abrasive Co., Westfield, Mass., a subsidiary of Bendix Corp. of Detroit, ceased operations in December 1970 and was to be liquidated.

In 1970 crude silicon carbide was produced in the United States and Canada by six firms. The Carborundum Co., which operates plants in both countries, Electro-Refractories & Abrasives, Ltd., The Exolon Co., General Abrasive Co., Division of U.S. Industries, Inc., and Norton Co., produced crude for both abrasive and nonabrasive uses. Satellite Alloy Corp., with facilities only in the United States, produced silicon carbide exclusively for refractories and other nonabrasive applications. Production was estimated at 93 percent of capacity, and consumption was estimated at about 50 percent each for abrasive and nonabrasive purposes.

As of December 31, 1970, GSA reported 377,588 tons of fused aluminum oxide crude in inventory, of which 128,493 tons was in excess of objective; 50,905 tons of fused aluminum oxide grain at objective; and 196,453 tons of silicon carbon crude, of which 166,453 tons was in excess of objective.

Metallic abrasives production in 1970 decreased by 10 percent in quantity and 2 percent in value compared with 1969. Steel shot and grit was predominant. Iron shot and grit was evenly divided between chilled iron and annealed iron. Minor quantities of other metallic oxides and carbides were reported. Ohio maintained its position as the number one producing State with 32 percent of the total quantity. Michigan, Indiana, and Pennsylvania, followed in order of quantity and combined accounted for 58 percent of the total. New York, Illinois, New Hampshire, and Connecticut combined accounted for the remaining 10 percent of quantity. The order of rank for value was similar to that of quantity, except that the value of metallic abrasives produced in Indiana exceeded that of Michigan.

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

(Thousand short tons and thousand dollars)

Kind	1966	1967	1968	1969	1970
Silicon carbide [1]	159	142	159	161	167
Value	$21,674	$19,612	$23,833	$23,945	$24,038
Aluminum oxide (abrasive grade) [1]	244	207	192	217	195
Value	$29,981	$28,183	$27,705	$31,276	$27,402
Metallic abrasives [2]	205	204	216	230	199
Value	$31,139	$32,610	$34,778	$37,369	$34,332
Total [3]	608	553	568	609	561
Value [3]	$82,794	$80,405	$86,316	$92,589	$85,772

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

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

Year and product	Manufactured		Sold or used		Stocks Dec. 31 (short tons)	Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)		
1969						
Chilled iron shot and grit	34,407	$3,605	34,528	$3,825	5,176	244,625
Annealed iron shot and grit	45,865	4,895	47,281	6,042	619	[1] 158,343
Steel shot and grit	149,466	21,160	146,487	27,049	13,092	168,163
Other [2]	2,190	352	2,199	452	153	10,250
Total [3]	231,928	30,012	230,495	37,369	19,040	423,038
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	[1] 158,843
Steel shot and grit	140,707	21,344	132,204	25,366	21,579	190,163
Other [2]	1,687	224	1,782	300	57	10,750
Total [3]	208,431	29,417	199,119	34,332	26,866	455,150

[1] Included in capacity of chilled iron shot and grit.
[2] Includes cut wire shot.
[3] Data may not add to totals 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
1966	17.5	174.4	18.6	310.8	12.7	373.5
1967	12.9	176.1	30.2	330.2	15.6	400.1
1968	17.7	179.7	25.5	357.2	[r] 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

[r] Revised.
[1] United States only.

TECHNOLOGY

The development of desirable finish on a part of tumbling or vibrating it in contact with small abrasive nuggets called media, is defined by the term "mass finishing." The media first were made by crushing, shaping and sizing crude abrasive. Recently, manufacturers have trended to preforms in which the abrasive grains are ceramic bonded or resin bonded and which provide a wide variety of shapes and structures.[16]

Usually a high rate of stock removal is associated with high-speed grinding wheels, but coated abrasive producers have developed strong belts with machines capable of exerting high pressure and high horsepower so that belts are superior to wheels in rate of stock removal and in economics.[17]

Patents on the materials used in abrasives and refractories were directed to minor improvements of existing materials and to the machines that apply them. However, the total number of patents is imposing and indicates that the effort to improve existing technology is fruitful.

[16] Matchulat, John G. Abrasive Grain Manufacturers Keep Pace. Abrasive Eng., v. 16, No. 12, December 1970, p. 10.
[17] McKee, Richard S. Abrasive-Belt Machining Saves Time. Abrasive Eng., v. 16, No. 8, August 1970, pp. 20–22.

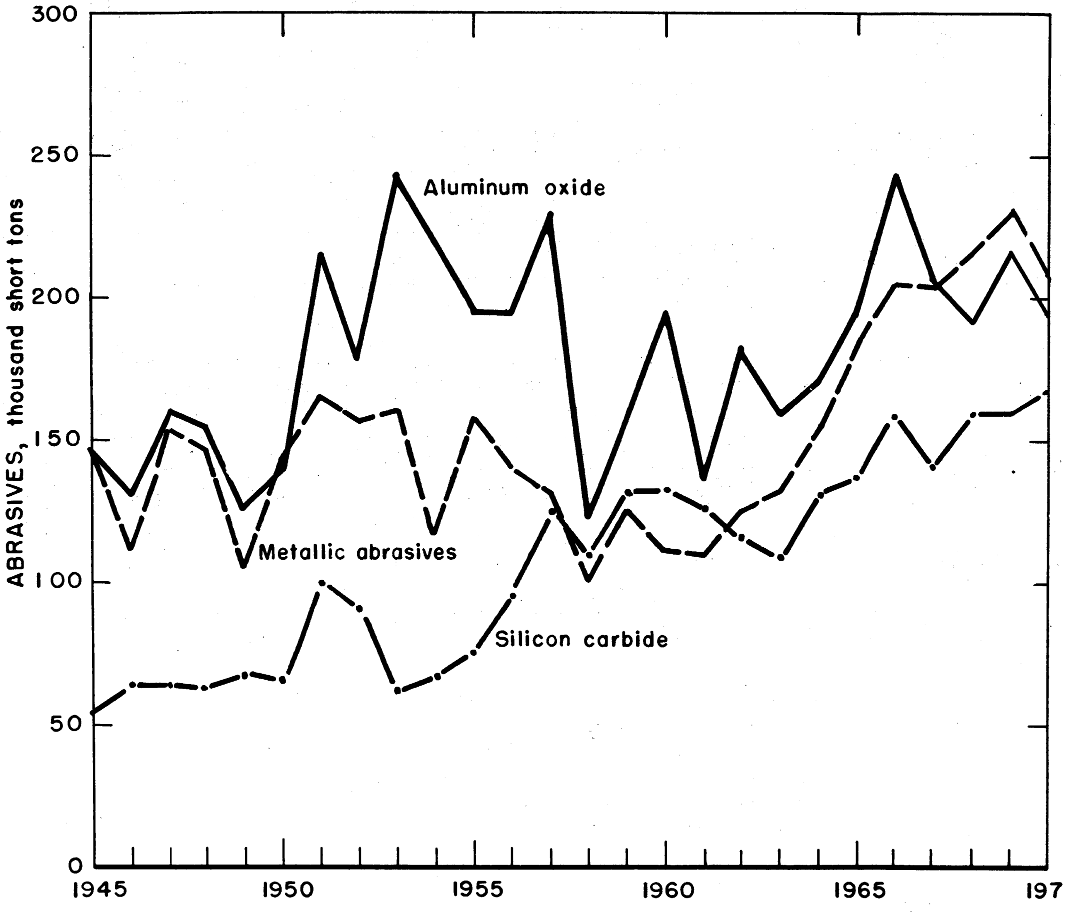

Figure 1.—Artificial abrasives production.

Aluminum

By John W. Stamper [1]

In 1970, production of primary aluminum in the United States was 5 percent higher than in 1969. Apparent demand however, declined markedly and producers closed down production facilities equivalent to 8 percent of overall capacity at yearend.

World production of primary aluminum increased 7 percent to a new record of 10,655,000 short tons despite an increase only about 1 to 2 percent in world demand. Demand in some major consuming countries, such as West Germany, was less than in 1969.

Legislation and Government Programs.—The Bureau of Domestic Commerce (BDC), U.S. Department of Commerce, established aluminum set-asides each quarter during 1970 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 455,000 tons, compared with 600,000 tons during 1969.

Shipments of aluminum ingot from the Government stockpile by the General Services Administration was 24,261 short tons.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Primary production	2,968	3,269	3,255	3,793	3,976
Value	$1,446,011	$1,614,483	$1,639,621	$2,013,403	$2,190,087
Price: Ingot, average cents per pound	24.5	25.0	25.6	27.2	28.7
Secondary recovery	693	698	817	901	781
Exports (crude and semicrude)	330	366	351	575	612
Imports for consumption (crude and semicrude)	679	539	793	558	468
Consumption, apparent	4,002	4,009	4,663	4,710	4,519
World: Production	7,583	8,343	8,839	9,932	10,655

DOMESTIC PRODUCTION

Primary.—Because of declining demand in 1970 and continuing concern about excess capacity, producers closed potlines and delayed new construction and expansion of existing facilities. By yearend, the cutbacks, which began in September 1970, affected about 8 percent of the total production capacity. Despite the oversupply situation two new aluminum plants and construction of other new plants continued on schedule. Primary aluminum production increased to a new record, nearly 5 percent above the 1969 output.

In September, Aluminum Co. of America (Alcoa), closed a 25,000-ton-per-year aluminum potline at its Alcoa, Tenn., reduction plant. The company also announced that construction of a new 100,000-ton-per-year potline at the same site, which was originally scheduled for initial operation in 1972, and the addition of two 50,000-ton-per-year lines at its Warrick, Ind., reduction plant would be delayed until market forecasts showed a need for additional ingot capacity.

At a new plant near Ft. Meade, Fla., Alcoa, jointly with the United States Steel Corp., began production of aluminum fluoride and synthetic cryolite from fluosilicic acid, a byproduct of the phosphate chemical industry in the area. The fluoride

[1] Physical scientist, Division of Nonferrous Metals.

chemicals are essential raw materials in the production of aluminum metal. The firm also announced plans to further diversify into magnesium metal production, an important alloying ingredient in aluminum. The company will use the silicothermic process to produce 25,000 tons of magnesium per year from dolomite and limestone deposits near Addy, Wash.

American Metal Climax, Inc. (AMAX), purchased land near Astoria, Oreg., from Bell Intercontinental Corp., which had partially prepared the site to build an alumina reduction plant and had acquired future rights to electric power from the Bonneville Power Administration (BPA). AMAX also assumed the long-term power contract with the BPA and planned to construct a primary aluminum plant at the site.

Anaconda Aluminum Co. started construction of a new 120,000-ton-per-year primary aluminum plant near Sebree, Ky. The plant is scheduled to start operation in mid-1973. Alcoa will design, engineer, and act as general contractor in building the facility, which will utilize prebaked anodes and will be capable of expansion to 244,000 tons per year. Late in the year, Anaconda reduced output at its Columbia Falls, Mont., reduction plant by 10 percent, which was equivalent to 17,500 tons per year of primary aluminum.

Harvey Aluminum Inc. continued construction of its 100,000-ton-per-year alumina reduction plant near the John Day Dam in Klickitat County, Wash., which was scheduled to start production in the latter half of 1971.

Corporate changes in Howmet Corp. during the year were expected to make it the fourth largest producer of primary aluminum by 1971. Péchiney Enterprises Inc. (a U.S. subsidiary of Péchiney Compagnie de Produits Chimiques et Electrométallurgiques of France) increased its interest in Howmet from 45 to 56 percent and was merged with Howmet. Howmet then became a 50-percent owner of the Intalco Aluminum Corp. plant at Ferndale, Wash. Production was started at a new 85,000-ton-per-year reduction plant near Frederick, Md., operated by the Eastalco Aluminum Co., a 100-percent-owned subsidiary of Howmet. During the year the operating rate at the Intalco smelter was reduced by 6 percent or about 15,000 tons.

In October Kaiser Aluminum & Chemical Corp. shut down two alumina reduction lines—one at its Chalmette, La., primary plant and one at its Mead, Wash., plant. The closings decreased capacity at Chalmette and Mead by 29,000 tons and 26,000 tons, respectively. An additional 26,000-ton-per-year line was shut down at Mead in December.

Kaiser also announced that it planned to construct a $7.5 million coke calcining plant at Gramercy, La. The facilities will include a bulk coke handling terminal and covered storage area. Construction was expected to begin in early 1971; plant operation is scheduled for mid-1972. Calcined coke is essentially pure carbon used in the production of aluminum. Raw material in the form of green coke will be barged to the plant from Gulf Oil Co.'s refinery, under construction at Myrtle Grove, La. The plant will be the sixth of its type for the company, with others located at Norco and Chalmette, La.; Mead, Wash.; Purvis, Miss.; and Gary, Ind.

The alumina reduction plant of National-Southwire Aluminum Co. at Hawesville, Ky., was completed early in 1970, bringing total capacity of the plant, which opened in 1969, to 180,000 tons per year. The first shipment of hot (molten) metal from the plant was delivered to the nearby rod and cable plant of the Southwire Co., a 50-percent owner of the reduction plant.

Construction continued on the new alumina reduction facility of Noranda Aluminum, Inc. The first unit of the 70,000-ton-per-year aluminum plant was expected to be operational early in 1971. Design of the plant provides for ultimate expansion to 210,000 tons per year.

Ormet Corp. closed down a 40,000-ton-per-year aluminum potline at its Hannibal, Ohio, reduction plant in September.

A memorandum of agreement concerning a possible merger between Swiss Aluminium Ltd. (Alusuisse), a Zurich-based firm with worldwide interests in aluminum ranging from bauxite mining and processing to fabricated products, and Phelps Dodge Corp., a U.S.-based firm with major interests in copper smelting and aluminum fabricating, reportedly was signed late in the year. Alusuisse owns Consolidated Aluminum Corp. (Conalco) and Gulf Coast Aluminum Corp. Conalco operates a 140,000-ton-per-year alumina reduction plant at New Johnsonville, Tenn. A line with 35,000-ton-per-year capacity at this plant was shut down in September. Gulf Coast was completing construction of a new reduction plant at Lake Charles, La., which was expected to be on stream with a 35,000-ton-per-year capacity, early in 1971.

Under the proposed merger Alusuisse would own 60 percent of the combined operations of Conalco, Gulf Coast, and the Phelps Dodge Aluminum Products Division of Phelps Dodge, and Phelps Dodge Corp. would own 40 percent. Phelps Dodge purchases about 40,000 tons of primary aluminum per year from Conalco through a toll arrangement for alumina acquired by Phelps Dodge from Surinam.

Revere Copper & Brass, Inc., started production from its new alumina reduction plant on Goose Pond Island in the Tennessee River near Scottsboro, Ala. A major portion of primary aluminum output from the plant will go in molten form to Revere's adjacent rolling mill. Alumina raw material will come from Revere's new alumina plant in Jamaica.

Late in the year Reynolds Metals Co. temporarily shut down aluminum potlines at four of its seven domestic alumina reduction plants. The cutbacks affected a 72,000-ton-capacity potline at Listerhill, Ala., and each of three 24,000-ton potlines at Jones Mills, Ark., Longview, Wash., and Troutdale, Oreg. The company also delayed startup of a new 30,000-ton-per-year line under construction at its Troutdale, Oreg., reduction facility.

Secondary.—Decreasing activity at aluminum semifabricating and fabricating operations and a work stoppage in the automotive industry combined to cause a marked decline in secondary aluminum operations during the year.

Total consumption of aluminum based scrap metal, as calculated from data on industry purchases and stocks of scrap reported to the Bureau of Mines, dropped to 973,000 tons, about 12 percent below the calculated consumption of aluminum scrap in 1969. Virtually all of the decreased con-

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

(Short tons)

Quarter	1969		1970	
	Production	Shipments	Production	Shipments
First	916,925	933,201	978,914	980,640
Second	946,194	957,482	997,183	976,816
Third	952,204	952,750	993,222	939,720
Fourth	977,739	977,568	1,006,829	981,744
Total	3,793,062	3,821,001	3,976,148	3,878,920

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

(Short tons)

Kind of scrap	1969	1970
New scrap:		
Aluminum-base	[1] 752,180	[2] 635,357
Copper-base	73	107
Zinc-base	77	96
Magnesium-base	295	283
Total	752,625	635,843
Old scrap:		
Aluminum-base	[1] 147,510	[2] 144,869
Copper-base	70	59
Zinc-base	520	554
Magnesium base	105	94
Total	148,205	145,576
Grand total	900,830	781,419

Form of recovery	1969	1970
As metal	88,204	70,873
Aluminum alloys	797,002	698,415
In brass and bronze	789	817
In zinc-base alloys	6,380	5,164
In magnesium alloys	909	783
In chemical compounds	7,546	5,367
Total	900,830	781,419

[1] Aluminum alloys recovered from aluminum-base scrap in 1969, including all constituents, were 793,188 tons from new scrap and 167,541 tons from old scrap and sweated pig, a total of 960,729 tons.

[2] 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.

sumption was accounted for in new scrap because the supply of old scrap was essentially independent of current semifabricating and fabricating operations where the new scrap is generated.

Recovery of secondary aluminum, calculated from industry reports, was 781,000 tons, 13 percent below the 1969 level. Recovery of all metallic constituents from aluminum-base scrap dropped 14 percent to 832,000 tons.

The Bureau of Mines estimated that full coverage of the industry would show a total scrap consumption of 1,330,000 short tons in 1969 and 1,170,000 short tons in 1970. Aluminum recovery, based on full coverage would total 1,080,000 tons in 1969 and 940,000 tons in 1970. Metallic aluminum recovery would total 1,150,000 tons in 1969 and 1 million tons in 1970.

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.

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

(Thousand short tons)

Company and plant location	Actual capacity, yearend 1969	Actual capacity, yearend 1970	Ownership
Aluminum Co. of America (Alcoa):			Self 100 percent.
Alcoa, Tenn	r 200	200	
Badin, N.C	r 100	100	
Evansville (Warrick), Ind	175	175	
Massena, N.Y	125	125	
Point Comfort, Tex	175	175	
Rockdale, Tex	r 275	275	
Vancouver, Wash	100	100	
Wenatchee, Wash	175	175	
Total	r 1,325	1,325	
Reynolds Metals Co.:			Self 100 percent.
Arkadelphia, Ark	63	63	
Corpus Christi (San Patricio), Tex	r 111	111	
Jones Mills, Ark	122	122	
Listerhill (Sheffield), Ala	r 221	221	
Longview, Wash	r 190	200	
Massena, N.Y	128	128	
Troutdale, Oreg	100	100	
Total	r 935	945	
Kaiser Aluminum & Chemical Corp.:			Self 100 percent.
Chalmette, La	260	260	
Mead, Wash	206	206	
Ravenswood, W. Va	163	163	
Tacoma, Wash	r 81	81	
Total	r 710	710	
Intalco Aluminum Corp., Ferndale (Bellingham), Wash	r 260	260	American Metal Climax, Inc. 50 percent; Howmet Corp. 50 percent.
Eastalco Aluminum Co., Frederick, Md	--------	85	Howmet Corp. 100 percent (subsidiary of Péchiney).
Ormet Corp., Hannibal, Ohio	240	240	Olin Corp. 50 percent; Revere Copper & Brass, Inc. 50 percent.
Anaconda Aluminum Co., Columbia Falls, Mont	175	175	The Anaconda Co. 100 percent.
Consolidated Aluminum Corp., (Conalco) New Johnsville, Tenn	140	140	Swiss Aluminum, Ltd. (Alusuisse) 100 percent.
Harvey Aluminum Inc., The Dalles, Oreg	91	91	Martin Marietta Corp. 87.2 percent.
Revere Copper & Brass Inc., Scottsboro, Ala	--------	112	Revere Copper & Brass, Inc.
National-Southwire Aluminum Co., Hawesville, Ky	r 45	180	National Steel Corp. 50 percent; Southwire Co. 50 percent.
Total United States	r 3,921	4,263	

r Revised.

Table 5.—Stocks, receipts, and consumption of new and old aluminum scrap and sweated pig in the United States in 1969 and 1970 [1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption [2]	Stocks Dec. 31
1969				
Secondary smelters: [3]				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	4,690	125,866	125,810	4,746
Segregated high copper	835	18,926	18,864	897
Mixed low copper (Cu maximum, 0.4 percent)	2,055	74,714	74,578	2,191
High zinc (7000 series type)	422	10,076	9,668	830
Mixed clips	W	W	W	W
Borings and turnings:				
Low copper (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	1,203	63,825	63,557	1,471
Foil, dross, skimmings, and other	12,306	105,021	103,891	13,436
Total new scrap [4]	27,660	572,537	571,375	28,822
Old scrap (solids)	6,731	118,110	118,388	6,453
Sweated pig (purchased for own use)	2,753	54,176	52,355	4,574
Total all classes	37,144	744,823	742,118	39,849
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	2,707	177,575	176,903	3,379
Segregated high copper	165	15,983	15,992	156
Mixed low copper (Cu maximum, 0.4 percent)	5,031	56,577	59,166	2,442
High zinc (7000 series type)	277	2,625	2,503	399
Mixed clips	W	W	W	W
Borings and turnings:				
Low copper (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	166	28,580	28,464	282
Foil, dross, skimmings, and other	2,383	47,021	47,097	2,307
Total new scrap [4]	11,155	337,591	339,583	9,163
Old scrap (solids)	329	9,305	9,382	252
Sweated pig (purchased for own use)	3,697	18,662	18,014	4,345
Total all classes	15,181	365,558	366,979	13,760
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	7,397	303,441	302,713	8,125
Segregated high copper	1,000	34,909	34,856	1,053
Mixed low copper (Cu maximum, 0.4 percent)	7,086	131,291	133,744	4,633
High zinc (7000 series type)	699	12,701	12,171	1,229
Mixed clips	2,559	76,637	76,888	2,308
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	1,369	17,865	18,630	604
Zinc, under 0.5 percent	784	25,866	26,026	624
Zinc, 0.5 to 1.0 percent	1,863	62,971	62,921	1,913
Other	1,369	92,405	92,021	1,753
Foil, dross, skimmings, and other	14,689	152,042	150,988	15,743
Total new scrap	38,815	910,128	910,958	37,985
Old scrap (solids)	7,060	127,415	127,770	6,705
Sweated pig (purchased for own use)	6,450	72,838	70,369	8,919
Total all classes	52,325	1,110,381	1,109,097	53,609

See footnotes at end of table.

Table 5.—Stocks, receipts, and consumption of new and old aluminum scrap and sweated pig in the United States in 1969 and 1970 [1]—Continued

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption [2]	Stocks Dec. 31
1970				
Secondary smelters: [3]				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	4,732	107,780	108,874	3,638
Segregated high copper	509	13,535	13,397	647
Mixed low copper (Cu maximum, 0.4 percent)	2,282	65,350	64,930	2,702
High zinc (7000 series type)	798	8,706	9,125	379
Mixed clips	2,459	50,342	51,010	1,791
Borings and turnings:				
Low copper (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	1,471	46,212	46,621	1,062
Foil, dross, skimmings, and other	12,770	110,591	111,208	12,153
Total new scrap [4]	28,100	475,059	477,307	25,852
Old scrap (solids)	6,097	126,493	125,647	6,943
Sweated pig (purchased for own use)	4,588	53,401	47,373	10,616
Total all classes	38,785	654,953	650,327	43,411
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	3,379	153,436	154,067	2,748
Segregated high copper	156	6,508	6,620	44
Mixed low copper (Cu maximum, 0.4 percent)	2,442	58,933	56,504	4,871
High zinc (7000 series type)	399	1,610	1,876	133
Mixed clips	53	9,556	9,561	48
Borings and turnings:				
Low copper (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	282	21,702	21,366	618
Foil, dross, skimmings, and other	2,308	49,865	49,324	2,849
Total new scrap [4]	9,163	302,519	300,250	11,432
Old scrap (solids)	252	10,431	10,479	204
Sweated pig (purchased for own use)	4,345	10,954	11,477	3,822
Total all classes	13,760	323,904	322,206	15,458
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	8,111	261,216	262,941	6,386
Segregated high copper	665	20,043	20,017	691
Mixed low copper (Cu maximum, 0.4 percent)	4,724	124,283	121,434	7,573
High zinc (7000 series type)	1,197	10,316	11,001	512
Mixed clips	2,512	59,898	60,571	1,839
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	604	7,807	7,879	532
Zinc, under 0.5 percent	624	20,097	20,121	600
Zinc, 0.5 to 1.0 percent	1,995	45,548	45,074	2,469
Other	1,753	67,914	67,987	1,680
Foil, dross, skimmings, and other	15,078	160,456	160,532	15,002
Total new scrap	37,263	777,578	777,557	37,284
Old scrap (solids)	6,349	136,924	136,126	7,147
Sweated pig (purchased for own use)	8,933	64,355	58,850	14,438
Total all classes	52,545	978,857	972,533	58,869

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

The aluminum beverage can recyling program, initiated by Reynolds, was continued, and Alcoa, Kaiser, and the Adolph Coors Co. also conducted programs to collect and recycle aluminum cans. Investigations by the Bureau of Mines [2] indicated that approximately 3 billion all-aluminum cans (equivalent to about 57,000 tons of aluminum) were used in 1970. It is estimated that the can recycling programs resulted in collections and reuse of about 10 percent of the all aluminum cans used in 1970.

The A & M Division of Vulcan Materials Co. reported an increase in sales of secondary aluminum, despite the automotive industry shutdowns, and announced plans for a 65-percent expansion of production capacity of its Oak Creek aluminum smelter in Milwaukee, Wis.

Alloys and Chemical Corp. announced its capability to deliver secondary aluminum in molten form to distances of up to 300 miles of its Cleveland plant. The hot metal is trucked to customers' plants in two ladles each holding 12,500 to 15,000 pounds.

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

(Short tons) [1]

	1969		1970	
	Production [2]	Shipments [2]	Production [2]	Shipments [2]
Pure aluminum (Al minimum, 97.0 percent)	88,204	87,769	70,873	70,626
Aluminum-silicon:				
95/5 Al-Si, 356, etc. (maximum Cu 0.6 percent)	17,568	17,768	16,907	16,750
13 percent Si, 360, etc. (maximum Cu 0.6 percent)	46,545	45,611	46,331	45,712
Aluminum-silicon (Cu 0.6 to 2 percent)	7,689	7,747	5,889	5,483
No. 12 and variations	6,236	6,281	8,512	8,623
Aluminum-copper (maximum Si, 1.5 percent)	789	772	817	752
No. 319 and variations	54,066	53,285	49,679	48,788
Nos. 122, 138	343	337	1,012	1,015
AXS-679 and variations	358,597	355,893	308,875	304,204
Aluminum-silicon-copper-nickel	25,557	25,619	17,508	17,444
Deoxidizing and other destructive uses:				
Grades 1 and 2	19,573	19,741	17,260	17,305
Grades 3 and 4	12,477	12,399	10,336	10,306
Aluminum-base hardeners	6,643	6,434	4,765	5,058
Aluminum-magnesium	909	884	783	780
Aluminum-zinc	6,380	6,690	5,164	4,708
Miscellaneous	30,826	30,334	24,109	24,114
Total	682,402	677,564	588,820	581,668

[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 28,400 and 15,655 tons of primary aluminum in 1969 and 1970, respectively, in producing secondary aluminum-base alloys.
[2] No allowance was made for consumption or receipts by producing plants.

CONSUMPTION

Total shipments of aluminum by the domestic industry in 1970, estimated by the Aluminum Association, was about 5 million tons, equivalent to a 7-percent drop from the 1969 shipments. Gains in shipments to the container and packaging industry of about 23 percent over 1969 and in exports (15 percent) did not offset declines in shipments to the transportation industry and in all other categories.

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

Industry	Percent of total 1969	Percent of total 1970
Building and construction	21.9	22.2
Transportation	18.4	15.1
Electrical	13.2	13.4
Containers and packaging	11.0	14.5
Consumer durables	9.8	9.2
Machinery and equipment	6.5	6.0
Exports	9.3	11.5
Other	9.9	8.1
Total	100.0	100.0

[2] Siebert, Donald L. Impact of Technology on the Commercial Secondary Aluminum Industry. BuMines Inf. Circ. 8445, 1970, 76 pp.

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
1966	2,958,274	+350,400	136,876	556,155	4,001,705
1967	3,136,136	+174,723	128,504	569,247	4,008,610
1968	3,403,055	r +443,464	154,711	662,197	r 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

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

Almost 4,500 tons of aluminum was expected to be used for sheathing, window sills and jams, and support beams for the lobby areas of the 110-story World Trade Center under construction in New York City. Aluminum also was planned for extensive use in covering the Sears Tower being built in Chicago. This 109-story building reportedly will be the largest in the world.

About 40 percent of all registered boats in the United States 16 feet in length or less in 1969 were made of aluminum. In 1970 the total number of aluminum boats produced dropped from a record 331,000 in 1969 to 283,000. However, aluminum continued to make inroads on other materials of construction for large boats such as houseboats, pontoon boats, cruisers, and custom yachts, both power and sail.

Construction of the all-aluminum *Alcoa Seaprobe,* reportedly the largest and most advanced surface ship ever built for deep-ocean search and recovery, was nearing completion at the end of the year. About 500 tons of aluminum was used in the ship. The experience gained in building such a large craft of aluminum was expected to assist industry in applying advanced fabricating techniques to aluminum shipbuilding.

Other large aluminum ships built in 1970 included a Navy Landing Craft Utility (LCU), which was capable of carrying three of the largest armored tanks in use, and the first of five planned 165-ton, 78-foot-long shrimp trawlers.

A report indicated that consumption of aluminum in the automobile increased faster in the past 10 years than the use of any other metal for this purpose.[3] The major areas of aluminum usage in domestic passenger cars and the percentages of total automotive market for aluminum were reported as follows:

	Percent
Automatic transmission	40
Engine, (including electrical)	37
Air conditioning	13
Hardware and trim	5
Brakes	2
Steering	2
Other	1
Total	100

Most of the aluminum in automatic transmissions is for the case and cover, which weigh up to 20 pounds. Although some engine blocks, such as the 1970 model Chevrolet Vega, were cast aluminum, pistons, which weighed up to 2 pounds each, comprised the largest use in engines. Small quantities of aluminum foil and magnet wire are used in secondary motor coils and distributor parts.

The average factory-installed automobile air conditioner uses 10 to 15 pounds of aluminum tubing and fin stock and about 3 pounds of die or permanent mold aluminum castings for the compressor crankcase, pistons, and connecting rods.

A major builder of electrical transformers began converting from copper to aluminum for primary and secondary windings.[4] The high cost of copper relative to that of aluminum was given as the principal reason for the change. The competition between aluminum and copper for the electric conductor wire and cable market continued; three new wire and cable products that utilized aluminum in combination with copper,[5] steel,[6] and nickel,[7] were marketed.

3 Metals Week. Metals in Autos: A to Z. V. 1, No. 47, Nov. 23, 1970, pp. 12A–26A.
4 Shobe, D. W. Aluminum Replacing Copper in Electrical Transformers. Mod. Metals, v. 26, No. 4, May 1970, pp. 37–40.
5 Hoffman, W. E. Copper-Clad Aluminum Wire Economical. Am. Metal Market, v. 77, No. 145, July 30, 1970, pp. 1, 6.
6 American Metal Market. Overhead Power Lines Use Clad Steel Wire. V. 78, No. 78, Mar. 11, 1971, p. 9.
7 Metals Week. Another Kind of Clad Aluminum Wire. V. 42, No. 15, Apr. 12, 1971, p. 26.

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

(Short tons)

	1969	1970 p
Wrought products:		
Sheet, plate, and foil	2,143,374	2,123,669
Rolled and continuous cast rod and bar; wire	482,273	495,687
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing and rolled structural shapes	991,212	911,286
Powder, flake, and paste	137,982	102,268
Forgings (including impacts)	78,298	60,194
Total	3,833,139	3,693,104
Castings:		
Sand	110,421	99,173
Permanent mold	217,023	175,048
Die	513,798	470,964
Others	7,799	7,412
Total	[2] 849,041	752,597
Grand total	4,682,180	4,445,701

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

Table 9.—Distribution of wrought products

(Percent)

	1969	1970 p
Sheet, plate, and foil:		
Non-heat-treatable	44.4	47.0
Heat-treatable	4.2	3.0
Foil	7.3	7.6
Rolled and continuous cast rod and bar; wire:		
Rod, bar, etc.	1.9	1.9
Bare wire, conductor and nonconductor	1.2	1.3
Bare cable (including steel-reinforced)	6.2	6.8
Wire and cable, insulated or covered	3.3	3.5
Extruded products:		
Rod and bar	.8	.8
Pipe and tube	2.6	2.4
Shapes [1]	20.0	19.1
Tubing:		
Drawn	1.2	1.1
Welded, non-heat-treatable [2]	1.3	1.2
Powder, flake, and paste:		
Atomized	3.2	2.3
Flaked	(3)	(3)
Paste	.3	.3
Powder, n.e.c.	.1	.1
Forgings (including impacts)	2.0	1.6
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

Stocks of aluminum ingot reported at reduction plants rose sharply from 42,975 short tons at the beginning of the year to 140,203 tons at yearend. All of the primary producers do not report stocks at their reduction plants to the Bureau. The BDC, Department of Commerce, 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 as follows:

Metal inventory at yearend, short tons

1967	1,766,000
1968	1,862,000
1969	1,892,000
1970	2,198,000

PRICES

The price for 99.5-percent primary aluminum ingot, quoted in the American Metal Market, increased from 28 cents per pound at the beginning of the year to 29 cents per pound on April 14, 1970, and remained at that level for the remainder of the year. Low demand during the year, however, resulted in substantial discounting, some ingot reportedly selling for as little as 22 cents per pound by yearend.

Quoted prices for secondary aluminum alloy ingot also increased during the year about 1 cent per pound.

FOREIGN TRADE

Total U.S. exports of aluminum increased 8 percent in 1970; 18 percent of the ingots, slabs, and crude went to France, 17 percent to Japan, and 14 percent to West Germany. Exports of crude and semicrude aluminum increased 6 percent; exports of wire and cable and other manufactures increased about 70 percent.

Domestic exports of aluminum scrap decreased by 34 percent, reflecting the low level of activity at aluminum fabricating plants in the United States. Japan, Italy, and West Germany received about 70 percent of the total.

The total quantity of crude and semicrude aluminum imported was 16 percent less than in 1969, largely because of a sharp decline in receipts of crude aluminum and alloy from Canada, Norway, France, and Poland. Although shipments from Canada of aluminum dropped about 17 percent, that country continued to be the principal overseas source of aluminum for the United States.

Effective January 1, 1970, in accordance with "Kennedy round" trade agreements, duties on certain unwrought and wrought aluminum products were reduced and, during the year, were as follows: (in coils), 1.7 cents per pound; unwrought (other than aluminum silicon alloys) 1 cent per pound; wrought (bars, plates, sheets, strip), 2.2 cents per pound.

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

Class	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	344,414	$172,137	408,452	$214,780
Scrap	86,255	33,827	57,159	20,945
Plates, sheets, bars, etc	135,707	99,596	137,675	106,913
Castings and forgings	4,360	10,473	3,438	9,068
Semifabricated forms, n.e.c	4,134	7,722	4,843	9,302
Total	574,870	323,755	611,567	361,008
Manufactures:				
Foil and leaf	5,300	8,481	6,648	10,990
Powders and pastes	1,299	1,510	3,078	3,088
Wire and cable	10,082	7,942	18,505	15,695
Total	16,681	17,933	28,231	29,773
Grand total	591,551	341,688	639,798	390,781

Table 11.—U.S. exports of aluminum by classes and countries

Country	1969						1970					
	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	14,446	$7,223	1,802	$1,263	--------	--------	28,841	$16,004	647	$989	2	$1
Australia	115	56	1,001	732	--------	--------	83	53	1,185	1,332	--------	--------
Belgium-Luxembourg	37,046	17,560	244	485	974	$364	33,203	16,170	276	493	1,422	559
Brazil	17,508	8,735	2,370	1,770	--------	--------	16,803	9,103	363	399	1	1
Canada	9,754	6,326	88,405	68,036	9,039	3,554	9,415	7,651	79,027	59,339	6,349	2,416
Chile	1,600	803	102	184	2	1	1,991	1,006	100	170	18	7
Colombia	33	22	213	396	3	2	12	16	463	404	1	(2)
El Salvador	1,210	655	607	366	--------	--------	1,188	648	674	446	--------	--------
France	29,862	14,494	621	793	5,010	2,023	72,408	36,166	999	1,197	1,797	744
Germany, West	47,020	23,406	4,374	4,344	28,596	11,240	55,711	29,365	6,351	7,071	23,800	8,677
Ghana	12	19	55	57	--------	--------	36	51	1,302	974	--------	--------
Hong Kong	2,594	1,341	73	79	23	7	5,196	2,604	85	103	11	4
India	1,106	586	62	80	--------	--------	2,455	1,293	41	59	--------	--------
Iran	6,146	3,151	268	302	--------	--------	1,509	755	208	220	--------	--------
Israel	2,116	1,104	1,004	1,513	--------	--------	3,907	2,093	1,214	1,589	--------	--------
Italy	10,478	5,347	2,126	3,583	20,291	7,982	23,262	12,524	2,537	3,737	10,861	4,109
Jamaica	71	50	299	445	7	3	33	26	556	510	4	3
Japan	109,698	53,915	3,246	3,800	10,860	3,998	71,470	35,617	1,629	3,083	5,460	1,824
Korea, Republic of	9,545	4,778	102	93	224	64	3,184	1,903	94	124	356	118
Mexico	569	328	9,831	6,407	29	5	203	110	10,241	7,436	23	5
Netherlands	2,088	1,001	1,107	1,496	2,522	1,022	4,935	2,279	1,696	2,356	555	207
New Zealand	1,179	691	45	83	--------	--------	1,536	881	104	151	--------	--------
Pakistan	361	196	790	594	--------	--------	551	252	804	618	--------	--------
Panama	767	368	116	264	59	20	1,087	585	170	201	--------	--------
Peru	1,262	643	78	122	578	301	1,117	601	85	132	320	175
Philippines	5,087	2,747	85	134	128	45	6,698	3,780	78	199	74	37
South Africa, Republic of	4,661	2,488	1,854	1,511	--------	--------	4,225	2,382	6,532	4,761	--------	--------
Spain	21	10	91	138	370	122	11	5	109	167	666	191
Sweden	1,522	805	2,870	2,620	39	19	2,412	1,289	3,297	2,696	202	89
Switzerland	5,097	2,763	294	295	323	131	1,463	872	324	332	61	25
Taiwan	2,416	1,165	121	164	745	218	10,199	5,239	78	106	1,910	410
Thailand	3,081	1,544	209	169	--------	--------	6,526	3,233	73	141	1	(2)
United Kingdom	4,935	2,586	5,324	5,757	6,253	2,634	16,835	8,564	13,283	12,112	2,445	995
Venezuela	112	75	1,650	1,742	46	17	78	86	1,091	1,355	10	5
Vietnam, South	4	5	7,659	5,179	--------	--------	--------	--------	3,719	2,461	--------	--------
Other	10,892	5,151	5,103	2,795	134	55	19,869	11,574	6,521	7,820	810	343
Total	344,414	172,137	144,201	117,791	86,255	33,827	408,452	214,780	145,956	125,283	57,159	20,945

[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 classes

Class	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metal and alloys, crude	468,236	$214,845	350,060	$164,227
Circles and disks	7,014	4,610	9,284	6,434
Plates, sheets, etc. n.e.c	r 37,538	r 24,226	59,137	39,294
Rods and bars	12,616	9,601	10,239	8,108
Pipes, tubes, etc	3,457	3,471	2,234	2,419
Scrap	28,850	11,003	36,779	12,979
Total	r 557,711	r 267,756	467,733	233,461
Manufactures:				
Foil	1,924	3,405	14,067	14,209
Leaf (5.5 by 5.5 inches)	(1)	34	(1)	27
Flakes and powders	773	597	164	193
Wire	837	777	946	928
Total	3,534	4,813	15,177	15,357
Grand total	r 561,245	r 272,569	482,910	248,818

r Revised.
1 1969: 2,690,000 leaves and 78,143,447 square inches; 1970: 1,787,500 leaves and 51,944,636 square inches.

Table 13.—U.S. imports for consumption of aluminum, by classes and countries

Country	1969						1970					
	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	25	$10	224	$156	--------	--------	60	$27	242	$190	--------	--------
Austria	9	6	2,568	1,937	--------	--------	2	1	2,203	1,708	--------	--------
Belgium-Luxembourg	15	10	7,000	4,403	--------	--------	26	16	27,720	17,637	--------	--------
Canada	401,423	183,863	r 8,134	r 6,802	26,352	$10,194	327,024	153,144	6,171	5,396	30,002	$10,372
France	2,664	1,288	2,082	1,652	1	1	3	8	13,869	9,216	480	196
Germany, West	11	12	2,297	1,822	--------	--------	2	2	2,249	2,254	550	212
Greece	1,107	424	37	23	--------	--------	--------	--------	86	56	--------	--------
Italy	1	17	8,521	5,381	--------	--------	1	8	4,442	3,120	--------	--------
Japan	724	376	16,089	10,417	--------	--------	452	231	14,296	9,773	110	51
Norway	50,198	23,198	944	522	--------	--------	20,040	9,536	1,105	704	--------	--------
Poland	4,078	1,643	--------	--------	661	242	1,650	691	--------	--------	--------	--------
Spain	--------	--------	2,974	1,723	596	227	11	5	1,973	1,219	--------	--------
Sweden	--------	--------	12	19	33	10	--------	--------	16	25	--------	--------
Switzerland	--------	--------	200	181	--------	--------	--------	--------	96	104	--------	--------
United Kingdom	1,706	922	137	222	65	18	360	355	122	184	3,459	1,514
Venezuela	--------	--------	1	1	231	88	--------	--------	8	5	--------	--------
Yugoslavia	341	148	8,722	6,237	2	2	--------	--------	5,683	4,278	--------	--------
Other	5,934	2,928	683	410	909	221	429	203	613	386	2,178	634
Total	468,236	214,845	r 60,625	r 41,908	28,850	11,003	350,060	164,227	80,894	56,255	36,779	12,979

r Revised.
[1] Includes circle, disks, bars, rod, plates, sheets, pipes, etc.

WORLD REVIEW

World demand for aluminum in 1970 reportedly increased about 1 to 2 percent over the 1969 level, to about 10.5 million tons compared with world production of 10.7 million tons. Since much of the demand was met by secondary sources, world stocks of primary metal probably increased significantly. Despite the low demand, new capacity added during the year was 5 percent higher than 1969 yearend capacity.

Algeria.—British Smelter Constructions was awarded a contract for a feasibility study on a primary aluminum project. The proposed smelter would be located in western Algeria, close to the Hassi-R'Mel-Arzew natural gas deposits in order to supply low-cost power for the smelter. Alumina was expected to be imported from the Eurallumina plant in Sardinia.

Australia.—The Comalco Ltd. (Comalco) (Bell Bay) smelter's new half-potline, which was due on stream in April 1971, was near completion at yearend. The new line will raise capacity at Bell Bay to 105,000 tons per year. Production on the new line was expected to start in January. Alcan Australia, Ltd. of Canada's Kurri Kurri New South Wales smelter began expanding to increase capacity to 55,000 tons per year. Upon approval of the Australian and Japanese Governments, Alcan will supply 500,000 tons of primary ingot over a 10-year period to Kobe Steel Works, Ltd. of Japan.

Table 14.—Aluminum: World production, by countries [1]

(Thousand short tons)

Country	1968	1969	1970 [p]
North America:			
Canada	979	1,098	1,063
Mexico	25	36	37
United States	3,255	3,793	3,976
South America:			
Brazil	r 43	56	e 63
Surinam [2]	48	59	58
Venezuela	11	15	25
Europe:			
Austria	95	99	99
Czechoslovakia	72	72	72
France	403	410	419
Germany, East [e]	r 55	55	55
Germany, West	284	290	340
Greece	84	90	96
Hungary	69	71	73
Iceland	------	14	41
Italy	157	156	162
Netherlands	54	80	82
Norway	516	560	584
Poland [3]	103	107	109
Romania [4]	84	99	112
Spain	98	114	127
Sweden	62	74	73
Switzerland	85	85	101
U.S.S.R. [e]	r 1,100	r 1,160	1,210
United Kingdom	42	37	44
Yugoslavia	53	53	53
Africa:			
Cameroon, Republic of	50	52	58
Ghana	120	125	125
Asia:			
China, mainland [e]	r 100	r 130	140
India	132	145	178
Japan [5]	531	627	808
Korea, Republic of	------	7	17
Taiwan	22	24	30
Oceania: Australia	107	139	225
Total	r 8,839	r 9,932	10,655

e Estimate. p Preliminary. r Revised.
[1] Output of primary unalloyed ingot unless otherwise specified.
[2] Exports.
[3] Includes secondary.
[4] Includes alloys.
[5] Includes super-purity aluminum as follows in tons: 1968, 3,912; 1969, 4,183; 1970, 5,050.

Table 15.—World producers of primary aluminum

(Thousand short tons)

Country, company, and plant location	Actual capacity, yearend 1970	Ownership
NORTH AMERICA		
Canada:		
Aluminium Company of Canada, Ltd.:		Alcan Aluminium Ltd. 100 percent.
Arvida, Quebec	450	
Beauharnois, Quebec	48	
Isle Maligne, Quebec	130	
Kitimat, British Columbia	300	
Shawinigan Falls, Quebec	95	
Total	1,023	
Canadian Reynolds Metals Co. Ltd., Baie Comeau, Quebec	175	Reynolds Metals Co. 100 percent.
Total	1,198	
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)	4,263	
Total North America	5,505	
SOUTH AMERICA		
Brazil:		
Aluminio Minas Gerais, S.A., Saramenha, Minas Gerais	28	Alcan Aluminium Ltd. 100 percent.
Cia. Brasileira de Aluminio S.A. (C.B.A.), Sorocaba, São Paulo	55	Industria Votorantim, Ltd. 80 percent; Government 20 percent.
Companhia Mineira de Aluminis, Poços de Caldas	27	Aluminum Co. of America, Hanna Mining Co., Minas Gerais State 100 percent.
Surinam:		
Suriname Aluminium Co. (Suralco), 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	208	
EUROPE		
Austria:		
Salzburger Aluminum G.m.b.H. (SAG), Lend, Salzburg	13	Alusuisse.
Vereinigte Metallwerke Ranshofen-Berndorf, A.G. (VMRB), Ranshofen	88	Government.
Total	101	
Czechoslovakia:		
Ziar Aluminium Works, Ziar-on-Hron	72	State owned.
France:		
Compagnie Péchiney:		Péchiney 100 percent.
Auzat, Ariége	22	
Chedde, Haute-Savoie	9	
La Praz, Savoie	4	
L'Argentière, Haute-Alpes	42	
La Saussaz, Savoie	13	
Nogueres, Basses-Pyrénées	123	
Rioupéroux-Isére	26	
St. Jean de Maurienne-Savoie	89	
Sabart-Ariege	26	
Societé d'Electrochemie, d'Electrometallurgie et des Acieries Electriques d'Ugine (Ugine):		Ugine-Kuhlman S.A.
Lannemezan-Haute Pyrénées	58	
Venthon-Savoie	28	
Total	440	
Germany, East:		
Electrochemisches Kombinat:		State owned.
Bitterfeld	55	
Lautawerk	33	
Total	88	

Table 15.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Actual capacity, yearend 1970	Ownership
EUROPE—Continued		
Germany, West:		
Aluminium-Hütte Rheinfelden G.m.b.H., Rheinfelden, Baden	75	Alusuisse.
Vereinigte Aluminium-Werke A.G. (VAW):		Government.
Erftwerke, Grevenbroich	40	
Innwerke, Toging	77	
Lippenwerke, Lunen	55	
Rheinwerke	99	
Gebrueder Giulini G.m.b.H., Ludwigshafen	24	Gebrueder Giulini G.m.b.H.
Total	370	
Greece:		
Aluminium de Grèce S.A. (ADG), Distomon	160	Péchiney 72 percent; Ugine 18 percent; Government 10 percent.
Hungary:		
Magyarsoviet Bauxite Ipar:		State owned.
Ajka	19	
Inota	33	
Tatabanya	17	
Iceland:		
Icelandic Aluminium Co., Hafnarfjordur	49	Alusuisse.
Italy:		
Alcan Alluminio Italiano S.p.A.:		Alcan.
Borgo-Franco d'Ivrea	6	
Montecantini-Edison S.p.A.:		Government 11 percent; Montecantini Edison 89 percent.
Bolzano	66	
Fusina	40	
Mori	26	
Societe Alluminio Veneto per Azioni S.p.A. (SAVA):		Alusuisse.
Fusina	33	
Portó Marghera	31	
Total	202	
Netherlands:		
Aluminium Delfzijl N.V. (Aldel), Delfzijl	93	Hoogovens 50 percent; Alusuisse 33 percent; Billiton 17 percent.
Norway:		
Alnor A/S (Alnor), Karmay Island	99	Harvey 49 percent; Norsk Hydro 51 percent.
A/S Ardal og Sunndal Verk (ASV):		Government 50 percent; Alcan 50 percent.
Ardal	156	
Høyanger	32	
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; Elekem 50 percent.
Søer-Norge Aluminium A/S (Soral), Husnes	76	Alusuisse 100 percent.
Total	634	
Poland:		
Ministry of Heavy Industry:		State owned.
Konin Works (1)	61	
Skawina Works	61	
Romania:		
Slatina	112	State owned.
Tarnaveni	13	
Spain:		
Aluminio de Galicia, S.A. (Alugasa):		
La Coruna	39	
Sabinanego, Huesca	14	Péchiney 66 percent; Endasa 17 percent; Government 17 percent.
Empresa Nacional del Aluminio, S.A. (Endasa):		Government 54 percent; Alcan 25 percent; Spanish interests 21 percent.
Aviles	40	
Valladolid	26	
Total	119	

Table 15.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Actual capacity, yearend 1970	Ownership
EUROPE—Continued		
Sweden:		
A/B Svenska Aluminiumkompaniet (Sako), Sundsvall, Kubikenborg	94	Svenska Metallverken 79 percent; Alcan 21 percent.
Switzerland:		
Swiss Aluminium Ltd. (Alusuisse):		Alusuisse 100 percent.
Chippis	40	
Steg	51	
Usine d'Aluminium Martigny, S.A., Martigny	12	Self 100 percent.
Total	103	
United Kingdom:		
The British Aluminium Co., Ltd. (Baco):		Tube Investments, Ltd., Reynolds Metals Co. 100 percent.
Kinlochleven, Scotland	12	
Lochaber (Ft. William), Scotland	28	
Total	40	
U.S.S.R.:		
Bogoslovsk (Krasnoturinsk), Sverdlovskaya Oblast, Urals	154	State owned.
Bratsk, Irkutskaya Oblast, Siberia	220	
Irkutsk (Shelekhovo), 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	1,578	
Yugoslavia:		
Yogoslovenisk:		State owned.
Kidricevo, Slovenia	55	
Lozovac	7	
Razine	8	
Total	70	
Total Europe	4,529	
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):		Kaiser 90 percent; Reynolds 10 percent.
Tema	121	
Total Africa	182	
ASIA		
China, mainland: Twenty locations	210	
India:		
Aluminium Corp. of India Ltd. (Alucoin), Asansol, West Bengal	10	Self 100 percent.
Hindustan Aluminium Corp. Ltd. (Hindalco), Renn-kott, 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	33	
Alupuram, Kerala	20	
Hirakud, Orissa	24	
Madras Aluminium Co. Ltd. (Malco), Mettur, Madras	28	Montecantini Edison 27 percent; Madras State Government 73 percent.
Total	203	

Table 15.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Actual capacity, yearend 1970	Ownership
ASIA—Continued		
Japan:		
Mitsubishi Chemical Industries, Ltd., Naoetsu	173	Self 100 percent.
Nippon Light Metal Co. Ltd. (NKK):		Alcan 50 percent; Japanese interests 50 percent.
Kambara	123	
Hokkaido (Tomakomai)	64	
Niigata	62	
Showa Denko K. K.:		Self 100 percent.
Chiba (1)	90	
Kitakata	47	
Omachi	46	
Chiba (2)	88	
Sumitomo Chemical Co., Ltd.:		Self 100 percent.
Isoura	64	
Kikumoto	36	
Nagoya	55	
Toyama	62	
Total	910	
North Korea: Three locations	35	
Korea, Republic of: Korean Aluminum Co. (South Korea, Han Kuk), Ulsan	18	Korean interests 100 percent.
Taiwan: Taiwan Aluminium Corp. (Taialco), Kaohsiung Takao)	36	Government.
Total Asia	1,412	
OCEANIA		
Australia:		
Alcan Australia, Ltd., Kurri-Kurri	30	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	81	Kaiser 50 percent; Conzinc Rio Tinto of Australia, Ltd. 50 percent.
Total	210	
Total world	12,046	

Bahrain.—The 120,000-ton-per-year aluminum reduction plant of Aluminum Bahrain Ltd. (Alba) was scheduled to come on stream in April 1971, and to reach full capacity by 1972. The smelter will use Bahrain's ample supplies of natural gas and alumina from Australia. The Bahrain Government provided incentives to the $144 million smelter project, particularly by agreeing to remit profit taxes and customs duties over a 20-year period. When completed, the project will comprise the smelter, a powerhouse with a capacity of 300 megawatts, a factory for the manufacture of anodes, and a cast house. The ownership of Alba was reported as follows:

Company	*Percent owned*
Bahrain Government	19.0
Kaiser Aluminum & Chemical Corp	17.0
General Cable Corp	17.0
Western Metals Corp	8.5
British Metals Corp	17.0
Bretton Investments	9.5
Aktiebolaget Electrokopper	12.0

Brazil.—Brazilian aluminum capacity increased about 60 percent after the Companhia Mineira de Aluminos new 27,000-ton-per-year reduction plant opened at Poços de Caldas. Raw material for the plant comes from the Poços de Caldas bauxite mines; reserves have been reported at 50 million tons. The integrated project also includes a 50,000-ton-per-year alumina plant.

Cameroon, Republic of.—Completion of a dam on the Sanaga River resulted in an increase in production at Compagnie Camerounaise de L'Aluminium Péchiney-Ugine's (Alucam) Edea smelter. Capacity was raised from 50,000 to 58,000 tons per year. The planned installation of additional generators at Edea eventually will permit Alucam to increase production capacity to 61,000 tons per year.

Canada.—On July 13, the United Steelworkers of America went on strike at the

Aluminum Co. of Canada Ltd.'s (Alcan) Kitimat smelter. The work stoppage lasted for 3½ months and involved a production loss of approximately 120,000 tons. Because of a decline in demand for primary aluminum in the world market, Alcan reduced the operating rates of all its Canadian smelters during the year.

The loss of production by Alcan was partially offset by an increase in output at the Baie Comeau plant of Canadian Reynolds Metals Co. Ltd., formerly Canadian British Aluminum Co. Ltd. Capacity of the Baie Comeau smelter was increased from 115,000 to 175,000 tons per year. Reynolds Metals Co. acquired all of the common stock of the Canadian firm.

Congo, Republic of (Kinshasa).—An agreement was reached between Kaiser Aluminum Co. and the Democratic Republic of the Congo for Kaiser to build a 77,000-ton-per-year smelter at Moanda. Construction was expected to start late in the year and production, late in 1973. Power was scheduled to come from the Inga hydroelectric project on the Congo River. Alumina was expected to be supplied by Kaiser's facilities in the Caribbean or Australia.

France.—Compagnie Péchiney and Ugine Kuhlmann, the sole producers of primary aluminum in France, announced the formation of a joint committee to assess the legal and financial conditions necessary for a proposed merger. The object of such a merger would be to increase efficiency, which would be in both companies' interest, in order to cope with North American competition. The final decision on the regrouping, which should be made in 1971 or the beginning of 1972, will entail the formation of a complete primary aluminum monopoly in France. Péchiney interests are strong in aluminum and copper, and Ugine in stainless steel, ferrochrome, and, potentially, nickel.

Germany, West.—Production increased 17.2 percent over the previous year as a result of new smelter operations and expansions at existing plants. However, total consumption of aluminum increased only 1.9 percent in 1970, compared with a growth rate of 27.5 and 17.3 in 1968 and 1969, respectively. Imports of aluminum increased only 2.8 percent compared with 44.5 percent in 1969.

Vereinigte Aluminium-Werke A.G. (VAW) doubled capacity of its Rheinwerke smelter to 99,000 tons per year. Construction began on a third stage to raise annual capacity to 154,000 tons by late 1971.

Gebrueder Giulini G.m.b.H. of Ludwigshafen, which started production in January, had plans to double capacity from 22,000 to 44,000 tons per year by 1973.

Kaiser-Preussag Aluminium G.m.b.H. completed the first stage of its Düsberg smelter. The 71,000-ton-per-year smelter was scheduled to start production in 1971. Construction on a second stage, which would raise annual capacity to 141,000 tons is to be completed in 1973.

Construction was nearing completion on Leichtmetall's G.m.b.H. (LMG), smelter at Essen. The first two potlines, comprising the initial 93,000 tons per year, were expected to come on stream in 1971. Construction on a third line, which would increase capacity to 139,000 tons per year, is due for completion in 1972.

Greece.—According to Péchiney, Aluminium de Grèce S.A. (ADG), a subsidiary of Péchiney, completed expansion at its Distomon smelter. Capacity was increased from 90,000 to 160,000 tons per year.

India.—The new 33,000-ton-per-year smelter of Indian Aluminium Co., Ltd. (Indal), at Belgaum, which began production in 1969, was officially opened late in 1970 and reportedly was operating at capacity. The plant was designed to permit expansion to 110,000 tons per year. Indal converted about 45 percent of its 1970 ingot production into sheet, extrusions, rod, and foil for domestic consumption. India's consumption of aluminum has grown at about 13 percent per year since 1950.[8]

The Bihar State authorities reportedly were considering the construction of an alumina-aluminum complex at Latehar in the Palaman District, based on a local reserve of bauxite, containing over 50-percent Al_2O_3 of about 10 million tons.

Indonesia.—Showa Denko K.K., Nippon Light Metal Co., Ltd. (NKK), and Sumitomo Chemical Co., Ltd., reportedly carried out research on the feasibility of constructing a 220,000-ton-per-year smelter on Bintan Island. According to Nippon Loei Co., the Indonesian Government intended

[8] Metal Bulletin. Another Indian Smelter? No. 5549, Nov. 13, 1970, p. 20.

to construct seven hydraulic power stations, making low-cost electrical power available. Kaiser was reportedly planning to build an aluminum smelter in the same area, and it was possible that the Japanese and American companies would form some type of cooperative arrangement.

Japan.—Despite a slowing of demand growth from an average of 23 percent per year during 1965 to 1969 to an estimated 10 percent during 1970, primary aluminum demand was expected to continue to expand sharply, reaching 1.1 million tons by 1971 and 2.2 million tons by 1975. To meet these demands, Japanese aluminum companies have announced plans to expand production facilities.

Nippon Light Metal reported that the five leading aluminum companies in Japan have formed a new company, Okinawa Aluminum Co., which was expected to start construction of a 55,000-ton-per-year smelter on Okinawa in 1972, to be completed in 1974. In 1971 Nippon was to expand its Tomakomai and Niigata smelters to 143,000 and 158,000 tons per year, respectively. Showa Denko announced that it planned to build two new primary smelters at Oita and Fukupama simultaneously; the ultimate combined capacities would be 550,000 to 660,000 tons per year.

Several Japanese primary aluminum producers are studying the feasibility of establishing aluminum smelters in Ghana and Indonesia.

Mexico.—Mexico's only primary aluminum smelter, Aluminio S.A. de C.V., Vera Cruz, completed the first phase of an expansion program that began in 1969. The addition of 38 new cells, costing $4.6 million, brings the smelter's capacity to 44,000 tons per year. Two more phases of the expansion program include a new potroom, which was expected to increase capacity to 37,000 tons per year in 1973 and 70,000 tons per year in 1975.

A record high output of about 36,000 short tons of primary aluminum at the plant was made possible by increased supplies of electricity from the new Malpaso dam of the Federal Electricity Commission of the State of Chipas.

New Zealand.—In August 1970, the first stage of New Zealand Aluminium Smelters Ltd.'s smelter at Bluff was about half finished. The first stage, which will have a 73,000-ton-per-year capacity, was to be completed in July 1971. Work on the expansion was scheduled to start immediately after that date. The additional capacity, which should be operative in 1972, will increase capacity to 121,000 tons per year. Comalco and Alex Harvey Industries were planning to form two companies for the production of aluminum extrusions, using primary ingot from the Bluff smelter. In addition Comalco was planning to establish semifabricating facilities at Auckland and at Bluff.

Norway.—According to Elkem A/S, 50-percent owner of Mosjøen Aluminumverk A/S (Mosal), capacity at the Mosjøen smelter was increased to 95,000 tons per year. This expansion was the first since the smelter opened. There are no further major expansions planned for the Mosjøen smelter owing to a limited power supply and because construction of Mosal's new 55,000-ton-per-year smelter at Lista was expected to be completed in 1971.

Norsk Hydro is reportedly planning to construct a primary aluminum smelter at Glomfjord. The eventual capacity of the 55,000-ton-per-year smelter will be decided by power availability. The plant was scheduled to begin operations in 1975 or 1976.

According to the annual report of British Aluminium Co. Ltd. (BACO), the company along with VAW, formed a joint company, Vigeland Metal Refinery, A/S, which operates a super-purity refinery at Vigelands. The Vigelands refinery, which planned to raise capacity by 893 tons per year, reached a record output in 1970 of 3,071 tons. Vigeland Metal Refinery also planned to arrange financing for the construction of a new hydroelectric power station to replace the existing power station.

Philippines.—A consortium to construct the first aluminum smelter in the Philippines was expected to formally incorporate early in 1971. Reportedly, Republic Flour Mills and Reynolds International would each hold 40-percent equity; Hooven, 7 percent; and the Private Development Corp. of the Philippines, 13 percent. The smelter reportedly will have a capacity of 44,000 tons per year; production would be targeted mainly for the domestic market. Domestic consumption was about 11,000 tons per year, but expansions planned by major aluminum fabricators may increase demand to over 41,000 tons per year by

1975. Estimated cost of the reduction plant and equipment was $48 million, and according to the Board of Investments, the smelter will have "pioneer" status and therefore will qualify for various investment incentives, including tax exemptions and tariff protection. The smelter site was planned for Iligan City to take advantage of port and water facilities and the power supply of National Power Corp's Maria Christina power plant. Raw materials, including alumina and coke, will be imported.

United Arab Republic.—The Council of the Supreme Soviet ratified an agreement providing for the construction of a 110,000-ton-per-year aluminum smelter at Aswan. Most of the production, which was to begin in 1973, will be exported. The Soviet loan was to be repaid in the form of aluminum.

United Kingdom.—The carbon-baking furnaces of BACO's Invergordon, electrode plant were fired for the first time. The carbon plant will use calcined petroleum coke from the United States for production of anodes and cathodes for the 110,000-ton-per-year smelter, expected to be completed in 1971. The smelter will have 320 cells and each cell will require 18 prebaked anodes, weighing 1,400 pounds apiece. The carbon plant has a capacity of 94,000 tons per year—92,500 tons for the anode blocks and 1,500 tons for the cathode linings of the reduction cells.

Yugoslavia.—East Germany reportedly granted Yugoslavia a 15-year loan for the construction of an aluminum smelter and alumina plant. The 55,000-ton-per-year smelter was to be located at the Adriatic port of Sibenik. The smelter was scheduled for completion in 1973 and the 331,000-ton-per-year alumina plant, in 1975.

TECHNOLOGY

Technological progress in the commercial secondary aluminum industry, was reviewed in detail by the Bureau of Mines.[9] Secrecy among competing firms in the secondary aluminum industry, prior to the 1950's was the chief cause of technological inertia in the processing, smelting, and use of secondary aluminum. Significant technological progress in processing and mining aluminum scrap was confined largely to the two decades between 1950 and 1970.

In addition to improved methods of collecting and handling aluminum scrap developed during, that period, maximum capacity of reverberatory furnaces used for smelting aluminum scrap was increased from about 30,000 pounds, to 180,000 pounds, which appears to be about the maximum economic scale. The salvaging of drosses and skimmings from smelting aluminum became a universal practice in all but the smallest operations. The first molten (hot metal) aluminum from a secondary smelter was shipped in 1964. Oxygen melting to increase the speed of production of secondary aluminum was developed in 1965.

Other innovations in quality control, equipment to prevent air pollution, and nitrogen agitation to reduce metal losses when melting foil or trimmings and borings were also initiated since 1950. Development of a pump to circulate molten metal appeared to be on the threshold of successful development in 1970.

The Bureau of Mines also assessed the feasibility of using lignite in place of petroleum coke in anodes for alumina electrolysis.[10] Anodes made from lignite pitch and commercial petroleum coke exhibited satisfactory performance in a small alumina reduction cell. However, the rate of carbon consumption was a few percentage points higher than for anodes made entirely of commercial materials, and the resistivity and compressive strength of the experimental anodes were somewhat inferior.

The current efficiency of two aluminum smelters, which utilize self-baking vertical stud soderberg electrodes, was increased during a 5-year period from a range of 82 to 85 percent to a range of 87 to 90 percent, by changing the operating condition of the individual cells.[11] The cell conditions, which were found to have the greatest effect on current efficiency were the

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[9] Work cited in footnote 2.

[10] Cammarota, V. A., Jr., and David Schlain. Anode Materials for Alumina Reduction: Evaluation of Lignite as a Carbon Source. BuMines Rept. of Inv. 7370, 1970, 45 pp.

[11] Kent, J. H. The Attainment of High Current Efficiency on Aluminum Reduction Furnaces by a Cold-Running Technique. J. Metals, v. 22, No. 11, November 1970, pp. 30–36.

need for a stationary metal pad, low operating temperature, and a proper ridge (frozen electrolyte on the walls of the cathode). The report stated that no automated system to control aluminum furnaces could be envisioned in the current state of the art that would obviate the need for reduction cell operators with experience in the described control techniques.

According to a report, the application of the computer to control alumina reduction cells has been attempted by most aluminum companies. Some have had success, but others have abandoned such systems.[12] The report suggests that the counterelectromotive force might serve as a means of early detection of anode problems.

The convection pattern in the electrolyte of alumina reduction cells was studied by using radioactive tracers.[13] Circulation rates of up to 100 centimeters per second were observed, and about 10 centimeters per second appeared to be the average rate. The study indicated that the less turbulent the convection, the lower the rate of reoxidation of aluminum will be, which decreases the current efficiency. Carbon particles, floating in the bath, reportedly increase the resistance of the bath and are concentrated in certain areas by the convection pattern, causing uneven anode consumption.

About 30 to 40 pounds of fluorine, in the form of gaseous compounds such as hydrogen fluoride or as particulate matter, are evolved from alumina reduction cells for each ton of aluminum produced. Modern plants achieve about 95-percent efficiency in removing the fluorine from the gases evolved from the cell before they are expelled to the atmosphere. The chemistry of the evolution and recovery of fluoride emissions from aluminum reduction cells was discussed in a report.[14]

Particulate matter and fluoride gases are removed by water scrubbers, sometimes in combination with electrostatic precipitators or by centrifugal precipitators, followed by water scrubbers. Materials obtained in the electrostatic and centrifugal precipitators can be returned directly to the electrolytic cells, but the fluorine compounds absorbed in water scrubbing operations are difficult to recycle. The report briefly describes a patented method of passing the cell gases through a fluidized bed of the alumina feed to the cell, whereby essentially all of the fluorides are recovered and recycled.[15]

One way to avoid the problem of flouride emissions from alumina reduction cells was investigated on a laboratory scale by the Bureau of Mines. Aluminum was deposited at 700° to 760° C from a molten bath of aluminum, sodium, and potassium chlorides.[16] The small, single-compartment, experimental cell was operated continuously for a period of 4½ months. Anode current efficiencies of 83 to 85 percent were attained. Most of the problems encountered in the operation of the cell were associated with construction materials and internal heating, which was required because of the small size of the cell.

Employment of electrochemical machining of the cylinder bores and development of a four-step process for coating pistons made possible the use of aluminum engine blocks for a light, four-cylinder automobile, produced by the Chevrolet Division of General Motors Corp.[17] The cylinder walls of the cast aluminum block, containing 17 percent silicon, were electrochemically machined, exposing the hard wear-resistant silicon phase of the alloy. The pistons, which also are of cast aluminum alloy, are given thin coatings of zinc, copper, iron, and tin.

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[12] Lewellyn, W. F. Determination of the Counter Electromotive Force of Operating Aluminum Reduction Cells. J. Metals, v. 22, No. 7, July 1970, pp. 57–59.

[13] Grjotheim, K., C. Krohn, R. Naeumann, and K. Tørklep. On Convection in Aluminum Reduction Cells. Trans. Met., v. 1, No. 11, November 1970, pp. 3133–3141.

[14] Cochran, C. N., W. C. Sleppy, and W. B. Frank. Fumes in Aluminum Smelting: Chemistry of Evolution and Recovery. J. Metals, v. 22, No. 9, September 1970, pp. 54–57.

[15] Knapp, Lester L., and C. C. Cook (assigned to Aluminum Co. of America). Treatment of Gases Evolved in Producing Aluminum. U.S. Pat. 3,503,184, Mar. 31, 1970.

[16] Kirby, D. E., E. L. Singleton, and T. A. Sullivan. Electrowinning Aluminum From Aluminum Chloride. BuMines Rept. of Inv. 7353, March 1970, 24 pp.

[17] Patton, W. G. How Aluminum Engines Are Made. Iron Age, v. 205, No. 22, May 28, 1970, pp. 104–105.

Antimony

By Charlie Wyche [1]

Domestic production of primary antimony increased significantly in 1970. This resulted from record high prices and large imports of antimony-containing lead ores and concentrates. Although prices dropped later in the year, at yearend they were still more than double those at the beginning of 1969. The high price level induced reopening of domestic mines, and upgrading the deposits for salable ore. In addition, companies in Idaho, Montana, Alaska, and Nevada made plans for production at previously uneconomical antimony deposits. Output from these deposits, added to that of the Sunshine Mining Co., increased domestic mine production to the highest level since the Korean war.

Hugh antimony prices and the decrease in antimony content of storage batteries resulted in a decline in the consumption of primary antimony in 1970 compared with 1969. The decrease from 11 percent to 4 percent antimony content for the antimonial lead battery alloy also resulted in a decrease in the output of byproduct antimony.

Legislation and Government Programs.—Effective January 1, 1970, the "General Modification of Tariff Schedules of the U.S.," Federal Register Document 67–14749, filed on December 18, 1967, reduced the import duty on antimony metal, TSUS No. 632.02, from 1.5 cents to 1.4 cents per pound, and on liquated antimony, TSUS No. 603.10, from 0.20 cents per pound to 0.1 cent per pound. Further tariff reductions are scheduled for the metal each year through 1972.

The quantity of stockpiled antimony available for disposal was exhausted in 1969. However, revision of the stockpile objective by the Office of Emergency Preparedness in April from 50,500 short tons to 40,700 short tons resulted in an excess of about 6,000 short tons of antimony. The General Services Administration proposed legislative disposal authorization for the antimony metal in excess of the objective, but by yearend no action had been taken by the Congress, and therefore no stockpile disposals occurred.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production increased 17 percent over that of 1969 and reached the highest level since 1952. Production was again confined almost entirely to the Sunshine Mining Co., Coeur d'Alene district, Idaho, where impure antimony metal was recovered as a byproduct of processing silver-lead-copper ore. Silver ores from the Sunshine mine, ores from associated companies, and custom ores from other mills were the source for the metal. Sunshine's total production increased approximately 5 percent above the 901 tons produced in 1969. The firms new plant, scheduled to start operating in January, was delayed in opening until April owing to the failure of some equipment to arrive on schedule. Output from the new plant was expected to double production.

Antimony concentrates containing about 63 tons of antimony were produced at the Stampede mine in Alaska. The Stibnite mine, Sanders County, Mont., although idle in 1969, started production of antimony metal in 1970. Ranchers Exploration in Idaho, and Agau Mines in Montana made plans for regular production from previously uneconomical antimony deposits. Approximately 46 tons of antimony contained in concentrates and ore was shipped from mines in Nevada to the Laredo, Tex., smelter.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient antimony statistics

(Short tons)

	1966	1967	1968	1969	1970
United States:					
Production:					
Primary:					
Mine	927	892	856	938	1,130
Smelter [1]	14,539	12,466	12,489	13,203	13,381
Secondary	24,258	23,664	23,699	23,840	21,424
Exports of ore, metal and alloys	29	82	109	207	543
Imports, general (antimony content)	19,712	17,419	17,343	17,032	18,654
Consumption [1]	19,681	17,350	18,520	17,843	13,937
Price: New York, average cents per pound	45.75	45.75	45.75	57.57	144.19
World: Production	67,627	63,565	67,628	73,044	73,152

[1] Includes primary antimony content of antimonial lead produced at primary lead refineries.

SMELTER PRODUCTION

Primary.—The total smelter output of antimony products from primary material in 1970 amounted to 13,381 short tons. This figure is slightly above the 13,203 tons produced in 1969. Smelter production was obtained from the following primary sources: 13 percent from domestic mine production of antimony concentrate and as a byproduct at domestic lead smelters, and 87 percent from foreign antimony ores and base metal ores. Antimony recovered as a lead-smelter byproduct represented 8 percent of the total primary antimony production. Approximately 94 percent of the byproduct antimony produced at primary lead smelters was consumed at the smelter in the manufacture of antimonial lead; the remainder was processed to oxide. The types of material produced by the smelters follow: Metal, 28 percent; oxide, 62 percent; antimonial lead, 7 percent; ground residue and sulfide for reprocessing, 3 percent. Antimony metal was produced by NL Industries, Inc., (formerly National Lead Co.) and Sunshine Mining Co. Oxide was produced by American Smelting and Refining Co., Harshaw Chemical Co., McGean Chemical, M & T Chemicals Inc., and NL Industries. Byproduct antimonial lead was produced at lead refineries operated by American Smelting and Refining Co, the Bunker Hill Company, St. Joseph Minerals Corporation (formerly St. Joseph Lead Co.) and United States Smelting Lead Refinery, Inc.

Secondary.—The antimony recovered from secondary sources decreased from 23,840 tons in 1969 to 21,424 tons in 1970. Secondary smelters recovered 20,480 tons, primary smelters recovered 203 tons, and manufacturers and foundries recovered the remaining 741 tons. Antimony from old scrap represented 87 percent of the total secondary output and consisted of the following: Batteries, 68 percent; type metal, 20 percent; babbitt, 6 percent; and all other material, 6 percent. New scrap in the form of residues and drosses resulting

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate (quantity)	Antimony Produced	Antimony Shipped
1966	5,582	927	930
1967	5,402	892	828
1968	5,263	856	941
1969	5,707	938	943
1970	6,681	1,130	1,029

Table 3.—Primary antimony produced in the United States

(Short tons, antimony content)

Year	Class of material produced: Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1966	4,567	7,794	126	219	1,833	14,539
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

from manufacturing and casting totaled 2,809 tons, or 13 percent of the total secondary smelter output. The antimony content of scrap is usually recovered and consumed as antimonial lead with removal or addition of antimony as required in the refining stage to meet specifications for various antimonial lead alloys. Approximately 2,465 tons of primary antimony was used in 1970 to supplement the secondary antimony supply at secondary smelters and foundries.

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1969	1970	Form of recovery	1969	1970
New scrap:			In antimonial lead [1]	17,948	16,002
Lead-base	2,860	2,761	In other lead alloys	5,879	5,412
Tin-base	62	48	In tin-base alloys	13	10
Total	2,922	2,809	Total	23,840	21,424
			Value (millions)	$27.4	$61.8
Old scrap:					
Lead-base	20,893	18,596			
Tin-base	25	19			
Total	20,918	18,615			
Grand total	23,840	21,424			

[1] Includes 179 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1969 and 203 tons in 1970.

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
1966	24,059	1,417	416	286	2,119	8.8
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

[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

Industrial antimony requirements for various end product uses were supplied from both secondary and primary sources. Total consumption was 35,361 tons, down considerably from the 41,683 tons consumed in 1969. Primary antimony contributed 13,937 tons to the total consumption, and secondary antimony 21,424 tons. Practically all secondary antimony was consumed in the manufacture of antimonial lead and other hard-lead alloys. Information on secondary antimony consumption is not reported by the Bureau of Mines.

Consumption of primary antimony decreased about 21 percent in comparison with 1969. Total demand for antimony metal and compounds declined 25 percent and 19 percent, respectively, in both metal and nonmetal products. In all categories the requirements for antimony metal and compounds declined. Antimony metal requirements, principally as an ingredient in lead alloys, experienced the most drastic decline (22 percent) since 1958. This sharp decline was attributed largely to a reduction in the antimony content of battery alloys, which resulted from the high antimony prices during 1970. Metallurgical usages of primary antimony metal in bearing, type, and cable covering were also down sharply.

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	
1966	450	6,269	10,829	81	219	1,833	19,681
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

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1966	1967	1968	1969	1970
METAL PRODUCTS					
Ammunition	154	209	156	115	102
Antimonial lead	6,285	5,539	6,817	6,723	5,246
Bearing metal and bearings	731	653	755	758	481
Cable covering	164	141	178	55	38
Castings	62	54	46	33	16
Collapsible tubes and foil	44	31	50	56	35
Sheet and pipe	107	118	105	105	77
Solder	155	184	255	242	286
Type metal	515	382	423	541	220
Other	219	223	258	137	73
Total	8,436	7,534	9,043	8,765	6,574
NONMETAL PRODUCTS					
Ammunition primers	27	30	33	37	27
Fireworks	50	43	37	30	17
Flameproofing chemicals and compounds	3,188	3,454	2,774	2,096	1,710
Ceramics and glass	2,074	1,884	2,037	2,108	1,820
Pigments	832	665	859	722	610
Plastics	2,224	1,785	2,318	2,558	1,667
Rubber products	870	948	440	433	519
Other	1,980	1,007	979	1,094	993
Total	11,245	9,816	9,477	9,078	7,363
Grand total	19,681	17,350	18,520	17,843	13,937

In nonmetal products, antimony consumption dropped about 400 tons in flameproofing chemicals alone. Large declines in antimony usage also occurred in the ceramics and glass and pigment industries. Antimony used in nonmetal products, basically as antimony oxide, represented 51 percent of the primary antimony consumed. The predominant uses were as fire-retardant compounds for textiles and plastics, and opacifying agents for ceramics and glass. In 1970 approximately 5,200 tons were used, or 23 percent less than the quantity used in 1969. A total of 993 tons of antimony was consumed in "other" nonmetal products. Of this total, nearly 40 percent was used as sodium antimonate as an opacifier in enamel frit. Additionally, antimony chloride was used in a wide range of applications and comprised 24 percent of the total used in "other" nonmetal products.

The data indicate consumer resistance to the high price level of 1970. Because of these high prices, users were forced to seek substitutes or supplements for antimony in flame retardants and antimonial lead alloys.

STOCKS

Industrial stocks of primary antimony increased in each of the last three quarters of 1970 to a total of 8,847 tons at yearend, the largest stocks reported since 1955. This increase represented a gain of 2,508 tons above the 1969 level. Ore and concentrate stocks of 2,973 tons were well above the 1969 total. Stocks of residues and slags more than tripled during the year. All other stocks except antimony sulfide were above the 1969 level.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1966	1967	1968	1969	1970
Ore and concentrate	2,720	2,469	2,791	2,227	2,973
Metal	1,572	1,719	1,323	1,273	1,598
Oxide	3,093	2,704	1,921	2,053	2,932
Sulfide	131	80	127	108	39
Residues and slags	519	916	199	307	948
Antimonial lead [1]	531	462	265	371	357
Total	8,566	8,350	6,626	6,339	8,847

[1] Inventories from primary sources at primary lead refineries only.

PRICES

Prices of antimony ore, metal, and compounds in early 1970 reached an alltime high, a result of short supply and high worldwide demand for antimony. The upward trend, however, was reversed in April and prices dropped sharply with the announced expansion in ore supply and the expectation of sales from Government stockpiles. Antimony ore was priced at $40 per short-ton unit for 60 percent lump ore in the European market in early April but dropped to around $17 at yearend. No quotation was listed for domestic ores in 1970. Antimony metal on the domestic market was priced at $1.76 per pound in March 1970 and stayed at that price through early August, but by yearend the price had dropped to 96 cents per pound. The free market antimony metal price was $4 per pound in early 1970 but was 90 cents per pound at the end of 1970. Antimony oxide was $1.70 per pound in midyear but had receded to $1 per pound at yearend.

Table 9.—Antimony price ranges in 1970

Type of antimony	Price, per pound
Domestic metal [1]	$0.96–1.76
Foreign metal [2]	.80–4.00
Antimony trioxide [3]	.975–1.70

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in Metals Week.

FOREIGN TRADE

Antimony exports in 1970 totaled 978 tons, of which 435 tons was oxide, and 543 tons was in the form of metal alloys, scrap, and waste. The total value of $1,135,253 was approximately four times the 1969 value. The oxide exported was more than twice the 1969 total, and alone had a value of $500,846. Of the 21 countries that imported antimony, antimony alloys, waste, and scrap, the Netherlands, Republic of Korea, and Japan, in descending order of importance, received over 55 percent of the total. Belgium-Luxembourg, France, and Austria received over 60 percent of the total oxide exported.

Imports of various antimony materials totaled 18,654 tons compared with 17,032 tons in 1969. Imports of ore and concentrates increased 42 percent, and metal imports were about 25 percent above the 1969 level. Oxide imports, however, declined approximately 10 percent. The Republic of South Africa was the largest ore and concentrate supplier with about 45 percent of the total. Mexico, Bolivia, and Guatemala contributed 26 percent, 15 percent, and 9 percent, respectively. Mexico and the United Kingdom supplied 52 percent of the total metal. Yugoslavia, Japan, Belgium-Luxembourg, and Argentina were the other significant sources in 1970. The United Kingdom supplied 67 percent of the oxide, and France and Belgium supplied practically all the remainder.

Imports of 210 tons of alloy containing 83 percent or less antimony represented a decline of about 49 percent compared with 1969. This alloy was obtained from the United Kingdom, Turkey, and Japan and had a total value of $460,497.

Table 10.—U.S. imports for consumption of antimony, by countries

Year and country	1969			1970		
	Short tons (gross weight)	Short tons (antimony content)	Value (thousands)	Short tons (gross weight)	Short tons (antimony content)	Value (thousands)
Antimony ore:						
Bolivia	4,431	2,802	$1,618	3,565	2,162	$4,415
Canada	------	------	------	21	7	8
Chile	65	52	17	96	42	70
Colombia	------	------	------	13	5	7
Ecuador	------	------	------	30	14	21
Guatemala	95	47	18	2,502	1,244	254
Honduras	203	81	36	981	367	151
Mexico	8,541	2,265	383	16,799	3,666	1,840
Morocco	21	8	4	112	50	124
Peru	366	217	126	14	6	10
South Africa, Republic of	10,436	6,626	3,046	10,242	6,239	5,789
Thailand	------	------	------	35	14	38
United Kingdom	------	------	------	5	4	6
Total	24,158	12,098	5,248	34,415	13,820	12,733
Antimony metal including needle or liquated: [1]						
Argentina	28	------	34	74	------	75
Belgium-Luxembourg	218	------	237	83	------	408
Bolivia	35	------	27	24	------	21
Canada	1	------	28	1	------	31
Chile	------	------	------	10	------	43
France	------	------	------	45	------	248
Germany, West	(2)	------	8	(2)	------	17
Italy	------	------	------	58	------	181
Japan	------	------	------	95	------	191
Mexico	181	------	97	377	------	565
Netherlands	------	------	------	34	------	67
Peru	14	------	11	------	------	------
Spain	------	------	------	18	------	65
Switzerland	55	------	69	------	------	------
Thailand	43	------	30	39	------	93
Turkey	------	------	------	33	------	213
United Kingdom	269	------	232	317	------	942
Yugoslavia	198	------	166	100	------	387
Total	1,042	(3)	939	1,308	(3)	3,547
Antimony oxide:						
Belgium-Luxembourg	896	------	786	258	------	1,031
Canada	4	------	5	------	------	------
France	846	------	755	984	------	2,669
Germany, West	20	------	15	62	------	217
Japan	122	------	87	75	------	304
Mexico	1	------	1	------	------	------
Netherlands	48	------	39	------	------	------
Switzerland	------	------	------	(2)	------	(2)
United Kingdom	2,778	------	2,164	2,877	------	5,802
Total	4,715	(3)	3,852	4,256	(3)	10,023

[1] Includes needle or liquated (value in thousands), as follows: 1969—Belgium-Luxembourg 39 tons ($33), United Kingdom 23 tons ($18); 1970—Belgium-Luxembourg 3 tons ($8), United Kingdom 15 tons ($46). 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: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Needle or liquated: Short tons (gross weight)	Needle or liquated: Value (thousands)	Antimony metal [1]: Short tons (gross weight)	Antimony metal [1]: Value (thousands)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1968	21,677	10,614	$4,145	60	$42	2,693	$2,037	4,801	$3,540
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

[1] Does not include alloy containing 83 percent or more of antimony, as follows: 1968—Mexico 193 short tons ($157,102), Peru 351 short tons ($230,845), United Kingdom 87 short tons ($55,894), France 24 short tons ($14,528), Japan 59 short tons ($35,345); 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).

WORLD REVIEW

The world supply-demand condition for antimony was greatly unbalanced at the beginning of 1970, as worldwide demand continued to rise at the spectacular pace of 1969. Demand exceeded supply in all major consuming countries. This unevenness was caused primarily when mainland China, the Far East's major supplier of antimonial products, withdrew from the market, and some of the eastern European countries turned to the West for antimony. This unexpected demand, coupled with the already over-extended Western suppliers' operations, created an unprecedented shortage of antimony. The shortage touched off heavy buying, which aggravated the situation and resulted in rapid increases in antimony prices.

High ore prices stimulated interest in low-grade antimony deposits throughout the world. The Australian Antimony Corp., started extracting ore from its mine at Wild Cattle Creek, near Dorrigo, New South Wales, at a rate of 4,000 to 5,000 tons per year. The Dorrigo mine was expected to have a life of about 8 years, on the basis of reserves of 530,000 tons. An antimony expansion program was being planned by Great Northern Corp. and Nuttall Holdings. Plant facilities were to be enlarged to enable it to process some 250,000 tons of ore per year.

As the year progressed consumer resistance developed with the result that lower, more normal prices prevaided. Consumers curtailed purchasing and reduced inventories in expectation of lower prices. Some substitution of alternate materials for antimony inevitably took place as a result of the unusually high prices. Because of these factors and the reduced demand for antimonial lead, output from the Republic of South Africa and Bolivia, the main sources of premium ores, declined slightly. Consolidated Murchison Goldfields and Development Co. Ltd., South Africa, produced 31,000 tons of concentrates and cobbed ore, compared with 32,600 tons in 1969. Production in Bolivia decreased from 14,484 tons of antimony metal in 1969 to 12,724 tons in 1970. Mexican production, principally ore for smelting at Laredo, Tex., totaled 4,925 tons, an increase of 1,368 tons from 1969 production. Spain, Italy, Morocco, Thailand, and Australia also increased output, but production was down in Yugoslavia, Burma, Canada, and Austria.

Table 12.—Antimony (content of ore except as indicated): World production by countries
(Short tons)

Country	1968	1969	1970 p
North America:			
Canada [1]	580	410	308
Guatemala	10	110	e 100
Honduras	286	125	e 100
Mexico [2]	3,819	3,557	4,925
United States	856	938	1,130
South America:			
Bolivia [2]	12,276	14,484	12,724
Peru (recoverable) [2]	900	944	660
Europe:			
Austria (recoverable)	775	687	672
Czechoslovakia e [3]	660	660	660
Italy	865	1,272	1,381
Portugal	55	50	e 50
Spain	146	135	142
U.S.S.R. e	7,200	7,300	7,400
Yugoslavia (metal)	r 2,929	2,278	e 2,200
Africa:			
Algeria	60	66	e 60
Morocco	1,336	1,551	2,175
South Africa, Republic of	18,514	20,080	18,841
Asia:			
Burma [2]	r 61	63	50
China, mainland e	r 13,000	13,000	13,000
Japan	21	6	20
Korea, South	34	e 30	e 30
Pakistan e	93	NA	NA
Malaysia (Sarawak)	25	43	e 40
Thailand	223	827	2,598
Turkey [4]	r 1,973	3,495	3,053
Oceania: Australia [5]	931	933	833
Total [6]	r 67,628	73,044	73,152

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Content of smelter products.
[2] Content of antimonial lead.
[3] Figures reported in previous issues were estimated metal output, including metal derived from imported Turkish ores.
[4] Content of ore and concentrates.
[5] Includes antimony in lead concentrates.
[6] Totals are of listed figures only.

TECHNOLOGY

The Material Science Division at the Sandia Laboratories, Livermore, Calif., published results of recent research concerned with methods of increasing the hardness and strength of electroformed lead alloys.[2] The study revealed that sound, thick, lead-antimony alloys can be obtained from fluoborate solutions, and that these alloys are harder and have higher tensile strengths than pure lead. During the study it was found that as the antimony concentration of the electrolyte increased, the antimony content of the deposited alloy also increased. The work also showed that for a specific electrolyte composition, an increase in current density or a decrease in temperature lowered the antimony concentration of the alloy deposit.

An investigation was conducted of the yttrium-antimony system covering the complete composition range.[3] An yttrium-antimony phase diagram was postulated which consisted of an inverse peritectic reaction, two eutectic reactions, and four intermetallic compounds. The result of research on the solidification of undercooled Pb-Sb system was reported.[4]

A U.S. patent was issued in 1970 relative to a process for smelting oxide ores of antimony in a shaft furnace.[5] The ore-coke ratio is substantially increased, and the rate at which the charge is consumed is accelerated by supplying tuyere burners with streams of fuel comprising hydrocarbon fluid surrounded by high-velocity streams of commercially pure oxygen.

[2] Dini, J. W., and J. R. Helms. Electrodeposition of Lead-Antimony Alloys. J. Electrochem. Soc., v. 117, February 1970, pp. 269–272.
[3] Schmidt, F. A., and O. D. McMasters. Yttrium Antimony Alloy System. J. Less-Common Metals, v. 21, No. 4, August 1970, pp. 415–425.
[4] Powell, G. L. F., and G. A. Colligan. Met. Trans., v. 1, No. 2, February 1970, pp. 269–272.
[5] Gray, B. G. (assigned to Air Reduction Co.) U.S. 3,547,624, Dec. 15, 1970.

Asbestos

By Robert A. Clifton [1]

The production (shipments) of asbestos in the United States decreased less than 1 percent from the record high of 1969. The continuation of the tight money market and high interest rates further depressed the home building industry and lessened the demand for asbestos. In 1970 imports were 93 percent of the 1969 level.

The free world's largest producer, Canada, shipped 7 percent less in quantity to its largest market, the United States, but total shipments for the year were over 5 percent more than in 1969.

Legislation and Government Programs.—The Clean Air Act of 1970 required Health, Education and Welfare to publish lists of hazardous air pollutants. Asbestos was among the three substances named on the first list. In 1970 the General Services Administration (GSA) reduced the government inventories by disposing of 1,326 short tons of amosite, 2,802 tons of crocidolite, and 654 tons of chrysotile.

[1] Chemist, Division of Nonmetallic Minerals.

Table 1.—Salient asbestos statistics

	1966	1967	1968	1969	1970
United States:					
Production (sales) short tons	125,928	123,189	120,690	125,936	125,314
Value thousands	$11,056	$11,102	$10,406	$10,648	$10,696
Exports and reexports (unmanufactured) short tons	46,996	47,718	41,236	36,173	46,585
Value thousands	$5,763	$6,025	$4,679	$4,979	$6,996
Exports and reexports of asbestos products (value) thousands	$21,963	$23,767	$24,527	$28,183	$25,391
Imports for consumption (unmanufactured) short tons	726,459	645,112	737,909	694,558	649,402
Value thousands	$73,100	$65,743	$72,930	$76,422	$75,146
Consumption, apparent [1] short tons	805,391	720,583	817,363	784,321	728,131
World: Production do	3,275,262	3,207,259	3,315,303	3,640,017	3,826,238

[1] Measured by quantity produced, plus imports, minus exports.

Table 2.—Stockpile objective and Government inventories as of December 31, 1970

(Short tons)

Mineral	Stockpile objective	Inventories			
		National	Supplemental	Defense Production Act	Total
Amosite	40,000	11,705	50,657	---	62,362
Chrysotile	13,700	6,174	7,378	502	14,054
Subspecification	---	115	2,494	502	3,111
Crocidolite	---	1,565	41,232	---	42,797

DOMESTIC PRODUCTION

United States mines produced nearly as much asbestos in 1970 as in 1969. The value increased slightly. Only four states produced asbestos. California, with 63 percent, was the leader followed in order by Vermont, Arizona, and North Carolina.

Califomia production increased 4 percent in 1970 to 78,966 short tons, and the value increased by $375,740. Quantity and value of the Vermont production decreased by 9 percent. Arizona production increased slightly, and that in North Carolina increased by 6 percent. The largely short fiber domestic production met 17 percent of the U.S. requirements. U.S. asbestos producers and mine sites are as follows:

State and company	County	Name of mine	Type of asbestos
Arizona:			
Asbestos Manufacturing Co	Gila	Phillips	Chrysotile.
Jaquays Mining Corp	do	Chrysotile	Do.
Metate Asbestos Corp	do	Lucky Seven	Do.
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.
Vermont:			
GAF	Orleans	Lowell	Chrysotile.

CONSUMPTION AND USES

There are literally thousands of direct and indirect uses for asbestos, but the major portion goes to only a few applications. Chief among these are asbestos cement building materials and asbestos cement pipe, which uses an estimated 70 percent of the world's production.[2] The next largest using domestic industry was floor tile where 1970 consumption was an estimated 10 percent of the total U.S. production. Other products using significant amounts of asbestos were brake linings, gaskets, clutch facings, plastics, roofing compounds, electrical and heat insulations, and textiles.

The continued slow down in the building and construction industries resulted in an apparent consumption in 1970 that was only 93 percent of that in 1969. Most of the asbestos consumed was chrysotile, which accounted for more than 96 percent of the domestic consumption. Amosite, crocidolite, and anthophyllite accounted for the remainder.

PRICES [3]

Quoted prices for Quebec and Vermont asbestos were increased approximately 3 percent effective January 1, 1970. The increases were not abnormal in an inflationary economy, but the price of British Columbia and Arizona asbestos remained unchanged.

[2] Industrial Minerals (London). No. 28, January 1970, p. 12.
[3] Asbestos. V. 51, No. 8, February 1970, p. 54.

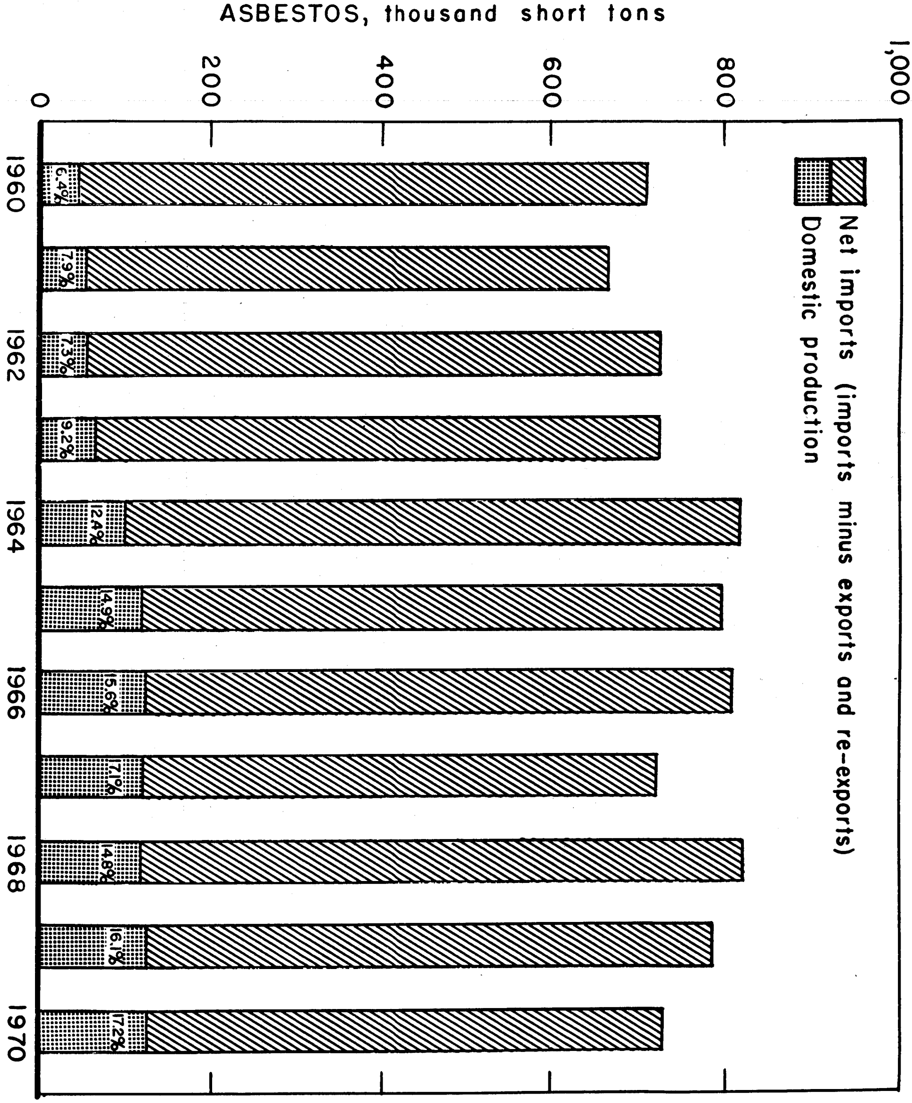

Figure 1.—Domestic consumption of asbestos.

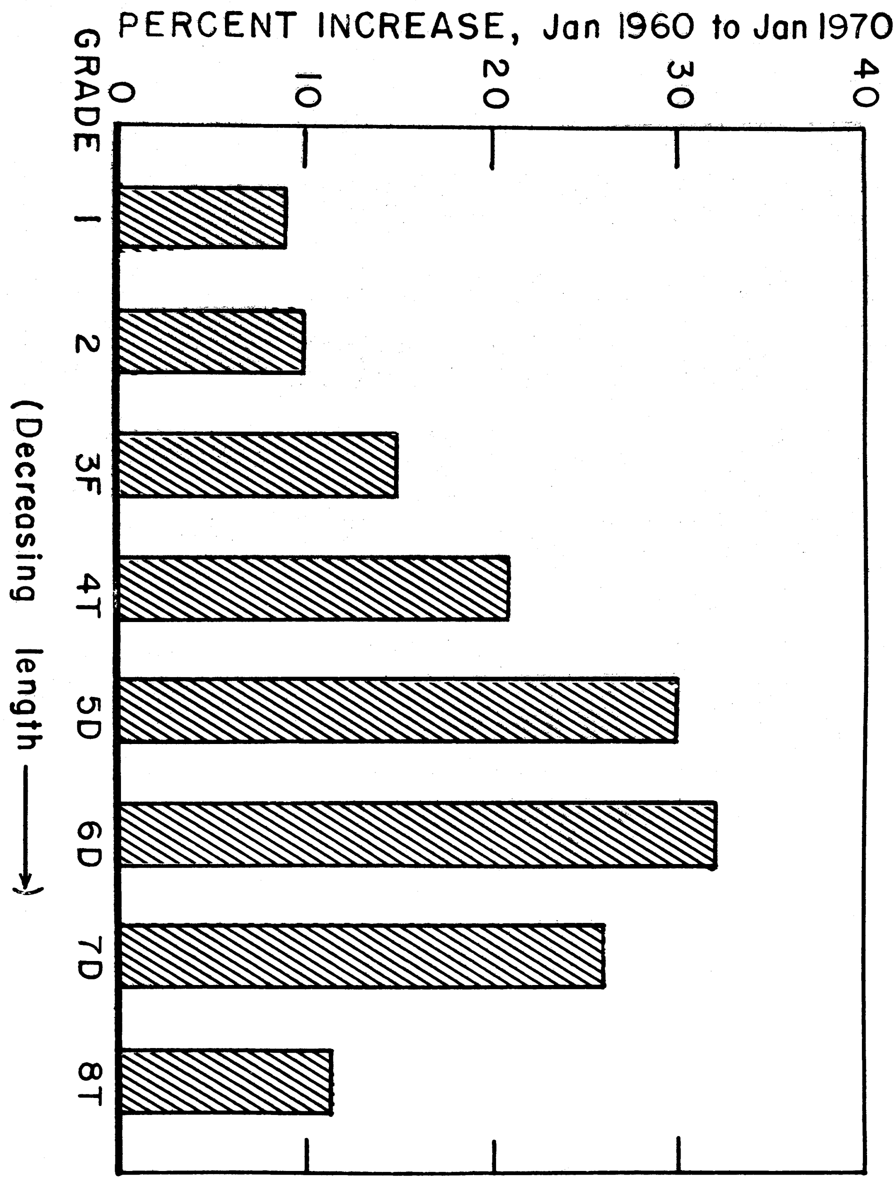

Figure 2.—Price increase by grade.

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 January 1, 1971, Vermont chrysotile asbestos, f.o.b. Morrisville, was priced as follows:

Grade	Description	Per short ton
Group No. 3	Spinning and filtering	$366.50–393.50
Group No. 4	Shingle fiber	201.00–341.00
Group No. 5	Paper fiber	145.00–170.00
Group No. 6	Waste, stucco or plaster fiber	105.00
Group No. 7	Shorts and floats	48.00– 87.50

Quotations for Canadian (Quebec) chrysotile, f.o.b. mine, were as follows, as of January 1, 1970:

Grade	Description	Per short ton
Group No. 1	Crude	Can$1,525
Group No. 2	do	825
Group No. 3	Spinning fiber	397-650
Group No. 4	Shingle fiber	218-369
Group No. 5	Paper fiber	157-184
Group No. 6	Waste, stucco or plaster	114
Group No. 7	Refuse or shorts	48- 95

Prices for British Columbia, Canada, chrysotile asbestos have remained unchanged since January 1, 1969. Quotations, f.o.b. Vancouver, were as follows:

Grade	Description	Per short ton
AAA	Nonferrous spinning fiber	Can$845
AA	do	673
A	do	508
AC	Asbestos cement fiber	363
AK	Shingle fiber	249
CP	do	234
AS	do	217
CT	do	211
AX	do	193
CY	do	136
AY	do	136

Private negotiated sales are the African asbestos producers' modus operandi. Because 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		
	1968	1969	1970
Amosite	$149	$153	$160
Crocidolite	193	189	196
Chrysotile	194	192	198

Figure 2 drawn from calculations on pertinent data,[4] shows clearly that the increased demand and greater price increases have gone to the asbestos used in cement products (groups 5–7).

[4] Industrial Minerals (London). No. 28, January 1970, pp. 9–29.

FOREIGN TRADE

Exports of asbestos products manufactured in the United States declined by 10 percent from the values of those exported in 1969. Five of the nearly one hundred countries buying these products accounted for more than half of the foreign sales. They were Canada (33 percent), West Germany (8 percent), United Kingdom (5 percent), Venezuela (4 percent), and Australia (3 percent).

In 1970 the United States imported 83 percent of its asbestos needs. This was a statistical improvement in U.S. self-sufficiency over the 84 percent of 1969, but only because of lessened demand. Canada provided more than 94 percent of the imports; the Republic of South Africa, a little over 4 percent; and 12 other countries, the remainder. Chrysotile, with more than 96 percent, dominated the imported types. There was a slight decrease in the value of the imported fibers. The Rhodesian values in table 4 do not indicate a 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	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
EXPORTS				
Unmanufactured:				
Crude and spinning fibers short tons	1,419	$314	4,300	$930
Nonspinning fibers do	14,407	2,274	12,477	1,961
Waste and refuse do	18,696	2,038	21,458	2,449
Total do	34,522	4,626	38,235	5,340
Products:				
Gaskets and packing do	2,519	6,917	2,546	6,964
Brake linings do	4,519	6,804	3,787	5,576
Clutch facings, including linings number	3,749,035	2,966	2,557,694	1,926
Textiles and yarn short tons	4,402	2,420	3,733	2,368
Shingles and clapboard do	8,606	1,599	8,356	1,659
Articles of asbestos cement do	5,120	1,779	3,440	1,202
Manufactures, n.e.c	NA	5,673	NA	5,605
Total	-----	28,158	-----	25,300
REEXPORTS				
Unmanufactured:				
Crude and spinning fibers short tons	589	122	7,441	1,511
Nonspinning fibers do	1,062	231	799	138
Waste and refuse do	-----	-----	110	7
Total do	1,651	353	8,350	1,656
Products:				
Gaskets and packing do	3	4	15	21
Brake linings do	-----	-----	6	8
Clutch facings, including linings number	2,281	2	5,196	5
Textiles and yarn short tons	-----	-----	43	19
Shingles and clapboard do	72	14	42	13
Articles of asbestos cement do	-----	-----	76	22
Manufactures, n.e.c	NA	5	NA	3
Total	-----	25	-----	91

NA Not available.

Table 4.—U.S imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber) Short tons	Crude (including blue fiber) Value (thousands)	Textile fiber Short tons	Textile fiber Value (thousands)	All other Short tons	All other Value (thousands)	Total Short tons	Total Value (thousands)
1969								
Angola	-----	-----	-----	-----	62	$5	62	$5
Canada	2,851	$393	15,974	$5,928	636,606	64,438	655,431	70,759
Finland	1,277	61	-----	-----	4,958	280	6,235	341
France	30	4	-----	-----	-----	-----	30	4
Italy	1	(1)	-----	-----	1	2	2	2
Malta and Gozo	-----	-----	-----	-----	1	2	1	2
Mozambique	55	8	-----	-----	217	18	272	26
Portugal	20	1	-----	-----	395	35	415	36
South Africa, Republic of	28,026	4,774	-----	-----	1,664	321	29,690	5,095
Southern Africa, n.e.c	245	48	-----	-----	-----	-----	245	48
United Kingdom	31	5	-----	-----	265	11	296	16
Yugoslavia	280	9	-----	-----	1,599	79	1,879	88
Total	32,816	5,303	15,974	5,928	645,768	65,191	694,558	76,422
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

1 Less than ½ unit.

Table 5.—U.S. imports for consumption of asbestos from specified countries, by grades

(Short tons)

Grade	1969 Canada	1969 Republic of South Africa	1970 Canada	1970 Southern Rhodesia	1970 Republic of South Africa
Chrysotile					
Crudes	2,851	2,850	80	---	591
Spinning fibers	15,974	---	15,398	---	85
All other	636,606	1,664	597,832	200	2,855
Crocidolite (blue)	---	10,558	---	---	8,936
Amosite	---	14,618	---	---	14,261
Total	655,431	29,690	613,310	200	26,728

WORLD REVIEW

Two trade journals[5] forecast a possible worldwide asbestos shortage by 1974, and a third[6] says that the new capacity being readied will just meet increased demand in the Western world during the next 2 years.

Accelerated exploration, development and modernization of asbestos properties throughout the world attest that the exporting countries foresee greater markets and that many importing countries hope to become self-sufficient.

[5] Mining Journal. V. 274, No. 2025, Apr. 10, 1970, p. 309.
Engineering Mining Journal. V. 171, No. 5, May 1970, p. 11.
[6] Chemical Week. V. 106, No. 24, June 17, 1963, p. 113.

Table 6.—Asbestos: World production, by countries [1]

(Short tons)

Country	1968	1969	1970 [p]
North America:			
Canada (sales)	1,509,699	1,576,876	1,663,355
United States (sold or used by producers)	120,690	125,936	125,314
Latin America:			
Argentina	381	359	[e] 350
Bolivia	1	-----	-----
Brazil	4,806	9,981	14,330
Europe:			
Bulgaria	[r] 2,300	3,100	[e] 3,900
Finland [2]	14,484	15,487	15,019
France	551	[e] 550	[e] 550
Italy	114,020	124,039	130,747
Portugal	[r] 94	224	200
U.S.S.R.[e]	900,000	1,100,000	1,150,000
Yugoslavia	11,456	12,634	13,342
Africa:			
Mozambique	132	868	NA
Rhodesia, Southern [e]	95,000	88,000	88,000
South Africa, Republic of	260,531	284,588	316,822
Swaziland	42,946	43,086	[e] 43,100
United Arab Republic	2,868	-----	-----
Asia:			
China, mainland [e]	170,000	180,000	190,000
Cyprus	21,293	23,927	28,253
India	9,992	10,734	10,840
Japan	24,251	23,148	23,576
Korea, Republic of (South)	3,650	6,515	1,513
Philippines	35	49	1,337
Taiwan	1,323	3,396	3,133
Turkey	[r] 3,905	5,698	1,857
Oceania: Australia	895	822	[e] 700
Total	3,315,303	3,640,017	3,826,238

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] In addition to the countries listed, Czechoslovakia, North Korea, and Romania also produce asbestos, but information is insufficient to make reliable estimates of output levels.
[2] Includes asbestos flour.

Australia.—Plant construction, mine preparation, and personnel recruitment are all well underway at the new Pacific Asbestos site at Barraba. Full operation at a rate of 70,000 tons per year of chrysotile fibers should be accomplished this year. An anticipated 100,000 tons per year should come by the end of 2 years' operation. There are 27 million tons of proven ore reserves with a potential of 90 million tons within the lease boundaries.[7]

Hammersley Iron Pty. Ltd. is investigating the feasibility of reactivating the crocidolite property at Wittenoom.

Bolivia.—Under a United Nations Development Program, the Bolivian crocidolite mines will become steadily rather than sporadically operated. Pilot plant studies have been promising, and an experimental plant with the capacity to produce 1,500 tons per year of fiber is being erected at Cochabamba.

Canada.—Sales by Canadian producers increased by 5 percent from 1969 to 1,663,355 short tons. A similar increase this year would come near to accomplishing a national goal of 1.77 million tons annually by 1971.

The Asbestos Corp. Ltd. has a unique solution to some of the problems attendant to having a mine within 300 miles of the arctic circle. The mine, Asbestos Hill on the Ungava peninsula, has 20 million tons of proven ore reserves, but has been shut down for 3 years because of high milling costs. The solution is to mine just 7 months a year, do only partial milling and drying at mine-site, and complete the processing at a new plant under construction at Nordenham, West Germany.

There are a least five new chrysotile deposits under active exploration or development planning in Canada:

(1) Abitibi Asbestos Mining Ltd. is planning a Can$57 to $87 million financing program to develop its property near Amos, Quebec, where drilling indicates reserves of 105 million short tons.

(2) McAdams Mining Corporation is making plans for developing its property at Chibougamou in northwest Quebec.

(3) Ascope Exploration Ltd. is exploring its find at Val d'Or, Quebec, adjacent to the Abitibi property.

(4) Cassiar Asbestos Corp. Ltd. and Kutchko Creek Asbestos Co. are exploring their joint property at Kutchko Creek southeast of Cassiar in British Columbia.

(5) Golden Gate Exploration Co. is examining the Rex property at Haines Junction, Yukon.

Colombia.—Nicolet Industries has a 70-percent share of the chrysotile mine near Medellin now under development. The production is scheduled to reach 40,000 to 70,000 tons annually starting in 1972.

South Africa, Republic of.—The Republic of South Africa remained solidly in third place among world producers with an 11 percent increase in production to 316,822 short tons per year.

U.S.S.R.—The U.S.S.R. remained second only to Canada in production and exports of asbestos fibers and shares title of the No. 1 consumer with the United States.

Data from the Soviet Ministry of Foreign Trade for the 3-year period 1966–68 show a considerable export market; about two-thirds of its customers are in the West. The data show a lessening of the annual increase of exports from 11 to 10 percent, and a projection of the data suggests that asbestos exports will be near 400,000 short tons in 1970. This is about one-third of the estimated 1.2 million short tons of production.

[7] Northern Miner (Toronto). V. 10, No. 8, May 14, 1970, p. 10.

Table 7.—Canada: Shipments [1] of asbestos, by grades
(Short tons)

Grade	1966	1967	1968	1969	1970
Quebec milled group:					
3 (spinning) [2]	28,716	25,391	32,248	29,291	24,648
4 (shingle)	371,837	336,568	335,807	326,146	341,723
5 (paper)	190,278	185,450	193,446	204,208	223,535
6 (stucco)	229,426	244,021	255,648	242,126	261,564
7 (refuse)	512,030	490,087	542,124	539,413	515,872
8 (sand)	8,706	7,149	3,037	2,023	1,793
Newfoundland, Ontario, and British Columbia	138,288	154,345	147,389	233,669	294,220
Total	1,479,281	1,443,011	1,509,699	1,576,876	1,663,355

[1] Includes tonnage for own use.
[2] Includes crude No. 1, No. 2, and other.

Source: Dominion Bureau of Statistics.

TECHNOLOGY

The technological event that has possibilities of having the greatest impact on the asbestos industry happened in the glass industry and wasn't announced until early in 1971.[8] Great Britain's Fiberglass, Ltd., in association with British National Research and Development Corp. and the British Building Research Station have developed a glass fiber that resists alkali.

The fibers, still available only in very limited quantities, would, if company expectations are met, become a replacement for asbestos in reinforcing portland cement. They even visualize lengths of up to 4 inches eventually replacing the steel now used for reinforcement.

Until much more information on costs and applicability is available, judgment will have to be reserved on the glass fibers' effect on the asbestos industry. If, however, there is even limited success in the construction industry, the glass fibers may help alleviate the potential mid 1970's asbestos shortage.

Monsanto has developed a new, low cost, general purpose, reflective coating to cover metal, wood, or concrete with a handsome aluminum-impregnated protective coating good for 15 to 20 years. The coating is six to eight times the thickness of ordinary paint and contains asphalt and long fibered asbestos as well as the aluminum.

The asbestos industry has begun to answer some of the widely distributed statements about the health hazards posed to the general public by the manufacture and use of asbestos and asbestos-based products.[9] Eight leading asbestos products manufacturers in the United States have organized the Asbestos Information Association/North America (AIA/NA). The basic objectives of AIA/NA are to (1) provide an authoritative channel of communication, (2) publicly rebut irresponsible and uninformed criticism, and (3) disseminate information on the uses of asbestos in our modern technological society.

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[8] Chemical Week. V. 108, No. 3, Jan. 20, 1971, p. 10.
[9] Asbestos. V. 52, No. 10, April 1971, pp. 2–3.

Barite

By Frank B. Fulkerson [1]

Domestic barite sold or used in 1970 totaled 854,000 short tons, the lowest since 1965 and a decrease of 21 percent from 1969. The decline was due to an increase in barite imports, a strike that shut down one of the principal mines, and a drop in demand for barite by consuming industries. Imports of crude barite increased 15 percent to 706,000 tons.

DOMESTIC PRODUCTION

Barite was mined by open pit and underground methods in seven States in 1970. Production in Missouri, Arkansas, Nevada, and Alaska accounted for nearly 85 percent of the total output. Missouri, despite lower output, regained its position as the largest barite producer after yielding this ranking to Nevada in 1969. Production from the National Lead Co., Baroid Div., mine at Magnet Cove, Ark., was interrupted by a strike.

Ground and crushed barite was produced in nine States; output was down 10 percent from 1969. Leading producing States were Louisiana and Texas (from imported barite) and Arkansas and Missouri (from domestic barite).

[1] Industry economist, Division of Nonmetallic Minerals.

Table 1.—Salient barite and barium-chemical statistics
(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Barite (primary):					
Mine or plant production	1,007	944	NA	NA	NA
Sold or used by producers	947	962	[1] 927	1,077	854
Value	$11,259	$11,604	[1] $13,706	$15,753	$12,800
Imports for consumption	699	532	663	614	706
Value	$5,764	$4,655	$5,666	$5,549	$6,314
Consumption [2]	1,417	1,371	NA	NA	NA
Ground and crushed sold by producers	1,209	1,144	1,266	1,537	1,388
Value	$30,641	$28,754	$30,563	$37,297	$34,294
Barium chemicals sold by producers	133	113	136	[r] 130	105
Value	$19,109	$16,283	$18,811	$19,101	$16,961
World: Production	4,068	3,933	3,769	4,235	4,221

[r] Revised. 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 States
(Thousand short tons and thousand dollars)

State	1969		1970	
	Quantity	Value	Quantity	Value
Alaska	W	W	134	$835
Arkansas	210	$4,616	168	3,721
California	W	W	W	W
Georgia	124	3,116	W	W
Missouri	304	4,220	230	3,555
Nevada	320	2,275	192	1,455
Tennessee	16	295	19	286
Undistributed	103	1,229	112	2,949
Total [1]	1,077	15,753	854	12,800

W Withheld to avoid disclosing individual company confidential data, included with undistributed.
[1] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Most of the ground barite produced in the United States was used as a weighting agent in oil and gas-well drilling muds. Barite demand for this use decreased in 1970 owing to a decline in drilling activity. Except for ground and crushed barite required in the rubber industry, where it was used as a filler, demand in all major uses declined sharply.

Producers of barium chemicals from barite included the following: J. T. Baker Chemical Co., Phillipsburg, N.J.; Chemetron Corp., Huntington, W. Va.; Chemical Products Corp., Cartersville, Ga.; Chicago Copper & Chemical Co., Blue Island, Ill.; The Great Western Sugar Co., Johnstown, Colo.; Inorganic Chemicals Division, FMC Corp., Modesto, Calif.; Mallinckrodt Chemical Works, St. Louis, Mo.; Ozark Smelting & Mining Co., Coffeyville, Kans.; PPG Industries, Inc., Chemical Division, New Martinsville, W. Va.; and Sherwin-Williams Co., Ashtabula, Ohio. Chicago Copper & Chemical Co., a producer of black ash and barium carbonate, suspended operations and went out of business in 1970.

Among the many uses for barium chemicals, barium chloride was used for case hardening iron and steel, producing magnesium metal, and treating water; barium carbonate was used in making glass, ceramic glazes, and enamels; and barium hydroxide was added to ceramic products and lubricating oils and was used in the process of refining sugar beets.

Table 3.—Ground and crushed barite sold by producers [1]

Use [2]	1968 Short tons	1968 Percent of total	1969 Short tons	1969 Percent of total	1970 Short tons	1970 Percent of total
Barium chemicals [3]	175,830	13	177,570	11	146,038	10
Glass	71,770	5	72,706	5	49,642	4
Filler or extender:						
Paint	60,894	4	52,306	3	43,919	3
Rubber	41,639	3	14,177	1	25,489	2
Other filler	NA		(4)		(4)	
Well drilling	1,006,418	73	1,235,229	77	1,118,973	79
Other uses	20,907	2	52,754	3	24,565	2
Total	1,377,458	100	1,604,742	100	1,408,626	100

NA Not available.
[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 used or sold by producers [1] in the United States in 1970

Chemical	Plants	Produced (short tons)	Sold or used by producers: Short tons	Sold or used by producers: Value
Barium carbonate	7	61,833	52,489	$5,956,411
Other barium chemicals [2]	(3)	57,001	52,546	11,004,975
Total [4]	9	118,834	105,035	16,961,386

[1] Only data reported by barium chemical producers that consume barite (primary) are included.
[2] Includes barium acetate, black ash, blanc fixe, chloride, hydroxide, lithopone, nitrate, oxide, peroxide, and other compounds for which separate data may not be revealed.
[3] Barium acetate, 1 plant; black ash, 1; blanc fixe, 3; chloride, 3; hydroxide, 4; lithopone, 1; nitrate, 1; oxide, 1; and peroxide 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 chemical grade and drilling-mud-grade ground barite and imported crude barite increased in July.

Table 5.—Price quotations for crude and ground barite in 1970

Item	Price per ton
Chemical grade, f.o.b. shipping point, carload lots, short ton:	
Hand picked, 95 percent $BaSO_4$, 1 percent iron	$20–$23.50
Water ground, 99.5 percent $BaSO_4$, 325 mesh, 50-pound bags	45–78
Drilling-mud grade, f.o.b. shipping point, carload lots: 83–93 percent $BaSO_4$, 3–12 percent iron, specific gravity 4.20–4.30, ground, short ton	31–36
Imported, 4.20–4.30 specific gravity, crude, bulk, c.i.f. gulf ports, long ton	16–20

Source: Engineering and Mining Journal.

FOREIGN TRADE

Principal countries receiving barite exports from the United States were Singapore, Indonesia, Canada, and Saudi Arabia. The tonnage was exported through the following customs districts:

Customs district	Quantity (short tons)	Value (thousands)
New Orleans	32,323	$1,100
Juneau	17,115	205
Detroit	6,507	241
Galveston	5,050	183
Other	1,543	97
Total	62,538	1,826

Imports of crude barite for consumption in 1970 totaled 706,000 tons, up 15 percent from 1969 imports. The growing economic advantage of foreign crude ore is reflected by the increase in imports and the decrease in domestic production; also, a strike that shut down a domestic mine from September to December significantly affected output. The imported barite entered the United States through the following customs districts: New Orleans, La., 49 percent; Port Arthur, Tex., 22 percent; Laredo, Tex., 20 percent; Houston, Tex., 7 percent; and El Paso and Galveston, Tex., 2 percent. Ireland was the principal source of imports, followed by Peru and Mexico.

Table 6.—U.S. exports of lithopone

Year	Short tons	Value (thousands)
1968	1,300	$281
1969	1,086	300
1970	1,541	523

Table 7.—U.S. imports for consumption of barite, by countries

(Thousand short tons and thousand dollars)

Type and country	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Crude barite:				
Algeria	5	$65	---	-----
Brazil	7	47	---	-----
Canada	107	913	88	$748
Greece	54	533	56	553
Ireland	111	836	203	1,540
Italy	59	697	29	416
Mexico	121	949	132	1,108
Morocco	41	441	28	319
Peru	98	966	170	1,630
Turkey	11	102	---	-----
Total	614	5,549	706	6,314
Ground barite:				
Canada	2	221	1	36
France	(1)	5	(1)	10
Italy	(1)	8	---	-----
Total	2	234	1	46

[1] Less than ½ unit.

Table 8.—U.S. imports for consumption of barium chemicals

Year	Lithopone Short tons	Lithopone Value (thousands)	Blanc fixe (precipitated barium sulfate) Short tons	Blanc fixe Value (thousands)	Barium chloride Short tons	Barium chloride Value (thousands)	Barium hydroxide Short tons	Barium hydroxide Value (thousands)
1968	246	$37	2,783	$397	1,413	$149	---	---
1969	261	40	2,705	399	1,083	118	r 37	r $2
1970	87	19	2,866	495	1,558	166	---	---

Year	Barium nitrate Short tons	Barium nitrate Value (thousands)	Barium carbonate, precipitated Short tons	Barium carbonate, precipitated Value (thousands)	Other barium compounds Short tons	Other barium compounds Value (thousands)
1968	710	$103	656	$43	415	$151
1969	1,035	144	887	70	944	381
1970	786	118	1,416	117	525	258

r Revised.

Table 9.—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)
1968	2,029	$59	25	$17
1969	392	15	67	7
1970	-----	---	182	35

WORLD REVIEW

Increased oil-well drilling in the Far East, particularly in Malaysia and Indonesia, led to greater demand for barite. Shipments were being made to this area from Australia, the United States, and other countries.

Table 10.—Barite: World production, by countries
(Short tons)

Country [1]	1968	1969	1970 p
North America:			
Canada	138,059	143,230	236,000
Mexico	271,762	195,022	351,738
United States [2]	926,729	1,077,208	854,132
South America:			
Argentina	r 26,670	29,751	e 30,000
Brazil	47,472	p r 51,800	e 28,200
Chile	4,053	8,824	4,760
Colombia	r 7,716	13,494	7,519
Peru	r 37,375	164,067	143,295
Europe:			
Austria	1,610	780	347
Czechoslovakia e	r 7,200	r 7,700	8,300
France	100,235	p 104,700	e 104,700
Germany, East e	r 33,000	r 33,000	33,000
Germany, West	r 467,011	482,232	454,798
Greece [3]	r 72,787	r 91,647	59,707
Ireland	r 149,050	176,926	e 177,000
Italy	224,849	268,213	245,882
Poland e	r 52,000	r 55,000	55,000
Portugal	353	119	474
Romania e	r 61,000	r 110,000	128,400
Spain	66,736	70,130	e 70,000
U.S.S.R. e	r 290,000	r 310,000	330,000
United Kingdom [4]	r 33,000	20,000	e 20,000
Yugoslavia	77,642	89,850	e 94,000
Africa:			
Algeria [5]	49,587	57,000	56,927
Kenya	r 386	479	493
Morocco	86,157	95,835	93,421
South Africa, Republic of	572	3,872	3,219
Swaziland	979	629	e 660
United Arab Republic	411	e 440	e 440
Asia:			
Burma	r 9,921	10,696	12,100
China, mainland e	r 132,000	r 154,000	165,000
India	57,009	57,094	79,281
Iran	r 58,774	64,616	66,380
Japan	65,152	68,506	72,950
Korea, North e	r 132,000	r 132,000	132,000
Korea, Republic of	6	---------	---------
Pakistan	11,416	e r 5,500	e 6,600
Thailand	---------	---------	18,177
Turkey	r 24,475	36,458	32,013
Oceania: Australia	r 43,854	44,309	e 44,000
Total	r 3,769,008	r 4,235,127	4,220,913

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: 1968, 207,234; 1969, 260,097; 1970, 151,000 (estimate).
[4] Includes witherite.
[5] Ground barite; total crude output reported as follows in short tons: 1968, not available; 1969, 45,258; 1970, 80,906.

A comprehensive review of the world barite industry was published.[2]

Australia.—To meet the demand from local and overseas markets, South Australian Barytes Ltd., which operates the Oraparinna open pit mine in the Flinders Ranges, was expanding the capacity of its grinding plant at Quorn about 100 miles from Port Augusta. The company also planned to develop a barite deposit at Inverway in the Northern Territory.[3]

Iran.—Sogemiran S.A., a subsidiary of a Belgian firm Société Générale des Minerais, operated a 250-metric-ton-per-day lead-barite flotation mill and an open pit mine and was developing an underground mine. The operation is in north central Iran. Barite concentrate was trucked to the grinding plant of Iran Magcobar Co. south of Teheran.[4]

Singapore.—IMC Drilling Mud, Inc., was constructing a barite grinding plant with a capacity of 40,000 tons per year on a 3½ acre site in Jurong Township. Grinding operations were to be based initially on barite produced in Thailand. The ground barite was to be sold to the drilling industry in the Far East.[5]

Thailand.—A barite deposit in the Tha-Sala district of the southern province of Songkla was acquired by Endeavor Oil NL. The company planned to begin mining by open pit methods at an initial rate of 20,000 tons per year. The ore would be shipped to Singapore, where Endeavor proposed to establish a grinding mill.[6]

WORLD RESERVES

The Geological Survey (USGS) published an appraisal of world barite reserves. The United States reserves were estimated to be 83 million tons, over 40 percent of the reported world reserves of 204 million tons. According to the report, geologic factors suggest that world barite reserves can be increased in coming years to meet the growing requirements. Possibilities for discovery of new barite deposits similar to the large high grade bedded deposits of Nevada and Arkansas were said to be good.[7]

[2] Industrial Minerals (London). The World's Barite Industry. No. 32, May 1970, pp. 15–27.
[3] Industrial Minerals (London). No. 32, May 1970, p. 23.
[4] World Mining. V. 6, No. 4, April 1970, p. 16.
[5] Industrial Minerals (London). No. 32, May 1970, p. 45.
[6] Industrial Minerals (London). No. 39, December 1970, p. 41.
[7] Brobst, Donald A. Barite: World Production, Reserves, and Future Prospects. Geol. Survey Bull. 1321, 1970, 46 pp.

Table 11.—World reserves of barite, by countries
(Million short tons)

Country	Reserves	Country	Reserves
North America:		Africa:	
Canada	5	Algeria	}12
Mexico	4	Morocco	
United States	83	Liberia	2
		South Africa, Republic of	3
Total	92	Other	3
South America:		Total	20
Brazil	3		
Chile	3	Asia:	
Other	2	China, mainland	10
Total	8	Iran	3
		Japan	3
Europe:		Korea:	
Bulgaria	5	North	3
Czechoslovakia	2	South	3
France	4	Pakistan	2
Germany:		Thailand	3
East	3	Turkey	4
West	7	Other	1
Greece	4	Total	32
Ireland	3	Oceania: Australia	5
Italy	5	Grand total	204
Poland	2		
Romania	2		
U.S.S.R.	3		
United Kingdom	2		
Yugoslavia	3		
Other	2		
Total	47		

Source: U.S. Geological Survey.

TECHNOLOGY

Alaska Barite Co. operated an underwater barite mine in Duncan Canal, Kupreanof Island, southeastern Alaska. Ore being mined was in 20 feet of water. A special mining barge 130 feet long and 50 feet wide carried the drilling and excavating equipment. The barge was equipped with six anchor lines and winches capable of overcoming the 4 to 5 knot currents prevailing in the area. The drilling unit consisted of a structural tower with a 40-foot drill mast, a pneumatic drill, a large tugger hoist, and an air compressor. The ore was blasted, recovered by a crane with a special digging bucket, and loaded into barges for transfer to a small island nearby, where the ore was crushed and screened. The operation was located in a shrimp, salmon, and crab harvesting area. Precautions were being taken against pollution and environmental damage.[8]

[8] Stevens, Joseph F. Mining the Alaska Seas. Ocean Industry, v. 5, No. 11, November 1970, pp. 47–51.

Bauxite

By Horace F. Kurtz [1]

World bauxite production increased 10 percent to 57 million tons in 1970, more than twice the production of a decade ago. New alumina production capacity was added or planned in many countries, and international shipments of alumina continued a rapidly rising trend. United States imports of both bauxite and alumina reached record levels. Domestic mine production of bauxite rose to its highest level since World War II; however, on an aluminum content basis, this production comprised only 10 percent of the new supply of aluminous raw materials, which includes imports of bauxite and alumina.

Legislation and Government Programs.—Excess bauxite and fused aluminum oxide in the national stockpile were available for commercial sale or exchange for items in deficit in the stockpile. Approximately 126,000 tons of bauxite were sold in 1970.

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Production, crude ore (dry equivalent)	1,796	1,654	1,665	1,843	2,082
Value	$20,095	$19,079	$23,752	$25,725	$30,070
Exports (as shipped)	62	2	7	5	3
Imports for consumption [1]	11,529	11,594	10,976	12,160	12,620
Consumption (dry equivalent)	14,084	14,503	14,097	15,580	15,646
World: Production	40,041	43,889	45,256	51,803	57,072

[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 bauxite imported into the Virgin Islands.

DOMESTIC PRODUCTION

The production of bauxite in the United States increased 13 percent to over 2 million long tons (dry equivalent) in 1970. Approximately 90 percent of the production was mined 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. operated mines in Saline County and American Cyanamid produced in Pulaski County. Bauxite processing plants were operated by American Cyanamid, A. P. Green, Porocel Corp., and Stauffer Chemical Co. A Bureau of Mines report described the bauxite industry in Arkansas.[2]

In Alabama, bauxite was mined by Wilson-Snead Mining Co., Eufaula Bauxite Mining Co., and A. P. Green in Barbour County, and by Harbison-Walker Refractories Co., A. P. Green, and General Refractories Co. in Henry County. Wilson-Snead, Eufaula Bauxite, Harbison-Walker, and A. P. Green also operated processing plants in Alabama.

American Cyanamid, the only producer in Georgia, mined and dried bauxite in Sumter County.

During the year, Reynolds took large samples of its laterite resources in the Northwest for test purposes. The material

[1] Industry economist, Division of Nonferrous Metals.

[2] Stroud, Raymond B., Robert H. Arndt, Frank B. Fulkerson, and W. G. Diamond. Mineral Resources and Industries of Arkansas. BuMines Bull. 645, 1969, 418 pp.

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:						
1966	102	78	$656	85	82	$1,108
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
Arkansas:						
1966	2,060	1,718	19,439	1,891	1,636	19,788
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
Total United States: [3]						
1966	2,162	1,796	20,095	1,976	1,718	20,896
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

[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
1966	202	117	157
1967	223	123	167
1968	210	108	152
1969	288	162	218
1970	428	259	343

[1] Dried, calcined, and activated bauxite.

was mined in Washington, Marion, and Columbia Counties, Ore. and Cowlitz County, Wash.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (percent)	1966	1967	1968	1969	1970
Less than 8	10	4	15	15	19
From 8 to 15	60	73	53	55	54
More than 15	30	23	32	30	27

International Minerals & Chemicals Corp. purchased the Eufaula Bauxite Mining Co. and planned to increase its capacity to produce bauxite and bauxitic clays for the refractory and chemical industries. C-E Minerals, a division of Combustion Engineering, Inc., announced that it was adding to its bauxite and kaolin calcining plant at Andersonville, Ga., and that annual capacity would be increased to 250,000 tons.

The eight alumina plants in the continental United States, located in four southern States, and the plant in the Virgin Islands had a combined production of 7.23 million short tons in 1970, down 1.5 percent from 1969. The total included 6.74 million tons of calcined alumina, 417,000 tons of commercial alumina trihydrate, and 66,000 tons of tabular and activated alumina. Shipments of alumina and aluminum oxide products totaled 7.0 million tons. About 6.49 million tons went to the aluminum industry, and the remainder was shipped to the chemical, ceramic, refractory, abrasive, and other industries.

Table 5.—Production of alumina in the United States

(Thousand short tons)

Year	Calcined alumina	Other alumina [1]	Total	
			As produced [2]	Calcined equivalent
1960	3,873	215	4,088	4,026
1961	3,688	221	3,909	3,844
1962	4,389	260	4,649	4,575
1963	4,799	263	5,062	4,987
1964	5,279	299	5,577	5,493
1965	5,538	326	5,864	5,771
1966	5,853	349	6,202	6,105
1967	6,153	352	6,505	6,392
1968	6,051	391	6,442	6,328
1969	6,920	414	7,334	7,214
1970	6,743	483	7,227	7,080

[1] Trihydrate, activated, tabular and other aluminas.
[2] Data may not add to totals shown because of independent rounding.

During the year, Alcoa was expanding its alumina plant at Point Comfort, Tex. On completion in mid-1971, the plant will have an annual capacity of over 1 million tons. Harvey Aluminum, Inc., began work late in the year on expanding its plant at St. Croix, Virgin Islands, and preparing it to use bauxite from Boké, Guinea. The Corpus Christi, Tex., alumina plant of Reynolds was damaged by a hurricane in August, but all damage was repaired by the end of the year.

Alcoa's new plant near Fort Meade, Fla., was put into operation to produce aluminum fluoride and synthetic cryolite from a byproduct of phosphate fertilizer production. Kaiser Aluminum & Chemical Corp. began construction at Gramercy, La., to double its aluminum fluoride capacity to 60,000 tons per year by mid-1971.

CONSUMPTION AND USES

The major bauxite-consuming industries in the United States used about the same quantities of bauxite in 1970 as the previous year. Nearly 88 percent of the 15.6 million tons of bauxite consumed was imported ore and about 70 percent was in crude or partially dried form.

Alumina production accounted for 94 percent of the total bauxite consumption. An average of 2.07 long tons (dry basis) of bauxite was required to produce 1 short ton (calcined basis) of alumina. Twenty-seven primary aluminum plants in the United States consumed 7.6 million tons of calcined alumina.

The refractory industry used 370,000 tons (dry basis) of bauxite. Most of the material was calcined bauxite and 84 percent was imported. The trend toward increased use of high-alumina refractories to meet higher temperature requirements of the pyroprocessing industries was verified in a study of refractories consumption.[3]

Table 6.—Bauxite consumed in the United States, by industries

(Thousand long tons, dry equivalent)

Year and industry	Domestic	Foreign	Total[1]
1969:			
Alumina	1,749	12,825	14,574
Abrasive[2]	W	254	[3] 254
Chemical	140	177	318
Refractory	58	308	366
Other	29	40	69
Total[1] [2]	1,976	13,605	15,580
1970:			
Alumina	1,718	12,936	14,653
Abrasive[2]	--------	253	253
Chemical	[4] 161	[4] 208	307
Refractory	60	310	370
Other	W	W	63
Total[1] [2]	1,940	13,707	15,646

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 consumption by Canadian abrasive industry.
[3] Excludes domestic.
[4] Includes other uses.

Table 7.—Crude and processed bauxite consumed in the United States in 1970

(Thousand long tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total[1]
Crude	1,731	9,297	11,028
Dried	21	3,847	3,869
Activated	33	--------	33
Calcined	154	563	717
Total[1]	1,940	13,707	15,646

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

All of the 253,000 tons (dry basis) of 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.

About 307,000 tons (dry basis) of dried, calcined, and activated bauxite was used by the chemical industry in 1970. Other consumers of bauxite, in descending order of magnitude, included the cement, oil and gas, and steel industries, and municipal waterworks. American Cyanamid announced the construction of new alum plants at Escanaba, Mich., and De Ridder, La. In 1969, the production of aluminum sulfate, aluminum chloride, and aluminum fluoride were increased 5, 8, and 3 percent, respectively.

[3] Kusler, David J., and Robert G. Clarke. Impact of Changing Technology on Refractories Consumption. BuMines Inf. Circ. 8494, 1970, 68 pp.

Table 8.—Production and shipments of selected aluminum salts in the United States in 1969

(Thousand short tons and thousand dollars)

Item	Number of producing plants	Production	Total shipments including interplant transfers	
			Quantity	Value (thousand)
Aluminum sulfate:				
Commercial (17 percent Al_2O_3)	63	1,244	1,202	$49,479
Municipal (17 percent Al_2O_3)	3	5	XX	XX
Iron-free (17 percent Al_2O_3)	19	71	46	2,944
Aluminum chloride:				
Liquid (32° Be), Crystal (32° Be)	7	24	10	905
Anhydrous (100 percent $AlCl_3$)	5	40	37	10,313
Aluminum fluoride, technical	6	143	143	28,161
Aluminum hydroxide, trihydrate (100 percent $Al_2O_3.3H_2O$)	7	326	345	21,988
Other inorganic aluminum compounds [1]	XX	XX	XX	18,383
Total	XX	XX	XX	132,173

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

Inventories of bauxite at mines, processing plants, and consumers increased 8 percent. Stocks of refractory-grade bauxite had the greatest proportional increase. The only change in Government stocks of bauxite was the disposal of 2,487 long tons of calcined refractory-grade bauxite; however, 123,529 long dry tons of metal-grade Surinam-type bauxite was committed for disposal.

Stocks of alumina and related products at plants producing alumina and aluminum rose from 839,000 short tons at the end of 1969 to 1,047,000 tons on December 31, 1970.

Table 9.—Stocks of bauxite in the United States [1]

(Thousand long tons, dry equivalent)

Sector	Dec. 31, 1969	Dec. 31, 1970
Producers and processors	r 878	930
Consumers	r 2,078	2,256
Government	17,021	17,017
Total	19,977	20,203

r Revised.
[1] Domestic and foreign bauxite; crude, dried, calcined, activated; all grades.

PRICES

According to Oil, Paint and Drug Reporter, the price of bauxite in bulk form at mines ranged from $7 to $10 per ton, unchanged from the previous year. The Bureau of Mines estimated that the value of crude, undried, domestic bauxite shipments, f.o.b. mine or plant, averaged $11.88 per long ton in 1970. The average value of domestic dried bauxite shipments was estimated at $13.29 per ton. The average value of imported bauxite at the port of shipment was $11.96 per ton (dry equivalent weight) for undried and dried bauxite and $34.59 per ton for calcined bauxite. The average value of imported bauxite consumed at domestic alumina plants was estimated at $14.49 per long dry ton. In December 1970, Engineering and Mining Journal published the following prices, unchanged from the previous December, on special grades of bauxite, f.o.b. cars, Atlantic ports, per long ton:

Imported, calcined, crushed:	
Abrasive grade, 87.25 percent minimum Al_2O_3, penalties for SiO_2 content over 7 percent	$35.80–36.30
Refractory grade:	
87.75 percent minimum Al_2O_3	39.55
88 percent minimum Al_2O_3, super calcined	43.05
Imported dried, crushed:	
Chemical grade, 60.25 percent Al_2O_3, 6 percent SiO_2, 1.25 percent Fe_2O_3 (approximately)	15.90–16.90

The average value of calcined alumina, as determined from producer reports, was $0.0339 per pound, the same as the preceding year. The average value of imported alumina, classified as alumina for use in making aluminum, was $0.0299 per pound at port of shipment, while the average value of exports of alumina was $0.0354 per pound.

Table 10.—Market quotations on alumina and aluminum compounds

Compounds	Dec. 29, 1969	Dec. 30, 1970
Alumina, calcined, bags, carlots, works per pound	$0.0530–0.0555	$0.0570–0.0585
Aluminum hydrate, heavy, bags, carlots, freight equalized per pound	.0400	.0420–0.0435
Aluminum sulfate, commercial, ground, bags, carlots, works, freight equalized per ton	58.25	62.25
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized per ton	83.05	83.05–87.05

Source: Oil, Paint and Drug Reporter.

Table 11.—Average value of U.S. exports and imports of bauxite [1]

(Per long ton)

Type and country	Average value port of shipment 1969	Average value port of shipment 1970
Exports: Bauxite and bauxite concentrate	$86.47	$74.74
Imports:		
Crude and dried:		
Australia	5.31	4.91
Dominican Republic [2]	16.05	16.88
Germany, West	9.00	------
Greece	8.09	10.14
Guinea	r 4.09	4.52
Guyana	9.15	9.84
Haiti [2]	13.55	10.02
Jamaica [2]	15.35	12.99
Surinam	9.61	10.59
Trinidad and Tobago	9.00	------
Venezuela	9.05	9.30
Average	r 13.25	11.96
Calcined: [3]		
Canada	38.02	19.07
Guyana	30.46	34.77
Surinam	27.36	32.63
Trinidad and Tobago	------	11.97
Venezuela	------	35.20
Average	30.09	34.59

r Revised.
[1] Includes the value of material brought into the Virgin Islands from Australia and Guinea.
[2] Dry equivalent tons adjusted by the Bureau of Mines used in computation.
[3] For refractory use.

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. Consequently, the data do not necessarily reflect market values in the country of origin.

FOREIGN TRADE

Bauxite exports diminished to only 3,279 tons in 1970. Canada and West Germany were the principal recipients. Exports of alumina increased 8 percent to 1,224,000 tons, including 165,000 tons exported to Norway from the Virgin Islands. About 32 percent of the alumina was shipped to Canada; 27 percent to the U.S.S.R.; 13 percent to Norway; 13 percent to Ghana; 6 percent to Mexico; 3 percent to Venezuela; 2 percent to Hungary; and the remaining 4 percent to 50 other countries.

Exports of aluminum hydroxide were increased 56 percent to 41,000 tons, valued at

$4.9 million. Shipments to Sweden, Mexico, and Canada accounted for 88 percent of the total. Aluminum sulfate exports rose 44 percent to about 18,000 tons, valued at $578,000. Nearly two-thirds of the aluminum sulfate was sent to Venezuela. Exports of artificial corundum are given in the Abrasive Materials chapter. Exports classified as "other aluminum compounds" totaled about 17,000 tons and were valued at $5.8 million.

The duties on crude and dried bauxite, calcined bauxite, and alumina imported for making aluminum continued suspended throughout the year. Under the "Kennedy round" trade agreements, the duty rates were lowered on January 1, 1970, to 20 cents per long ton on crude bauxite, 22 cents per long ton on calcined bauxite, and 0.17 cents per pound on alumina. Alumina and aluminum hydroxide imported for uses other than making aluminum was dutiable at 0.17 cents per pound throughout the year.

Table 12.—U.S. imports for consumption of bauxite (crude and dried) by countries [1]

(Thousand long tons and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Dominican Republic	783	$11,615	918	$14,738	910	$15,363
Greece	-------	--------	--------	--------	58	588
Guyana	390	3,532	333	3,048	317	3,118
Haiti	399	4,286	599	8,119	617	6,183
Jamaica	6,385	92,257	7,132	109,461	7,503	97,500
Surinam	2,865	27,216	2,816	27,070	2,923	30,969
Venezuela	107	957	r 318	r 2,899	276	2,560
Other countries	47	365	44	304	16	81
Total	10,976	140,228	r 12,160	r 165,639	12,620	156,362

r Revised.

[1] Official Bureau of the Census data for Jamaican, Haitian, and Dominican Republic bauxite have been converted to dry equivalent by deducting 13.6 percent free moisture for Jamaican and Haitian and 17.7 percent for Dominican Republic in 1968; in 1969 and 1970, Jamaican is 16 percent, Haitian 12.5 percent, and Dominican Republic 17.7 percent. Other imports, which are virtually all dried, are on as-shipped basis.

Note: Excludes bauxite imported into the Virgin Islands: 1968—247,000 tons from Australia, 389,000 from Guinea; 1969—69,000 from Australia, 435,000 from Guinea; 1970—235,000 from Australia, 506,000 from Guinea.

Table 13.—U.S. imports for consumption of bauxite (calcined) by countries

(Thousand long tons and thousand dollars)

Country	1966	1967	1968	1969	1970
	Quantity	Quantity	Quantity	Quantity	Quantity
Guyana	145	157	177	175	237
Surinam	39	48	30	25	16
Trinidad and Tobago	20	9	--------	--------	1
Other countries	(1)	(1)	(1)	(1)	2
Total	204	214	207	200	256
Value	$6,005	$6,283	$6,309	$6,017	$8,852

[1] Less than ½ unit.

Table 14.—U.S. imports for consumption of alumina for use in producing aluminum, by countries [1]

(Thousand short tons and thousand dollars)

Country	1969		1970	
	Quantity	Value	Quantity	Value
Australia	1,310	$70,029	1,185	$66,278
France	-------	-------	37	1,902
Germany, West	-------	-------	18	1,403
Greece	-------	-------	27	1,230
Guyana	-------	-------	38	2,379
Jamaica	104	6,955	868	55,866
Japan	68	4,098	36	3,357
Leeward and Windward Islands	25	1,859	-------	--------
Surinam	403	23,189	346	20,122
Other countries	2	203	-------	--------
Total	1,912	106,333	2,555	152,537

[1] Excludes shipments from Virgin Islands to continental United States.

Imports of crude, dried, and partially dried bauxite into the United States (including the Virgin Islands) increased 6 percent to 13,361,000 tons, valued at $160 million, in 1970. Most of the increase came from Jamaica which provided 56 percent of the imports. Shipments from other major sources were relatively unchanged: Surinam supplied 22 percent of the total; Dominican Republic, 7 percent; Haiti, 5 percent; Guinea, 4 percent; and Guyana, 2 percent. Another 2 percent shipped from Venezuela was probably all mined in Guyana. By customs districts, 44 percent of the crude and dried bauxite entered through the New Orleans district; 32 percent through the Galveston district; 15 percent through the Mobile district; and 6 percent at St. Croix, Virgin Islands. Imports of calcined bauxite, mainly from Guyana, rose 28 percent.

Imports of alumina for use in making aluminum established a record high level of over 2.5 million tons. Although Australia remained the largest source of imported alumina, shipments from Jamaica were increased eightfold. Imports of aluminum hydroxide and other oxides not classified as "for use in making aluminum" increased to 24,387 short tons. Canada again supplied 84 percent of the total, and seven other countries shared the remainder.

WORLD REVIEW

The total bauxite production of the 27 producing countries throughout the world rose 10 percent or over 5 million long tons in 1970. The largest gains were made in Jamaica and Australia, each of which increased nearly 1.5 million tons and together accounted for 37 percent of the world output. Large increases in production also were achieved in Indonesia, India, and Greece.

Table 15.—Bauxite: World production by countries

(Thousand long tons)

Country [1]	1968	1969	1970 [p]
North America: United States [2]	1,665	1,843	2,082
Latin America:			
Brazil	309	[e] 343	[e] 490
Dominican Republic (shipments) [2]	[r] 979	1,076	1,050
Guyana [2]	3,663	4,238	[e] 4,490
Haiti [3]	[r] 439	654	621
Jamaica [2]	[r] 8,391	10,333	11,820
Surinam	5,569	5,364	5,257
Europe:			
France	2,670	2,729	2,945
Germany, West	3	3	------
Greece	[r] 1,807	1,886	2,242
Hungary	1,928	1,904	1,990
Italy	213	216	221
Romania [e]	20	[r] 49	108
Spain	6	5	[e] 5
U.S.S.R. [e] [4]	[r] 4,900	[r] 4,900	4,900
Yugoslavia	2,039	2,094	2,066
Africa:			
Ghana	280	265	292
Guinea	2,084	2,420	[e] 2,600
Mozambique	3	4	7
Sierra Leone	[r] 463	447	433
Asia:			
China, mainland [e] [5]	374	443	492
India	922	976	1,338
Indonesia	865	753	1,210
Malaysia (West Malaysia)	786	1,056	1,121
Pakistan	1	2	1
Turkey	------	1	50
Oceania: Australia	[r] 4,877	7,799	9,241
Total	[r] 45,256	51,803	57,072

[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.

[2] Dry bauxite equivalent of crude ore.

[3] Dry bauxite equivalent of ore dried.

[4] Excludes materials other than bauxite used for the production of alumina estimated as follows: Nepheline concentrates (25 to 30 percent aluminum), 1968–70—980,000 tons annually; and alunite ore (16 to 18 percent aluminum), 1968–70—980,000 tons annually.

[5] Estimates include only diasporic bauxite for production of aluminum; in addition 98,000 to 196,000 tons were produced annually for refractory applications.

Table 16.—Alumina: World production by countries

(Thousand short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada [e]	1,100	1,100	1,240
United States [2]	6,442	7,334	7,227
Latin America:			
Brazil	89	96	131
Guyana	297	334	[e] 335
Jamaica (exports)	1,017	1,274	1,862
Surinam [e]	983	1,066	1,100
Europe:			
France	1,135	1,219	[e] 1,240
Germany, East	59	59	[e] 59
Germany, West	718	749	835
Greece	246	331	344
Hungary	420	450	486
Italy	324	322	334
Norway [e]	19	12	3
Romania [e]	160	187	231
United Kingdom [e]	100	100	100
U.S.S.R. [e]	2,300	2,200	2,200
Yugoslavia	130	134	138
Africa: Guinea	585	631	661
Asia:			
China, mainland [e]	209	254	276
India [e]	270	294	360
Japan	911	1,173	1,416
Taiwan	41	49	46
Oceania: Australia	1,443	2,130	2,357
Total	18,998	21,498	22,981

[e] Estimate. [p] Preliminary.

[1] In addition to the countries listed, Czechoslovakia may produce limited quantities of alumina, but information is inadequate to make reliable estimates of output levels. Austria produces a small quantity (about 30,000 tons annually) of fused aluminum oxide, but this is excluded from the table because it is used solely for the production of abrasives.

[2] Includes Virgin Islands.

World alumina production was increased 7 percent to 23 million short tons in 1970. The United States, with 31 percent of the total output, remained the largest producer. The largest increases were at new facilities in Jamaica, Japan, and Australia. Australia became the second largest producer, surpassing the estimated production of the U.S.S.R.

Argentina.—Alto Parana Mining Co. announced that it was producing alumina on a pilot plant scale using aluminous laterites from Misiones Province. The company planned to complete a 100,000-ton-per-year alumina plant by the end of 1971.

Australia.—Australia has approximately one-third of the world's known bauxite reserves. The rapid development of these reserves to meet a growing worldwide demand has been attributed to the political stability of Australia, the high level of its economic development, an educated labor force, the high grade of much of the ore, the occurrence of the bauxite in deposits amenable to large-scale operations, and the development of larger ore ships to reduce the costs of transportation to other continents.

Comalco Industries Pty., Ltd., owned by Kaiser Aluminum & Chemical Corp. (45 percent), Conzinc Riotinto of Australia Ltd. (CRA) (45 percent), and the public (10 percent), continued to increase its bauxite production at Weipa on the Cape York Peninsula, Queensland. Shipments, which totaled over 5.5 million long tons, were made to Japan, Europe, and North America, and to the alumina plants at Gladstone, Queensland, and Bell Bay, Tasmania. Weipa is the largest bauxite-shipping port in the world, and the port facilities are being expanded. Production of abrasive-grade calcined bauxite was begun at a new 100,000-ton-per-year calcining plant at Weipa.[4] Comalco planned to construct a 770,000-short-ton-per-year alumina plant at Weipa by 1974. Subsequent expansion of this plant to much greater capacity was also planned. Production of alumina at the Gladstone plant of Queensland Alumina, Ltd., continued to increase as annual capacity neared 1.43 million tons at yearend. A further expansion of capacity to 2.24 million tons was scheduled for completion by mid-1972.

Bauxite production in the Jarrahdale area of the Darling Range, Western Australia, was increased to meet the needs of the alumina plant at Kwinana, which was expanded to a capacity of 1.37 million tons per year. The mines and plant are operated by Alcoa of Australia (W.A.) N.L. (formerly Western Aluminum N.L.), which is wholly owned by Alcoa of Australia, Ltd. The Kwinana plant supplied Alcoa's Point Henry smelter in Victoria, but most of the alumina was exported to the United States, Japan, and other world markets. Alcoa's second alumina plant in Western Australia was under construction at Pinjarra. The plant will have a capacity of 550,000 tons and was scheduled for completion late in 1972. Alumina will be shipped from new port facilities at Bunbury.

AMAX Bauxite Corp., a subsidiary of American Metal Climax, Inc., continued exploration of bauxite deposits on the Mitchell Plateau in the North Kimberly District of Western Australia. The field work was said to have already demon-

[4] Industrial Minerals. Weipa Adds to World Calcined Bauxite Capacity. No. 42, March 1970, pp. 35–37.

strated reserves of about 200 million tons of washed and screened ore averaging 47 to 50 percent total alumina and 2.5 to 3.5 percent total silica. The deposits average 12 feet in thickness and have less than 2 feet of overburden. AMAX planned to complete a 1.34 million-ton-per-year alumina plant by the end of 1974 at Port Warrender, about 15 miles north of the initial mining area. The project also includes construction of ore transportation facilities, a port, a town, and other infrastructure. A consortium of companies capable of consuming the alumina was being formed. This consortium was expected to include AMAX, Sumitomo Chemical Co., Ltd., and Showa Denko K.K. of Japan, Holland Aluminium N.V. of the Netherlands, and Vereinigte Aluminium-Werke A.G. of West Germany. Twenty-five percent of the equity in the project was being reserved for Australian participants.

Nabalco Pty. Ltd. expected to ship its first bauxite from Gove (also called Nhulambuy), Northern Territory, by the middle of 1971. The ore will be transported to the port from deposits about 13 miles away by conveyor belt. The new port will be able to handle large ore carriers, loading at a rate of 30,000 tons per day of bauxite or 20,000 tons per day of alumina. The alumina plant being constructed at Gove was expected to be in production in the second half of 1972 with an initial capacity of 560,000 tons per year. Capacity is to be doubled the following year.

At least three other bauxite-alumina projects in Australia were being studied during 1970. News, Ltd., and Broken Hill Pty. Co. Ltd. (BHP) were considering a joint venture to mine bauxite in the Darling Range, Western Australia, and to produce alumina. Reynolds Metals Co., three Japanses companies, and possibly other companies may participate in the project.

Another consortium planning to mine bauxite from the Darling Range and to construct a large alumina plant involves Colonial Sugar Refining Co. Ltd. and Hanwright Iron Mines interests. Foreign companies may have also been asked to participate in this venture.

Tipperary Land and Exploration Corp. of Texas and Holland Aluminium announced that the Péchiney Co. of France had secured an option to acquire a 20-percent interest in their consortium. Other companies may be added to this group, which reportedly had large bauxite reserves on the Cape York Peninsula and was considering erection of an alumina plant.

Ocean Resources N.L. began offshore prospecting for bauxite in the Gulf of Carpentaria off Weipa in November. The company was investigating the possible continuation of the bauxite formation between the Weipa and Gove deposits.

Brazil.—Interest in the bauxite potentiality of the Amazon basin has continued high since the discovery of high-grade ore by Alcan Aluminium Ltd. near the confluence of the Trombetas and Amazon Rivers. Alcan announced that mining and development rights had been granted by the Government. Engineering was well underway at yearend, and construction of bauxite drying and shipping facilities was to begin in 1971. Initially, Alcan will be able to load at a rate of 3,000 tons per hour directly onto ocean carriers for shipment to Canada.

The bauxite mining to aluminum production complex of Cia. Mineira de Alumínio (ALCOMINAS) near Poços de Caldas, Minas Gerais, was put into operation ahead of schedule. The alumina plant has an annual capacity of 55,000 tons. Alcoa owns 50 percent of ALCOMINAS.

France.—Péchiney and Kaiser agreed to join in the construction of a 1.1-million-ton alumina plant at Dunkirk. The plant was expected to be completed in 1974, and its capacity may eventually be tripled. Government plans call for the development of port facilities at Dunkirk capable of handling 200,000-ton ore carriers.

Germany, West.—Reynolds International, Inc. and Vereinigte Aluminium-Werke, as equal partners, formed a new company, Aluminiumoxid Stade G.m.b.H., to construct and operate an alumina plant near Stade, Lower Saxony. The first stage of construction will provide an annual rated capacity of 770,000 tons of alumina and was scheduled for completion in 1973. Future expansion may increase capacity to 2.3 million tons.

Swiss Aluminium Ltd. (Alusuisse) was planning a joint venture to build an alumina plant at Wilhelmshaven, Lower Saxony, with an annual capacity of 1 million tons of alumina. Bauxite for this operation will probably come from Guinea. The plant is to be part of a large chemical complex which will also include a chlorine-caustic plant.

Ghana.—Three groups were seeking permission to develop bauxite deposits in Ghana. The deposits in the Kibi Hills appeared to attract the greatest interest. Kaiser, through its 90-percent-owned subsidiary Volta Aluminium Co., Ltd. (Valco), intended to build an alumina plant to supply Valco's Tema reduction plant if adequate bauxite reserves are available. Japan's primary aluminum producers sent a survey team to Ghana to study the bauxite resources and the feasibility of constructing an alumina plant. Proposals to develop a major aluminum complex were also said to have been submitted to the Government by a consortium comprised of Canadian, British, Romanian, Netherlands, and Ghanaian interests.

Greece.—Bauxite production increased 19 percent in 1970 although exports declined slightly to about 1.2 million long tons valued at $9.6 million. The Government set the following export quotas for 1971: European Economic Community (EEC) countries, 450,000 tons; U.S.S.R., 450,000 tons, United States, 75,000 tons; other countries, 320,000 tons.

Three companies, Parnassos Bauxite Mining Co., G. Barlos S.A., and Eleusis Bauxite Mines Inc. were all active in bauxite exploration and drilling and in expanding bauxite mining and handling facilities. Parnassos claimed reserves of 150 million tons. The country's proved bauxite reserves were estimated at 100 million tons, with an additional 200 million tons in the probable category.

Alumina output rose to 344,000 short tons. Aluminium de Grèce, S.A. (ADG), owned 80 percent by Péchiney, accounted for all of the alumina output at its Aspra Spitia, Distomon plant. The capacity of this plant was being expanded.

Guinea.—Construction of the infrastructure for the huge Boké Bauxite Project met with delays, and initial shipments were not expected until the end of 1972. Among the bauxite processing equipment contracts that have been placed were orders for three rotary dryers with a total daily capacity of 43,000 tons and a bauxite calcining kiln of 480-ton capacity.

Several foreign concerns indicated interest in participating with the Government in developing other bauxite deposits in Guinea. The U.S.S.R., Yugoslavia, and Alusuisse were considering deposits in the Kindia, Dabola, and Tougue regions.

An expansion of the annual alumina production capacity at Compagnie International pour la Production de l'Alumine (FRIA) to 770,000 tons was completed during the year.

Guyana.—A strike over wages at Demerara Bauxite Co., Ltd. (DEMBA), a subsidiary of Alcan Aluminium Ltd. was averted in November by the intervention of the Prime Minister and the subsequent agreement by DEMBA and the mine workers' union to submit the dispute to arbitration.

Following much speculation that Guyana would attempt to acquire controlling interest in its bauxite and alumina operations, the Government announced in November that discussions for this purpose would be held with DEMBA beginning December 7. The Government sought majority interest (51 percent) and management control of the company, with assets to be valued at their written-down value for income tax purposes and payment for the acquisition to be made from future after-tax earnings of the enterprise. The discussions were still continuing at yearend. The Government indicated that it wanted similar discussions with Reynolds but no date had been set.

Haiti.—Haiti Minerals Corp. of America announced that it had made arrangements with the Haitian Government through its Development Bank for the exploration and exploitation of bauxite throughout most of Haiti under 30-year concession agreements.

Hungary.—The Government's new 5-year plan calls for bauxite production to be increased to 3 million tons per year by 1975. The new alumina production goal is 800,000 tons per year.

India.—The bauxite industry, assisted by the Geological Survey of India, re-evaluated its ore reserves in 1969. The following table summarizes the proved or indicated bauxite reserves recoverable by open pit mining methods at prevailing costs and prices, in million long tons.

Region and state	Al_2O_3		
	Plus 50 percent	45 to 50 percent	Total
East-central region:			
Madhya Pradesh	21.2	6.0	27.2
Bihar	16.8	.2	17.0
Orissa	.9	.6	1.5
Total	38.9	6.8	45.7
Southern region:			
Tamil Nadu	.6	10.0	10.6
Mysore	.2	4.9	5.1
Kerala	------	1.9	1.9
Total	.8	16.8	17.6
Western region:			
Maharashtra	12.9	51.7	64.6
Gujarat	11.7	6.3	18.0
Total	24.6	58.0	82.6
Jammu and Kashmir	1.8	9.8	11.6
Grand total	66.1	91.4	157.5

Indian Aluminium Co., Ltd., began operations at a new alumina plant at Belgaum, Mysore. The plant will use bauxite from mines in the State of Maharashtra about 35 miles away.

Indonesia.—P. N. Aneka Tambang, a state mining company, increased its bauxite production on the island of Bintan by 60 percent. Improvements in the harbor facilities enabled the company to export 1.1 million tons of bauxite. About 86 percent of the exports went to Japan, and the remainder was shipped to Canada and European customers. Aneka Tambang received $5.70 per ton, based on 53 percent alumina. Three Japanese aluminum producers were studying the feasibility of building an alumina plant on Bintan.

In November Alcoa announced that its wholly owned subsidiary, P.T. Alcoa Minerals of Indonesia, had discovered bauxite along a 300 kilometer belt extending from the Kapaus River southeast to the Djelai River in southwest Kalimantan (Indonesian Borneo). The reserves appeared adequate to support an alumina plant, but confirmation will require at least a year of additional exploration and testing.

Jamaica.—Construction was underway to add 1,450,000 tons per year of new or expanded alumina capacity by the latter half of 1972.

Revere Jamaica Alumina, Ltd. (Revere Jamaica), a subsidiary of Revere Copper & Brass Corp., Inc., a producer of primary aluminum in the United States, expected to complete construction of the 220,000-ton-per-year first stage of an alumina production plant. The ultimate planned capacity of the plant is 660,000 tons per year and is scheduled to be ready by 1977. As part of its agreement with the Government of Jamaica. Revere Jamaica also may purchase and lease bauxite lands with sufficient reserves to provide bauxite for the plant.

Alcoa Minerals of Jamaica, Inc., an Alcoa subsidiary, experienced some work stoppages on construction of its 880,000-ton-per-year alumina plant because of labor problems. The plant, which is being built at Woodside in Clarendon Parish and was originally scheduled for completion in 1971, was expected to be ready by 1972.

An additional 350,000 tons per year of alumina capacity was under construction at the 950,000-ton-per-year plant of Alumina Partners of Jamaica, Ltd. (Alpart), at Nain in St. Elizabeth Parish. Alpart is owned by Anaconda (36.8 percent), Reynolds (36.8 percent), and Kaiser (26.4 percent)—all primary producers in the United States.

A 51,000-ton self-loading bauxite ship, probably the world's largest, was put into service by Reynolds to transport bauxite from Jamaica to the United States.

Japan.—Three aluminum companies, Nippon Light Metal Co., Showa Denko, and Sumitomo accounted for all of the 1.4 million tons of alumina produced in Japan. Australia, Indonesia, and Malaysia were the principal suppliers of the bauxite used for alumina. Mitsui Alumina Co. was proceeding with plans to construct an alumina plant in southwestern Japan and expected to be in production in the latter part of 1972.

Malagasy Republic.—Péchiney reported that the deposits it located at Manantenina in the southeast part of the island probably contained over 70 million tons of bauxite.

Malawi.—A consortium including the Government, Lonrho Ltd., and Portuguese interests was studying the feasibility of producing alumina and aluminum using bauxite from Mount Mlanje in Southern Malawi. The deposits were believed to contain 60 to 100 million tons of material averaging 43 percent alumina. The development of low-cost hydroelectric power in this area was a major stimulus to renewed interest in these deposits.

Mexico.—The Secretary of National Patrimony reported the discovery of a bauxite deposit near the city of Villa Juarez, State of Puebla. Preliminary tests conducted by the Government indicated that the ore is amenable to the standard alumina extraction process with only slight modifications.

Guanos y Fertilizantes de Mexico, S.A, planned to build a plant at Salamanca, Guanajuato, to produce aluminum salts and fertilizers from alunite using a new ammonia-sulfur process.[5] According to developers of the process, the plant will be able to produce 4,400 tons of 99-percent pure alumina annually at costs competitive with plants using bauxite.

Poland.—Two alumina plants designed to use raw materials other than bauxite were reported under construction.[6] A 330,000-ton-per-year plant to use an acid process on clay was being built between Glogov and Lobin. The other plant, located near Kielce, will have an annual capacity of 100,000 tons and will produce alumina and cement by sintering and decomposing coal schists and marl.

Solomon Islands (British).—Mitsui Mining and Smelting Co. Ltd., British Solomon Islands Protectorate (BSIP) continued exploration and planning for a bauxite mine on Rennell Island. Output would be shipped to Japan.

Surinam.—Bauxite exports declined approximately 7 percent, and alumina exports rose 4 percent. Exports of both products might have been greater than they were had it not been for shipping difficulties attributed to a customs and dockworkers slowdown in November and December. The bauxite exports included 284,000 long tons of calcined bauxite. Over 90 percent of the total bauxite and 284,000 short tons of alumina were shipped to the United States.

Alcoa has agreed to join with Péchiney in a plan to mine bauxite in French Guiana and convert it to alumina in the plant of Alcoa's subsidiary, Suriname Aluminum Co. (Suralco), at Paranam, Surinam. The plan, which was subject to the approval of the French Government, would require an expansion of Suralco's plant sufficient to produce up to 500,000 tons of alumina from French Guiana ore.

The Government heard proposals from a number of foreign aluminum producers to develop the bauxite deposits in the Bakhuys Mountains in western Surinam. In July, the Government and Reynolds Metals Co. signed a statement of intent covering two projects. One project calls for 50–50 participation by Reynolds and a government development corporation in the exploration and mining of bauxite in the Bakhuys Mountains, the production of alumina, and, if a power source is ultimately developed, the construction of reduction facilities. The Government corporation has the right of first refusal on the development of new power sources by Surinam. Reynolds will provide day-to-day management of the project, while the Government will provide rail transportation to deliver bauxite to an alumina plant which will be constructed at Apoera, the dredging of the Corantijn River to enable barging of the alumina to the coast, and land for townsites. The alumina plant will have an initial annual capacity of at least 200,000 tons. The second project involves exploration and development work by Reynolds in the Coppename River area. The Government has an option to participate in any alumina or reduction plants that are built in connection with this project.

U.S.S.R.—According to reports in the Soviet press, the large alumina plant at Achinsk in Siberia was completed after a long history of construction.[7] The plant has a capacity of 882,000 tons per year and uses nephelite as its source of alumina. The ore is mined at Belogorsk, 110 miles to the southwest. Achinsk was chosen as the plant site reportedly because it is near large deposits of limestone, which is needed in the alumina process. Achinsk is located on the Trans-Siberian Railroad and much closer to reduction plants in eastern Siberia than the alumina plants in the Urals.

Yugoslavia.—New bauxite discoveries were reported near Obrovac on the Dalmation coast and near Vlasenica northeast of Sarajevo. An alumina plant of 200,000-ton-per-year capacity was expected to be completed in Bosnia-Hercegovina in 1972, and a plant of 300,000 to 600,000 tons was being planned for the Obrovac-Zadar area.

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[5] Parkinson, Gerald. Low-Grade Alunite Yields Alumina and Fertilizers Too. Chem. Eng., v. 78, No. 9, Apr. 19, 1971, pp. 83–85.

[6] Metals Week. Aluminum, Soviets Launch Major Alumina Plant. V. 41, No. 8, May 4, 1970, p. 6.

[7] Work cited in footnote 6.

TECHNOLOGY

The procedures used to strip 140 feet of overburden and obtain stabilization of spoil banks at the bauxite pits of Reynolds Mining Corp. in Arkansas were described.[8]

A patent was issued covering a method for the continuous digestion of bauxite with a sodium aluminate lye in a reaction tube.[9] The process may be used in the new alumina plant to be constructed near Stade, West Germany. Other patents were issued on new methods of removing impurities in Bayer process liquors.[10] The Bureau of Mines reported that alumina could be recovered from blends of high-alumina materials and aluminum silicate materials by the lime-soda sinter process with minimum alumina and soda losses and no gelation if alumina-to-silica mole ratios are 0.90 or greater.[11]

The National Materials Advisory Board issued a report reviewing the most promising domestic raw materials and processes for obtaining alumina from other than commercial bauxite.[12] The report concluded that the most promising method appeared to be an acid process for the treatment of clay. The report recommended that the Bureau of Mines build and operate pilot plants to test a hydrochloric acid process and a nitric acid process and that the Bureau and others continue research on the use of the dawsonite deposits associated with oil shales. The Bureau's estimates based on available data indicated that operating costs using hydrochloric or nitric acid processes to recover alumina from clay would be 25 to 35 percent more than the Bayer process treating bauxite and that fixed capital costs would be 65 to 75 percent more than Bayer process facilities.[13] Analytical results for nahcolite, dawsonite, extractable alumina, and oil yield for samples of Green River Formation oil shales from Colorado were published to permit evaluation of the deposit for possible production of shale oil, alumina, and soda ash.[14]

Efforts were continued to find methods of using the red mud residues generated in the Bayer process production of alumina from bauxite.[15] Using a carbon-lime-soda sinter process to treat the muds, the Bureau of Mines was able to recover 85 to 90 percent of the alumina values and about 80 percent of the iron. A product containing 96 percent titania was subsequently obtained from Surinam red mud sinter by extraction with H_2SO_4. Using an electric-arc furnace process, iron recoveries up to 98 percent were achieved, and alumina recoveries up to 84 percent were obtained by leaching the slags and Na_2CO_3 solution. The leached slags are possible raw materials for making portland cement. A foaming process was also developed to use colloidal red mud wastes for the production of lightweight building materials.[16]

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[8] Buturala, Frank J., and Robert A. Tinstman. Multiple Lift Stripping. Min. Cong. J., v. 56, No. 10, October 1970, pp. 55–58.

[9] Tusche, K. J. (assigned to Vereinigte Aluminium-Werke A.G.). Method for Continuous Extraction of Bauxite in a Tubular Reactor. U.S. Pat. 3,497,317, Feb. 24, 1970.

[10] Cook, G. W. (assigned to Reynolds Metals Co.). Removal if Iron from Domestic Bauxite Liquor. U.S. Pat. 3,493,327, Feb. 3, 1970.
Mercier, H., and Cohen, J. (assigned to Péchiney-Compagnie des Produits Chimiques et Électrométallurgiques). Process for Purification of Sodium Aluminate Liquors. U.S. Pat. 3,512,926, May 19, 1970.

[11] Lundquist, R. V., and D. D. Blue. Role of Alumina-to-Silica Mole Ratio in the Lime-Soda Sinter Process. BuMines Rept. of Inv. 7434, 1970, 11 pp.

[12] National Materials Advisory Board. Processes for Extracting Alumina from Nonbauxite Ores. Nat. Acad. Sci-Nat. Acad. Eng. Washington, D.C., NMAB–278, December 1970, 105 pp.

[13] Peters, F. A. Clay, a Raw Material for Aluminum. Iron Age, v. 206, No. 13, Sept. 24, 1970, pp. 76–78.

[14] Young, Neil B., and John Ward Smith. Dawsonite and Nahcolite Analyses of Green River Formation Oil-Shale Sections, Piceance Creek Basin, Colo. BuMines Rept. of Inv. 7445, 1970, 22 pp.

[15] Ban, T. E. (assigned to McDowell-Wellman Engineering Co.). Gas-Solid Reaction. U.S. Pat. 3,495,973, Feb. 17, 1970.
Fursman, Oliver C., James E. Mauser, M. O. Butler, and W. A. Stickney. Utilization of Red Mud Residues From Alumina Production. BuMines Rept. of Inv. 7454, 1970, 32 pp.

[16] Nakamura, H. H., S. A. Bortz, and M. A. Schwartz. Use of Bauxite Wastes for Lightweight Building Products. Ceramic Bull., v. 50, No. 3, March 1971, pp. 248–250.

Beryllium

By Robert A. Whitman [1]

The beryllium industry of the United States became independent of beryl ore as its sole raw material source. The new bertrandite mine opened in Utah in 1969 completed it first full year of production and successfully established the availability of beryllium from a nonberyl ore. Although the industry will continue to import beryl to satisfy part of the domestic requirements, the new mine has ample reserves and capacity to support the entire domestic industry. Further expansion will depend upon the recovery of the economy and increased utilization of the metal and its alloys in the aerospace, computer, and communications industries.

Legislation and Government Program.—Government yearend stocks of beryl, beryllium-copper master alloy, and beryllium metal are shown in table 2. Government inventories of beryl decreased 2,095 short tons during 1970, as a result of the sales from the Government stockpile.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient beryllium mineral statistics

	1966	1967	1968	1969	1970 p
United States:					
Beryl, approximately 11 percent BeO:					
Shipped from mines ---short tons--	W	W	168	W	W
Imports ---do---	2,147	9,511	3,822	6,422	4,942
Consumption ---do---	6,026	7,087	9,244	[1] 8,483	[1] 9,511
Price, approximate, per unit BeO imported, cobbed beryl at port of exportation---	$25	$30	$34	$37	$35
Bertrandite ore: Utah, low-grade, shipped from mines short tons--	-----	-----	-----	W	W
World production of beryl ---do---	4,549	5,442	7,242	8,834	8,197

p Preliminary. 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---	13,622	1,593	15,215
Excess---	2,585	3,141	5,726
Total---	16,207	4,734	20,941
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 1970.

DOMESTIC PRODUCTION

Production of beryllium metal and beryllium oxide was less in 1970 than in 1969. There was some increase in the production of beryllium copper alloy, which resulted from an increase in exports to Europe.

The first mine to produce a beryllium concentrate from ore other than beryl completed its first full year of operation in 1970. The Brush Beryllium Co. processed bertrandite ore from its Roadside mine to beryllium hydroxide at a mill near Delta, Utah. The beryllium hydroxide was then shipped to company plants in Ohio for further processing into metal, alloys, and compounds. Industry now has developed a domestic source of beryllium with reserves sufficient to allow long-term planning for use of the metal.

Kawecki Berylco Industries, Inc. (KBI) used mostly imported beryl as a raw material in 1970. KBI installed new vacuum induction melting furnaces and semicontinuous direct-chill casting units for beryllium copper and other alloys at its Reading plant. A new rolling mill can handle hot or cold metal sheet; the metal can be rolled to wider widths than previoulsy available. The research department was expanded, and a new isostatic press, that can produce larger high-density beryllium parts from shaped powder charges, was installed at Hazelton.

The Anaconda Co. mine test work on beryllium claims in Utah discontinued during 1970.

Production data on domestic beryllium raw materials and on beryllium metal, alloys, and compounds are withheld from publication to avoid disclosing individual confidential data.

CONSUMPTION AND USES

The beryllium and ceramic industries consumed 9,511 tons of beryl, including some nonberyl ore calculated to the beryl equivalent. Kawecki Berylco Industries, Inc., at Reading and Hazelton, Pa., and The Brush Beryllium Co., at Elmore, Ohio, used beryl to produce beryllium metal, alloys, and compounds. The Brush Beryllium Co. also used beryllium hydroxide derived from its bertrandite mining and processing facilities near Delta, Utah, for the same purpose.

Lapp Insulator Co., LeRoy, N.Y., and Champion Spark Plug Co., Detroit, Mich., used beryl for ceramic purposes. General Astrometals Corp., Yonkers, N.Y., fabricated beryllium components from scrap and ingot beryllium.

The U.S. Atomic Energy Commission awarded 52 contracts for beryllium parts and materials totaling $3.5 million during fiscal year 1970. By comparison, they awarded 123 contracts valued at $4.7 million during fiscal year 1969.[2]

The Brush Beryllium Co. received the initial orders for beryllium brake components for the new S3A antisubmarine aircraft and the F14 advance fighter plane being built for the U.S. Navy.

Beryllium copper alloy continued to consume the major share of beryllium. An increase in exports helped to counteract a downtrend in domestic BeCu alloy sales during 1970.

Statistics on the recovery of beryllium from scrap, though incomplete, show that 71 tons of beryllium were recovered from beryllium copper alloy mill scrap and 2 tons were recovered from old alloy scrap.

STOCKS

Consumers' stocks of hand-sorted beryl at yearend totaled 5,698 tons, compared with 5,936 tons at yearend 1969. Dealers' stocks of beryl are not reported. Stocks of bertrandite ore are company confidential data.

[2] U.S. Atomic Energy Commission. The Nuclear Industry—1970, pp. 102–104.

PRICES AND SPECIFICATIONS

Domestic beryl prices are negotiated between producers and buyers and are not quoted in the trade press. The published nominal price of imported beryl, with 10 to 12 percent BeO, c.i.f. Philadelphia, Pa., was $42 to $45 at the beginning of 1970.[3] By May, the market quote was $37 to $45. By the end of September, the market had further weakened; the quote was $37 to $40. This held to the end of the year.

Prices were published for various forms of beryllium metal, delivered, with 98-percent-pure powder at $54 to $66 per pound, 1/4-inch-diameter rod at $83 per pound, and billet at $70 per pound throughout the year. These prices were unchanged from 1969. In December a price of $102 per pound was quoted for 5-inch diameter rod.

Beryllium copper master alloy (4 percent beryllium) in 5-pound ingots was quoted at $50 per pound of beryllium content after January, a $1 raise from 1969. This price continued throughout 1970. Alloy No. 25, in strip, rod, bar, and wire form, containing 2 percent beryllium, was reported at $2.91 per pound at the first of the year. The price was increased to $3.01 on Janurary 26 and $3.05 on April 13. By August 31, the quote dropped to $3; by October 27 to $2.96; and by December 3 to $2.93. Casting ingot containing 2 to 2.25 percent beryllium in 5-pound ingots was quoted at $2.03 per pound during January; at $2.08 on January 26; at $2.12 on April 13; at $2.07 on August 31; at $2.03 on November 27; and at $2 on December 3.

FOREIGN TRADE

Beryllium exports increased 43 percent in quantity and 62 percent in value over 1969. This increase in exports of unwrought and wrought beryllium metal, beryllium alloys, and beryllium waste and scrap was due largely to increased use of beryllium copper alloy in Europe. The export gain, together with a decrease in imports, resulted in a saving of nearly $1 million in foreign exchange in contrast with 1969.

In addition to the imports listed in table 4, there were also 18 pounds of beryllium compounds valued at $13,282; 5,956 pounds of unwrought beryllium, waste and scrap valued at $383,185; and 1,138 pounds of wrought beryllium valued at $77,221, all imported from France.

[3] Metals Week, V. 41, Nos. 1–52, January–December 1970.

Table 3.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap [1]

Country	1969		1970	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Austria	524	$43	------	------
Belgium-Luxembourg	31	4	------	------
Brazil	------	------	77	$4
Canada	7,086	48	11,340	50
Denmark	67	1	140	3
France	4,446	230	9,050	295
Germany, West	4,686	39	960	121
India	44	1	------	------
Israel	15	1	17	([2])
Italy	1,809	10	44	1
Japan	2,298	72	8,671	226
Korea, Republic of	------	------	8	1
Mexico	------	------	500	2
Netherlands	2,179	13	347	2
New Zealand	------	------	16	([2])
Spain	------	------	44	2
Sweden	13	([2])	------	------
Switzerland	2,387	9	4	([2])
United Kingdom	3,366	159	10,131	314
Yugoslavia	------	------	4	([2])
Total	28,951	630	41,353	1,021

[1] Consisting of beryllium lumps, single crystals, and powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.
[2] Less than 1/2 unit.

Table 4.—U.S. imports for consumption of beryl, by customs district and countries

Customs district and country	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Philadelphia district:				
Angola	17	$7	-----	-----
Argentina	600	227	275	$107
Australia	13	6	61	26
Brazil	4,098	1,695	3,411	1,340
Burundi-Rwanda	143	55	50	18
Congo	70	27	-----	-----
Kenya	44	19	-----	-----
Malagasy Republic	78	27	34	11
Malaysia	11	4	-----	-----
Mozambique	69	30	171	67
Portugal	94	44	27	10
Romania	-----	-----	25	8
South Africa, Republic of	691	308	294	101
Spain	3	1	-----	-----
Tanzania	22	9	-----	-----
United Kingdom	6	2	-----	-----
Uganda	295	117	373	132
Western Africa, n.e.c	-----	-----	23	10
Total	6,254	2,578	4,744	1,830
New York City district:				
Brazil	-----	-----	165	68
Burundi-Rwanda	22	8	-----	-----
South Africa, Republic of	12	5	-----	-----
Uganda	-----	-----	33	13
Total	34	13	198	81
Baltimore district:				
Brazil	40	19	-----	-----
Mozambique	27	12	-----	-----
Uganda	67	26	-----	-----
Total	134	57	-----	-----
Boston district: France	-----	-----	(1)	1
Grand total	6,422	2,648	4,942	1,912

[1] Less than ½ unit.

WORLD REVIEW

India.—India, through its Department of Atomic Energy, has continued geological exploration directed toward the establishment of accurate beryl reserve data. In addition, improvement of the Government's stockpile program for beryl continued. All statistics relating to mine development, exploration, and trade were confidential because India classified beryl as a mineral strategic to its national defense.[4]

Uganda.—The total production of Uganda was divided among 80 separate mining operations. This gave an average per mine of 4 tons annually. Operations of this size are unable to sustain a development program; this makes calculation of reserves very difficult.

[4] Bureau of Mines. Mineral Trade Notes. V. 67, No. 11, November 1970, p. 8.

Table 5.—Beryl: World production, by countries [1]

(Short tons)

Country	1968	1969	1970 p
Argentina	654	571	e 570
Australia	17	2	e 2
Brazil	[2] 2,291	[2] 3,964	e 3,500
Congo (Kinshasa)	-----	160	143
India e	r 1,450	1,450	1,450
Kenya	12	3	4
Malagasy Republic	85	83	57
Mozambique	105	134	36
Portugal	141	32	15
Rhodesia, Southern	[3] 97	e 100	e 100
Rwanda	164	294	e 300
South Africa, Republic of	340	345	355
Uganda	398	316	285
U.S.S.R. e	1,320	1,380	1,380
United States (mine shipments)	168	W	W
Total	r 7,242	r 8,834	8,197

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company 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.

[2] Exports.

[3] U.S. imports.

TECHNOLOGY

A report was published on the laboratory preparation of high-purity beryllium metal by a Kroll type process, which uses sodium as a reductant. Crude commercial beryllium chloride was purified, then vaporized and reacted at the controlled rate with molten sodium to form beryllium sponge. The sponge was then purified by vacuum distillation, wet ball-milled to a fine powder, and consolidated by isostatic pressing. Evaluation of the resulting powder-metal specimens indicated that the beryllium produced was of higher purity than comparable commercial grades of the metal with more ductility though of somewhat less strength.[5]

Much of the research and development work on beryllium is concerned with fabrication and structural applications. The Editorial Committee for the Beryllium Conference held in Arlington, Va., in March 1970 recommended that all the available enginering and design information be published in a beryllium handbook.[6] Apparently all the information and experience that is required to produce reliable hardware in production quantities is extant but has not been readily available to industry.

Other material published during the year included a final report on the program to determine the application of beryllium to turbine engine components;[7] an investigation of the economics of hot isostatic pressing of beryllium parts in production quantities;[8] and a study of the effects of spark machining on beryllium.[9]

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[5] Campbell, Thomas T., R. E. Mussler, and F. E. Block. Kroll Process Beryllium. Met. Trans. V. 1, No. 10, October 1970, pp. 2881–2887.

[6] National Materials Advisory Board. Overview of Beryllium Conference. Proceedings of the Beryllium Conference. V. 1, NMAB–272, July 1970, pp. 1–7.

[7] Young, J. H. Application of Beryllium to Turbine Engine Components. Final Report AFAPL–TR–69–93, Aircraft Engine Group, General Electric Co., Evendale, Ohio. Contract AF 33(615)–2241, August 1970.

[8] Lidman, W. G., and F. K. Younger. Hot Isostatic Pressing of Beryllium. National Materials Advisory Board. Proceedings of the Beryllium Conference. V. 1, NMAB–272, July 1970, pp. 87–108.

[9] Brewer, A. W. Spark Machining of Beryllium. Rocky Flats Division, Dow Chemical Co., Golden, Colorado, Contract AT(29–1)–1106, Microstructures, pp. 25–28 (August/September 1970).

Bismuth

By Lester G. Morrell [1]

Responding to a generally tight supply and high price, the worldwide uptrend in bismuth production continued through 1970. The three domestic bismuth refiners reported total output slightly above that of 1969, thus contributing to the 1970 record high world output. Despite general imports of nearly 1 million pounds of metallic bismuth and deliveries totaling 553,000 pounds from Government stocks, U.S. consumption of bismuth in 1970 fell approximately 500,000 pounds below the average of the preceding 5 years. Consumer and dealer stocks increased from 598,000 to over 722,000 pounds during the year, and total exports of bismuth, bismuth alloys, and waste and scrap, principally to West Europe, were more than double those of 1969.

Legislation and Government Programs.—The General Services Administration (GSA) as authorized under Public Law 90–153 enacted November 30, 1967, continued disposal of surplus Government stocks of bismuth at the rate of 150,000 pounds each calendar quarter. Sales were at current market price, which remained throughout the year at $6 per pound, in ton lots; and at $6.05 per pound in quantities of 500 to 1,999 pounds. 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. Sales in each of the first three quarters were close to the authorized limit, but in the final quarter amounted to only 104,000 pounds. Total shipments from Government stocks in 1970 amounted to 553,000 pounds. As of December 31, 1970, there was a 250,954-pound uncommitted excess to the 2.1-million-pound bismuth stockpile objective.

The Office of Minerals Exploration (OME), U.S. Geological Survey, 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.

During the year the Bureau of Mines published a brief analysis of U.S. bismuth supply availability and outlook.[2]

[1] Mining engineer, Division of Nonferrous Metals.
[2] Persse, Franklin H. Bismuth in the United States. BuMines Inf. Circ. 8439, 1970, 26 pp.

Table 1.—Salient bismuth statistics

(Pounds)

	1966	1967	1968	1969	1970
United States:					
Consumption	3,199,321	2,513,652	2,347,768	2,531,959	2,209,641
Exports [1]	89,382	152,684	120,466	447,931	910,275
Imports, general	1,681,472	1,379,729	1,265,671	894,804	997,924
Price: New York, average ton lots	$4.00	$4.00	$4.00	$4.63	$6.00
Stocks Dec. 31: Consumer and dealer	651,800	659,600	621,500	597,901	[2] 721,714
World: Production	6,861,000	7,441,000	8,312,000	8,460,000	8,918,000

[1] Includes bismuth, bismuth alloys, and waste and scrap.
[2] Consumer stocks only.

DOMESTIC PRODUCTION

Most of the domestic production of bismuth is as a refinery byproduct of copper, lead, and zinc ores. The bulk of U.S. production from such primary materials was recovered at the Omaha, Neb., plant of American Smelting & Refining Co. and the East Chicago, Ind., plant of United States Smelting, Refining & Mining Co. Although details are not available, more than half of the domestic output of bismuth has probably been derived from processing imported raw materials. Bismuth recovery from scrap, alloys, chemicals, spent catalysts, and other secondary sources accounts for about 5 to 8 percent of U.S. annual production. A relatively small quantity of metallic bismuth produced at Franklin Park, Ill., by United Refining & Smelting Co. has been from secondary materials.

Because of the limited number of producers, data regarding U.S. refinery output of bismuth are withheld. Statistics on mine production have never been systematically recorded. However, a Bureau of Mines study [3] covering 10 Western States yielded estimates of 590,000 to 750,000 pounds annually in 1962–66. Recoverable U.S. reserves (measured, indicated, and inferred) of bismuth, associated with copper, lead, and zinc ores were put at 26.4 million pounds.

CONSUMPTION AND USES

Consumption of bismuth, faced with a tight supply and high price, decreased about 13 percent, compared with 1969, to 2.2 million pounds. Requirements for chemical compounds for pharmaceutical, cosmetic, and other uses were 67,500 pounds below the 1969 level of 1.25 million pounds. Metallurgical uses also declined in 1970 to 1.02 million pounds, about 80 percent of the previous year's total for this category. Reflecting lower requirements by the automotive and aircraft industries, consumption of bismuth in low-melting-point alloys and metallurgical additives was down respectively 14 and 29 percent.

Among the wide variety of bismuth chemical applications, cosmetics containing bismuth oxychloride, which imparts a "pearlescent" glow to eye shadow, hair spray, lipstick, nail polish, and powders, comprised the largest end-use market in 1969 and 1970. The continued annual consumption of around 600,000 pounds of bismuth in cosmetics is subject to the uncertainty of fashion trends. Pharmaceutical uses of bismuth call for a score or more compounds used in astringents, antiseptics, antacids, and numerous other medicinals. Annual pharmaceutical usage has been estimated at about 350,000 pounds. The use of bismuth chemicals as catalysts in the U.S. petrochemical and synthetic fiber industries has been declining since 1965 when nonbismuth catalysts were introduced.

Manufacture of low-melting-point bismuth-lead alloys accounted for the principal metallurgical use of bismuth in 1969 and 1970. The alloys are used as a holding medium for machining fragile parts, for forming dies, for foundry patterns, and for bending thinwall tubing. Other applications include the fusible elements in fire prevention, safety, and control devices.

As a metallurgical additive, bismuth is alloyed with aluminum, steel, malleable iron, and nonferrous metals to improve machinability and other working characteristic of those metals.

[3] Work cited in footnote 2.

Table 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1969	1970
Fusible alloys [1]	748,393	643,691
Metallurgical additives	509,587	361,484
Other alloys	14,123	12,998
Pharmaceuticals [2]	1,250,539	1,183,035
Experimental uses	252	109
Other uses	9,065	8,324
Total	2,531,959	2,209,641

[1] Includes 62,995 pounds of bismuth contained in bismuth-lead bullion used directly in the production of an end product in 1969 and 32,605 pounds in 1970.
[2] Includes industrial and laboratory chemicals and cosmetics.

STOCKS

Reporting of dealer stocks of bismuth, representing less than 10 percent of combined consumer-dealer stocks, was discontinued at the close of 1969. Accordingly yearend stocks shown for 1970 in table 1 are not directly comparable with figures given for previous years. Stocks of bismuth held by consumers increased from 598,000 pounds at the start of the year to a high of nearly 909,000 pounds at the end of September and then were down to 722,000 pounds at yearend. Stocks of metal held by the three domestic producers increased about 25 percent during the year.

PRICES

The delivered price of refined bismuth metal held at $6 per pound in ton lots ($6.05 in quantities of 500 to 1,999 pounds), throughout 1970.

The London market (LME) price for imported metal after reaching a record of $10 per pound c.i.f. in December 1969 declined to a range of $7.50–$7.70 by mid-February, and to $6.45–$6.60 at the end of April. After holding relatively steady through the summer months, the price resumed a downtrend in September, leveling at $5.60–$5.70 during December and January 1971.

FOREIGN TRADE

U.S. exports of bismuth metal, alloys, and waste and scrap to 19 countries totaled 910,000 pounds gross weight, and were valued at $2.33 million in 1970. The United Kingdom, France, and the Netherlands accounted for 73 percent, and other countries of Western Europe took 7 percent of overseas shipments. Japan's share of the year's exports amounted to 13 percent of the total. Other countries took the remaining 7 percent.

General imports of metallic bismuth in 1970 totaled 998,000 pounds, valued at $5.6 million, compared with 895,000 pounds, valued at $3.7 million, in 1969. Country sources of these imports are given in table 4. In addition, imports of bismuth alloys, largely lead-base materials from Mexico and Peru, amounted to 844,000 pounds, gross weight, in 1970 (1,104,000 pounds in 1969). Imports of bismuth compounds totaled 24,000 pounds in 1970, compared with 4,000 pounds in 1969. The net bismuth content of imported alloys and compounds has not been defined.

Table 3.—U.S. exports of bismuth [1]

Year	Gross weight (pounds)	Value
1967	152,684	$395,695
1968	120,466	292,245
1969	447,931	1,515,363
1970	910,275	2,332,423

[1] Includes bismuth, bismuth alloys, and waste and scrap.

Table 4.—U.S. general imports of metallic bismuth, by countries

Country	1969		1970	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Belgium-Luxembourg	-----	-----	4,415	$35
Canada	142,013	$617	109,909	642
Japan	50,229	203	24,998	168
Mexico	382,630	1,473	364,962	1,923
Netherlands	-----	-----	221	3
Peru	319,932	1,419	491,118	2,842
United Kingdom	-----	-----	2,301	23
Total	894,804	3,712	997,924	5,636

WORLD REVIEW

World production of bismuth, exclusive of data withheld for the United States and based on incomplete data for several other countries, has been estimated at the record level of 8.9 million pounds. Recorded production has doubled since the early 1950's in response to growing industrial demand and rising price. Recovery of bismuth as a byproduct from commingled ores does not permit full recognition of the mine source,

Table 5.—Bismuth: World production by countries [1]
(Thousand pounds)

Country	1968	1969	1970 p
Argentina (in ore)	7	2	e 2
Australia (in concentrates)	r 403	496	e 518
Bolivia (exports as metal and in concentrates)	1,268	1,476	1,373
Canada [2]	648	579	571
China, mainland (in ore) e	551	551	551
France (in ore)	r 141	p 143	e 143
Germany, West (in ore) e	40	26	29
Italy (metal)	[3] 18	e 22	e 22
Japan (metal)	1,595	1,531	e 2,000
Korea, Republic of (metal)	229	245	234
Mexico [2]	1,157	1,336	e 1,300
Mozambique (in ore)	5	6	e 6
Peru [2]	r 1,783	1,500	1,682
Romania (in ore) e	132	176	176
South Africa, Republic of	(4)	(4)	-----
Spain (metal)	1	(4)	-----
Sweden (in ore) e	44	33	33
Uganda (in ore)	2	e 2	e 2
U.S.S.R. (metal) e	99	110	110
United States	W	W	W
Yugoslavia (metal)	189	226	166
Total [5]	r 8,312	8,460	8,918

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] In addition to countries listed, South-West Africa also produces bismuth in small quantities. Bismuth is believed to be produced in Brazil, Bulgaria, and East Germany, but information available is inadequate to make reliable estimates of production levels.
[2] Bismuth content of refined metal and bullion plus recoverable content of concentrates exported.
[3] Production of Monteponi-Montevecchio Co., probably including production from purchased and toll materials.
[4] Less than ½ unit.
[5] Total is of listed figures only.

and output is credited to the country that produces the metal. In 1970, Japan was the principal producer of metallic bismuth, largely from imported raw materials. Peru was again the largest mine source of indigenous bismuth.

Australia.—Prior to 1967, an insignificant quantity of bismuth was recovered annually as a byproduct of tungsten and iron ores mined at several localities in Queensland and the Northern Territory. Nearly all of the bismuth credited to Australia since 1967 has been from copper-gold-bismuth ores produced by Peko Wallsend Investments Ltd. from the Juno mine at Tennant Creek, in the Northern Territory. All concentrates have been exported, mainly to Japan. In 1970 the company embarked on an expansion project to include an Outokumpu flash smelter and bismuth recovery plant at Tennant Creek. The new plant, which will treat ores from the Juno and nearby Warrego mines, is expected to start operation in 1972 or 1973 at an annual capacity of 3 million pounds of contained bismuth. Reserves of copper-bismuth ore at the new Warrego property are estimated at 5 million tons averaging 0.30 percent bismuth. The Juno mine has reserves of 275,000 tons assaying 0.65 percent bismuth and 2.2 ounces of gold per ton.

Belgium.—A substantial quantity (423,000 pounds in 1969) of metallic bismuth was recovered in processing imported base-metal concentrates, smelter products, and secondary materials by Société Géneral Metallurgie de Hoboken S.A. at Hoboken and Société des Mines et Fonderies de Zinc de la Vieille-Montagne S.A. at Balen. The great bulk of bismuth products made in these plants is exported to the consuming industries of neighboring countries.

Bolivia.—Over 95 percent of the reported 1970 exports totaling 1,373,000 pounds of bismuth in concentrates was from the Government-owned Corporacíon Minera de Bolivia (COMIBOL) mines. The Tasna mine, the country's principal bismuth producer, is one of the few mines in the world worked primarily for bismuth. Ore reserves are said to be limited.

COMIBOL contracted construction of Bolivia's first bismuth smelter in Telemayu, near Tasna, in October 1969. The smelter, a $1.1 million project, was scheduled to start operation late in 1970 at an estimated annual capacity of 600 metric tons.

Canada.—All production of bismuth in Canada is as a minor byproduct of ores mined for other metals. The more important sources in eastern Canada are the lead-zinc-copper ores of New Brunswick, the copper ores mined on the Gaspé Peninsula, and the silver-cobalt ores produced in Ontario. In western Canada, the Cominco Ltd. smelter at Trail, British Columbia, which treats ores from the company's own mines and also from numerous other domestic and foreign shippers, is the only identifiable producer. In Quebec, metallic bismuth of 95-percent purity is produced by Gaspé Copper Mines Ltd. at Murdochville, by Molybdenite Corp. of Canada Ltd. in Lacorne Township, and by Preissac Molybdenite Mines Ltd. in Preissac Township. The combined annual capacity of these three facilities is 400,000 pounds. The Trail, British Columbia, bismuth facility of Cominco Ltd. is rated at 400,000 pounds annually of 99.99+ percent purity.

France.—The two metallurgical complexes of Société des Mines & Usines de Salsigne, and Société Minière et Métallurgique de Peñarroya both produce impure bismuth metal from lead-zinc ores. The crude bullion is refined in the United Kingdom.

Japan.—Although a relatively small part of the substantial quantity of bismuth metal credited to Japan is from domestic ores, the great bulk of production, by eight Japanese metallurgical plants, is from imported base-metal ores, concentrates, and smelter products.

Mexico.—Aside from small quantities exported in lead, zinc and copper concentrates, all reported production of bismuth in Mexico has been from lead refinery byproducts recovered by Met-Mex Peñoles, S.A. (formerly Metalurgica Mexicana Peñoles, S.A.) and Asarco Mexicana S.A., at Monterrey. The bismuth is refined and marketed in two forms: Impure metal ranging from 70 to 90 percent bismuth and bars of 99.99 percent purity. Approximately 40,000 pounds of the metal is consumed annually by domestic chemical, pharmaceutical, and alloy industries. The remainder is exported, principally to the United States and the United Kingdom.

Peru.—Mine production of bismuth in Peru is credited largely to the mines in central Peru, operated by Cerro Corp. (formerly Cerro de Pasco Corporation) and numerous other smaller base-metal ore producers. The concentrate products from these mines, together with substantial quantities of similar materials imported from Bolivia, are smelted and refined in Cerro's vast metallurgical complex at La Oroya. In 1970, the company output (which accounted for over 95 percent of national production in 1969) of refined and alloyed bismuth amounted to 1.68 million pounds. Of this total, 55 percent was derived from purchased source materials. Virtually all Peruvian refined bismuth is exported to the United States, Europe, and countries of Latin America.

Boron

By A. F. Grube [1]

Sales and exports of boron minerals continued the rising trend that began in 1961 and reached a new high in 1970. Despite a significant increase in exports, there was no reported shortage of boron compounds for the domestic market. During the year, colemanite production was inaugurated from deposits located in the Death Valley area of California.

Legislation and Government Programs.—During 1970 there were no government programs or legislation proposed or enacted pertaining to boron. There were no government stocks of boron, and no government procurement programs for borates were in effect in 1970. All government stocks of boron were 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)

	1966	1967	1968	1969	1970
Sold or used by producers:					
Quantity:					
Gross weight	866	892	963	1,020	1,041
Boron oxide	462	473	519	551	562
Value	$68,209	$69,819	$76,535	$81,261	$86,827
Imports for consumption:					
Quantity	12	27	19	25	26
Value	$1,034	$1,201	$1,184	$1,668	$2,415

DOMESTIC PRODUCTION

Domestic production and sales of borate minerals increased slightly in 1970 as compared with 1969. Production and sales increased by 2 percent. As in past years, most of the domestic boron production came from open pit mines in Inyo and Kern Counties, Calif., and lesser quantities from San Bernardino County, Calif. The boron mine of the U.S. Borax & Chemical Corp., a subsidiary of Rio Tinto Zinc Corp. Ltd., remained the world's foremost source of boron. This firm produced an upgraded crude sodium borate and finished products at Boron, Calif., and processed borates at plants located at Wilmington, Calif., and Burlington, Iowa. Wilmington was the company's port of export. During 1970 the U.S. Borax & Chemical Corp. installed a new processing line and two new thickeners at its Boron plant that increased plant capacity by roughly 20 percent. The firm maintains a storage center at Botlek, the Netherlands. From this center borax is transported to other parts of Europe. Stauffer Chemical Co. and American Potash & Chemical Co. produced boron compounds as coproducts from the brines of Searles Lake in San Bernardino County, Calif.

During 1970, the Tenneco Oil Co. initiated production of calcium borate (colemanite) from its deposit in Kern County. Searles Lake Chemical Co., a subsidiary of Occidental Petroleum Corp., a third leaseholder in Searles Lake, has constructed solar ponds on its property, but there has been no production to date.[2]

[1] Industry economist, Division of Nonmetallic Minerals.

[2] Industrial Minerals. Borates: An Expansion of Production Essential. No. 34, July 1970, pp. 29–35.

CONSUMPTION AND USES [3]

About 50 percent of U.S. production of boron minerals and compounds is exported. To reduce transportation and distribution costs for overseas sales, the U.S. Borax & Chemical Corp. has replaced all its 20,000 deadweight-ton (dwt) ships with 30,000 dwt ships. An estimated 32 percent of U.S. boron consumption was used in producing heat-resistant glass, glassware, and fiberglass. About 14 percent of the boron consumed was used in the manufacture of vitreous enamel, which is used as protective and decorative coatings on sinks, stoves, refrigerators, and many other household and industrial appliances.

Borax and boric acid were used in soaps, cleansers, and detergents because of their bactericidal properties, easy solubility in water, and excellent water-softening properties. Its mild alkalinity in water and its germicidal properties make it useful in toothpaste, mouthwash, and eyewash. An estimated 16 percent was used in soaps and cleansers. In agriculture, borax was added to fertilizers to supply boron as an essential plant nutrient. Boron compounds were also used to exterminate weeds. Agricultural chemicals accounted for estimated 14 percent of the demand.

Boron compounds, being excellent fluxing materials, are especially useful in welding, soldering, and brazing metals and in metal refining. About 2 percent was estimated for this use in 1970.

Other uses of boron included compounds 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 actions fuses, as an ignitor in radio tubes, and as a coating material in solar batteries.

Water solutions of borax were used in dyeing leather and textiles, in cleansing hides and skins, in plasters and paints to prevent mildew and give a higher gloss to starches, and to prevent mold on leather textiles and citrus fruits.

Compounds of boron carbide, titanium boride, and tungsten borides are among the hardest substances known. Boron carbide was used in manufacturing abrasion-resistant parts of spray nozzles, bearing liners, and furnace parts; in the atomic energy field, it was used as nuclear reactor control elements and radiation shields and as an abrasive for ultrasonic grinding and drilling. Boron nitride is useful as a thermal insulator and as a mold lubricant in glass manufacture. Titanium boride is available in commercial quantities, but its use is not widespread.

Increasing use was being made of boron trichloride as a catalyst in silicone production, a synthesis intermediate, and an extinguishing agent for magnesium fires. Boron trifluoride was used as a catalyst for many organic reactions such as polymerization, esterfications, and alkylations.

Organic boron compounds such as borate esters were finding greater use as dehydrating agents, synthesis intermediates, special solvents, and catalysts. Boron compounds were used as plasticizers, adhesive additives for latex paint, and fire retardants in plastics and protective coatings. Boron compounds such as diborane (B_2H_6), pentaborane (B_5H_9), decaborane ($B_{10}H_{14}$), and aklylboranes are potential jet and rocket fuels. It is estimated that 22 percent of domestic boron demand was for consumption in these many miscellaneous uses.

PRICES

Prices of virtually all borate products at yearend 1970 were higher than prices posted for yearend 1969. Elemental boron prices were quoted at yearend by 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 other borates are shown in table 2.

[3] Stanford Research Institute Chemical Economics Handbook. Boron. 1970.

Table 2.—Borate prices at yearend, 1970

	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. NF $30 per ton higher in bags.

Source: Oil, Paint and Drug Reporter and industry sources.

FOREIGN TRADE

U.S. exports of boric acid in 1970 increased 44 percent in quantity and 46 percent in value compared with 1969 data.

In contrast, exports of refined sodium borate decreased 8 percent in quantity and 3 percent in value. The largest tonnages of

Table 3.—U.S. exports of boric acid and sodium borates, in 1970 [1]

Destination	Boric acid (H_3BO_3 content)		Sodium borates (refined)	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	2,747	$393	5,306	$487
Belgium-Luxembourg	39	4	376	27
Brazil	1,993	294	1,220	140
Canada	4,551	508	10,373	926
Chile	205	31	927	107
Colombia	470	70	1,493	161
Finland	------	------	409	37
France	------	------	8,949	919
Germany, West	4,601	470	1,324	124
Hong Kong	181	26	5,249	553
Indonesia	55	4	421	31
Israel	12	2	486	42
Italy	903	114	6,720	731
Japan	13,862	1,847	40,848	3,954
Korea, Republic of	208	33	1,260	91
Mexico	1,793	287	8,928	883
Netherlands	13,547	1,907	61,177	6,923
New Guinea	203	34	127	16
New Zealand	441	62	3,102	465
Pakistan	215	32	234	38
Peru	701	97	296	23
Philippines	514	72	955	111
Singapore	30	4	333	38
South Africa, Republic of	239	46	758	90
Spain	22	3	1,363	149
Sweden	172	20	1,838	182
Switzerland	------	------	1,491	122
Taiwan	295	40	2,381	205
Thailand	89	15	867	75
United Kingdom	3,140	287	898	49
Venezuela	321	53	287	26
Vietnam, South	199	28	3,003	268
Yugoslavia	------	------	5,203	557
Other	621	126	2,229	221
Total	52,369	6,909	180,831	18,771

[1] Excludes unknown quantities of crude sodium borate and other borate compounds estimated to be over 100,000 tons, but exact data are not available.

both boric acid and refined sodium borate exports were consigned to Japan and the Netherlands. Data are given in table 3. In addition to the quantities of boric acid and refined sodium borate exports listed in the table, a large quantity (more than 100,000 tons) of unrefined sodium borate was exported. These data are company confidential and may not be published.

In 1970 the United States imported 27,336 short tons of calcium borate (colemanite) valued at $831,550 from Turkey, 26 short tons of boron carbide primarily from Canada and West Germany valued at $165,665, and less than 1 short ton of boron metal from France and West Germany valued at $75,794.

WORLD REVIEW

Argentina.—During 1970, Argentina was the only South American country producing borates. Boroquimica Limitada, a subsidiary of Rio Tinto Zinc Corp., produced 35,044 short tons of borates in 1970. This represented a production increase of 51 percent over that produced in 1969. During the year, Boroquimica was developing the deposit at Tincalayu in the Solar del Hambre Muerto region of the province of Salta.

China, mainland.—Sodium borate is produced from deposits in the Iksaydam area Sinkiang Province. Data on output are not available.

Turkey.—In 1970, the production of boron minerals and compounds in Turkey totaled 428,113 short tons (analyzes about 43 percent B_2O_3), a 20-percent increase over the 1969 output of 356,569 short tons. About one-half of 1970 production was accounted for by the Turkish Government-owned company, Etibank. The remainder was produced by Türks Boraks Madençilik Co., a subsidiary of Rio Tinto Zinc Corp., and the Turkish firms Rasih ve Ihsan and Hasmettin Yakal.

It was announced in April 1970 that the Ministry of Energy and Natural Resources had cancelled the exploitation licenses on five deposits of the Türks Boraks Co. The deposits involved are located in Seyitgazi, Eskişehir and contain more than 600 million tons of ore. In the same area, Türks Boraks still holds a license for a sixth deposit, which contains from 200 to 300 million tons.

U.S.S.R.—The U.S.S.R. produce and uses boron raw materials from deposits north of the Caspian Sea. Indications are that the Soviet demand for boron compounds is about 30,000 tons per year of B_2O_3.

TECHNOLOGY

A potential market for colemanite and perhaps sodium borate is a substitute for fluorspar in the basic oxygen furnace (BOF) steel manufacturing process, for which the Flintkote Co. has been granted a patent (U.S. Pat. 3,574,597). Flintkote cooperated with a steel company in testing the process on a pilot plant scale. Results of the tests indicated that the addition of uncalcined colemanite to the charge in a (BOF) furnace accelerated the dissolution of lime in the slag, reduced the heat time, and increased the life of the furnace refractories. As the colemanite replaced fluorspar in the melt, the need for this mineral, currently in short supply, was eliminated along with the fluoride emissions from the stacks, which are potential pollutants of the atmosphere.

During 1970 two French research teams employed by Société Industrielle des Minerais de L'Quest (SIMO) and Exchangeurs d'Ions Minéraux (EDIM) discovered a new process for separating the isotope boron-10 from boron-11. As a result of this research, the two companies are building a plant for separating the isotopes. The plant will produce 200 kilograms per year of boron-10 assaying over 99-percent boron-10, which normally makes up 19.78 percent of elemental boron. This is of interest in control rods for fast-breeder reactors. In this country the isotopes have been separated by fractionation of the dimethyl ether complex of boron trifluoride.[4]

[4] Chemical Engineering. Solar Evaporation Will be Used on Searles Lake (Calif.) Brine. V. 78, No. 11, May 17, 1971, p. 77.

Bromine

By Robert T. MacMillan [1]

Increasing demand for bromine as a component of motor fuel additives, flame retardants, and sanitizers, resulted in continued growth in production of the commodity chiefly from brines in Arkansas and Michigan. Expansion of production facilities that process oilfield brines permitted Arkansas to supplant Michigan as the largest producer of bromine in 1970. Public concern over air pollution from motor vehicle exhausts may cause reduction or complete removal of lead and bromine from motor fuels. This would result in a lessening of demand for bromine. The phase out of this end use, however, is expected to be gradual.

DOMESTIC PRODUCTION

Total U.S. production expressed as elemental bromine set a record of nearly 350 million pounds in 1970, compared with 335 million in 1969. Most of the output was converted and sold as bromine compounds by the primary producers. Only about 34 million pounds or 10 percent was marketed as elemental bromine to nonproducers of bromine. The 1970 quantity, shown in table 1 as elemental bromine sold, is considerably less than the 61 million pounds sold in 1969. However, before 1970, the data for elemental bromine sold included the elemental bromine transferred among companies producing primary bromine. The quantities of bromine compounds produced were adjusted to avoid duplication in total production figures. This practice has been discontinued and the 1970 figures in table 1 are a more accurate presentation of the quantities of bromine sold as elemental bromine and used by the industry to produce compounds. Because previously published figures cannot be reconstructed to reflect the new procedure, no comparison with 1969 figures is shown.

The gross weight of all bromine compounds increased substantially in 1970 compared with 1969. Part of this increase resulted from the revised tabulating procedure, which indicated less elemental bromine being sold to nonproducers of bromine, but larger quantities of bromine compounds being produced by the industry.

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)

	Quantity	Value
Sold	33,602	$6,221
Used	316,146	54,339
Total	349,748	60,560

Table 2.—Bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

Compound	Quantity: Gross weight	Quantity: Bromine content	Value
Ethylene dibromide	291,002	247,555	$47,187
Other compounds: (Includes ammonium, sodium, potassium, ethyl, methyl, and other bromides)	93,265	66,626	41,747
Total	384,267	314,181	88,934

Seven primary bromine producing companies operated 11 plants in three states. Arkansas, with five plants, became the leading state in bromine production; Michigan ranked second. California, with one producer, ranked third. Production of primary

[1] Physical scientist, Division of Nonmetallic Minerals.

bromine in Texas was discontinued in 1969 when the Ethyl-Dow Chemical Co. plant at Freeport stopped producing ethylene dibromide from bromine extracted from seawater. Ethylene dibromide continued to be produced in Texas, however, by the Houston Chemical Co., which obtained bromine from Arkansas Chemical Co., Eldorado, Ark.

For the second consecutive year, the largest increase in bromine production occurred in Arkansas where output of the Bromet Co., which came on stream in 1969, helped to boost the state's production 47 percent in 1970. Production in Michigan and California showed little change from their respective 1969 levels. Domestic producers of primary bromine and bromine compounds in 1970 were as follows:

State	Company	County	Plant	Production source
Arkansas	Arkansas Chemicals, Inc	Union	Arkansas Chemicals	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	Michigan Chemical Corp.	Do.
California	American Potash and Chemical Corp.	San Bernardino	Trona	Searles Lake brines.
Michigan	The Dow Chemical Co	Mason	Ludington	Well brines.
	Do	Midland	Midland	Do.
	Michigan Chemical Corp	Manistee	East Lake	Do.
	Do	Gratiot	St. Louis	Do.
	Morton Chemical Co	Manistee	Manistee	Do.

CONSUMPTION AND USES

The most important use of bromine was in the production of ethylene dibromide used mainly as a lead-scavenging agent with tetraethyl lead, a gasoline antiknock additive. About 71 percent of the total bromine output was used to produce ethylene dibromide.

The Clean Air Act of 1970, which requires a 90-percent reduction of current auto emission levels by 1975, makes the large-scale production of unleaded or low-lead automotive fuels highly probable in future years. Partial or total removal of lead from gasoline would substantially reduce the demand for bromine in its most important use.

Other uses for bromine and bromine compounds included fire extinguisher charges; flame retardants for plastics, textiles, and other materials; pharmaceuticals; hydraulic and gage fluids; sanitizers; and chemicals used in agriculture, pharmaceuticals, water treatment, and other products. Increasing growth in demand for bromine chemicals other than ethylene dibromide indicated a trend toward diversification in the industry.

PRICES

Prices quoted at yearend for bromine and bromine compounds in the Oil, Paint and Drug Reporter were as follows:

	Cents per pound
Bromine, purified:	
Cases, carlots, ton lots, delivered east of Rocky Mountains	36
Zone I:[1]	
Returnable drums, carlots, ton lots, delivered	27
Tank carlots, delivered	16.75
Tank truck lots, delivered	18.5
Ammonium bromide, National Formulary (N.F.), granular drums, carlots, ton lots, freight equalized	48
Bromochloromethane:	
Drums, carlots, freight equalized	51.5
Tanks, same basis	50
Ethyl bromide 98 percent drums, carlots, freight equalized	68
Ethylene dibromide:	
Drums, carlots, freight equalized	25
Tanks, same basis	20
Methyl bromide:	
Service organization prices, 40- to 375-pound cylinders, large lots, freight allowed	57–64
Potassium bromate, 200-pound drums, carlots, freight allowed	59
Potassium bromide, N.F., granular drums	43
Sodium bromide, N.F., granular, barrels, drums, freight equalized	40

[1] Prices in Zone II are 1 cent per pound higher. Prices in Zone III are 2 cents per pound higher.

Prices were the same as those in 1969, except for a 4-cent-per-pound increase for potassium bromate, 3-cent-per-pound increases in purified bromine and potassium bromide and a 2-cent-per-pound increase in ammonium bromide.

FOREIGN TRADE

Imports of bromine compounds were substantially greater in 1970, compared with those of 1969, and included the following quantities of potassium bromide: 19,201 pounds valued at $3,295 from the United Kingdom; 16,536 pounds valued at $4,957 from France; and 72,139 pounds valued at $10,580 from West Germany. Other imports included 84,656 pounds of ethylene dibromide valued at $11,599 from Japan. These compare with 1969 imports of 330 pounds of potassium bromide from West Germany valued at $2,914, and 58,201 pounds of ethylene dibromide valued at $6,054 from Israel. No elemental bromine imports have been reported since 1964. All other imports of bromine compounds are included with other chemicals and are not separately classified.

WORLD REVIEW

Israel.—Israel reported production of 8,816 short tons of elemental bromine and 4,408 short tons of bromine compounds from the Dead Sea. Bromine Products Ltd., reported sales totaling $2.5 million in the form of pesticides.[2] Reserves of bromine in the Dead Sea have been estimated at 870 million tons.

Japan.—Bromine output in 1970 was reported to be 10,504 short tons of elemental bromine and 585 tons of potassium bromide, compared with 1969 production of 7,844 tons of elemental bromine and 591 tons of potassium bromide. A reciprocal agreement between Hitachi Chemical Co. and Michigan Chemical Corp. was approved by the Japanese Government. The agreement provides for the exchange of certain patent rights and technology between the two companies.[3]

TECHNOLOGY

An experimental study of the toxic potential of brominated vegetable oils on rats was conducted.[4] Groups of rats fed diets containing 0.5 to 2.5 percent brominated cottonseed oil showed growth retardation, impaired food utilization, and other pathological symptoms, compared with rats fed normal diets. Symptoms were more pronounced at the higher levels of bromine in the diet. A level at which no effect is observed is being determined. Brominated vegetable oils are used to adjust the density of flavoring oils and to act as clouding agents to retard layer formation, for example, in fruit juice.

Bromine is one of 11 chemical elements potentially recoverable from brines associated with petroleum production. The mineral values of these brines are not only wasted under present technology, but are a disposal problem of the petroleum industry. An investigation of the concentrations of these minerals available from oilfield brines and the economic feasability of recovering all or part of them was undertaken by the Bureau of Mines.[5]

The concentration of minerals contained in 13 different oilfield brines in several midwestern states was reported together with the concentration needed to produce $250 worth of mineral production from processing 1 million gallons of the brines. Possible recovery techniques included brine desalting processes and ion exchange. Variability of the brines both in composition and rates of flow cause some difficulties in determining quantities available, and for this reason are deterrents to large-scale oilfield brine processing.

[2] Chemical Week. Israel's Pesticide Exports Triple. V. 106, No. 23, Aug. 10, 1970, p. 36.
[3] Oil, Paint and Drug Reporter. Flame Retardant License Okayed by Japan's Government. V. 198, No. 7, Aug. 17, 1970 p. 7.
[4] Munro, I. C., E. J. Middleton, and H. C. Rice. Biochemical and Pathological Changes in Rats Fed Brominated Cottonseed Oil for 80 days. Food and Cosmetic Toxicology (Pergamon Press, Oxford, England), v. 7, No. 1, 1969, pp. 25–33.
[5] Collins, A. G. Finding Profits in Oil-Well Waste Waters. Chem. Eng., v. 77, No. 20, September 1970, pp. 165–168.

A new formulation of bromides and iodides of lithium in aqueous solution was patented for use as an absorption refrigeration fluid. The preferred composition comprised 30 to 40 percent lithium iodide and the remainder, lithium bromide. Glycerine or ethylene glycol may be used optionally in the two-pressure system.[6]

Major technical and economic problems are involved in developing the refinery capacity necessary to produce unleaded automotive fuel with the necessary octane rating. Consequently, the use of lead and bromine in gasoline additive mixtures is expected to persist for a reasonable time before new refinery equipment capable of producing motor fuel of satisfactory octane rating by catalytic reforming processes becomes available.

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[6] Hensel, W. E., Jr. and W. W. Harlowe, Jr. Assigned to Arkla Industries, Inc., Lithium Bromide-Lithium Iodide Compositions for Absorption Refrigeration System. U.S. Patent 3,524,815, Aug. 18, 1970.

Cadmium

By Burton E. Ashley [1]

Cadmium showed some signs of weakness in early 1970, but price and demand generally held steady. A decided reversal was evident in the second quarter, and by the end of the year, the cadmium market had all but disappeared compared with 1969. Production for the year declined 25 percent and producers' shipments by 47 percent. Metal imports increased 131 percent; Japan supplied 37 percent, by volume, of the cadmium metal imported. Exports in the first quarter, at over one-quarter million pounds, were up over 62 percent from the final quarter of 1969. Foreign markets disappeared during the second half of the year, and exports declined drastically to end the year at 66 percent under 1969 exports.

Industry stocks of metal at yearend were 168 percent higher than stocks at yearend 1969, the highest since 1958.

Statistics for the first quarter of 1970 gave a misleading direction to the state of the cadmium market for the remainder of the year. Planned reduction in zinc output indicated a tighter supply of byproduct cadmium. That the supply situation might be tight was substantiated by the 18.9-percent decline in cadmium metal output in the first quarter from the fourth quarter of 1969. Exports increased and imports decreased for the quarter, which also pointed to a lesser supply, as well as the considerable drawdown on stocks.

During the second quarter the statistical position reversed, except for metal production which continued to decline. Imports of metal rose by 15 percent and exports fell 64 percent. Stocks of metal producers gained over 80 percent. The third and fourth quarter figures continued the general trend started in the second quarter.

The producer price held at $4.00 per pound until cuts occurred in August, October, and December, bringing a total price decrease of 44 percent for the year.

During the last 6 months of the year, supply outstripped demand, helped by free-market imports from Japan at less than the domestic producer price.

Cadmium sales from the stockpile were negligible, and cadmium ended the year as a metal that few dealers and consumers wanted at any price.

Legislation and Government Programs.—Public Law 91–314, signed by the President on July 10, 1970, authorized the release of 4,180,000 pounds of cadmium from the national stockpile. In August the General Services Administration announced that 600,000 pounds of cadmium would be available during each calendar quarter of fiscal year 1971. Domestic consumers bought 1,600 pounds in September and 4,600 pounds in the October-December quarter. As of yearend 1970, 4,173,800 pounds remained of the total authorized for disposal. The Government price for ingots at storage depots continued at 12 cents per pound below the domestic quoted price to compensate for conversion to electroplating shapes; the new law permitted the sale of balls and sticks from the stockpile at market price.

At the end of 1970, with an allowance for inventory adjustment, there were 10,148,836 pounds of cadmium remaining in the stockpile with a market value of $22,834,881. Acquisition cost was $18,166,416, averaging $1.79 per pound.

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.

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[1] Physical scientist, Division of Nonferrous Metals.

DOMESTIC PRODUCTION

Production of cadmium metal opened the first quarter of 1970 with a decline of 18.9 percent from that produced in the final 3 months of 1969. Output declined each succeeding quarter to total 9.5 million pounds for the year; this was a decline of 25 percent from the record production of 12.6 million pounds set in 1969. Value of producer shipments followed the downward trend of production and ended the year at $24.1 million, a decided drop from shipments of $40.6 million during 1969.

Flue dust imported from Mexico contained 1.1 million pounds of cadmium for domestic recovery and refining. Imported zinc ore and small amounts of cadmium waste and scrap from Mexico and Japan also provided cadmium for domestic recovery.

Cadmium content of sulfide compounds produced (which includes lithopone and cadmium sulfoselenide) declined during the year to 2.1 million pounds, 12.4 percent below the 1969 level.

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 1966–70; table 2 refers to sulfide output during the same period.

Table 1.—Salient cadmium statistics
(Thousand pounds)

	1966	1967	1968	1969	1970
United States:					
Production [1]	10,460	8,699	10,651	12,646	9,465
Shipments by producers [2]	11,792	9,606	11,244	12,978	6,848
Value ... thousands	$26,771	$24,665	$28,409	$40,636	$24,163
Exports	379	691	530	1,085	373
Imports for consumption, metal	3,358	1,587	1,927	1,078	2,492
Consumption	14,780	11,578	13,328	15,062	9,186
Price: Average [3] per pound	$2.42	$2.64	$2.65	$3.27	$3.57
World: Production	28,643	29,069	33,105	38,653	35,245

[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.

Table 2.—Cadmium sulfide [1] produced in the United States
(Thousand pounds)

Year	Sulfide [2] (cadmium content)
1966	2,267
1967	1,536
1968	2,457
1969	2,439
1970	2,137

[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 9.2 million pounds. Compared with the 1969 figure, consumption in 1970 decreased 39 percent. Government sales in 1970 at 6,200 pounds were negligible when compared with the 2.8 million pounds of Government sales in 1969 (table 3).

The Bureau of Mines does not sponsor an annual survey of cadmium uses, so pertinent figures must be estimated. Electroplating is the most important single use

Table 3.—Apparent consumption of cadmium
(Thousand pounds)

	1969	1970
Stocks—beginning	1,099	1,432
Production	12,646	9,465
Imports, metal	1,078	2,492
Government sales	2,756	6
Total (supply)	17,579	13,395
Exports	1,085	373
Stocks—end	1,432	3,836
Apparent consumption	r 15,062	9,186

r Revised.

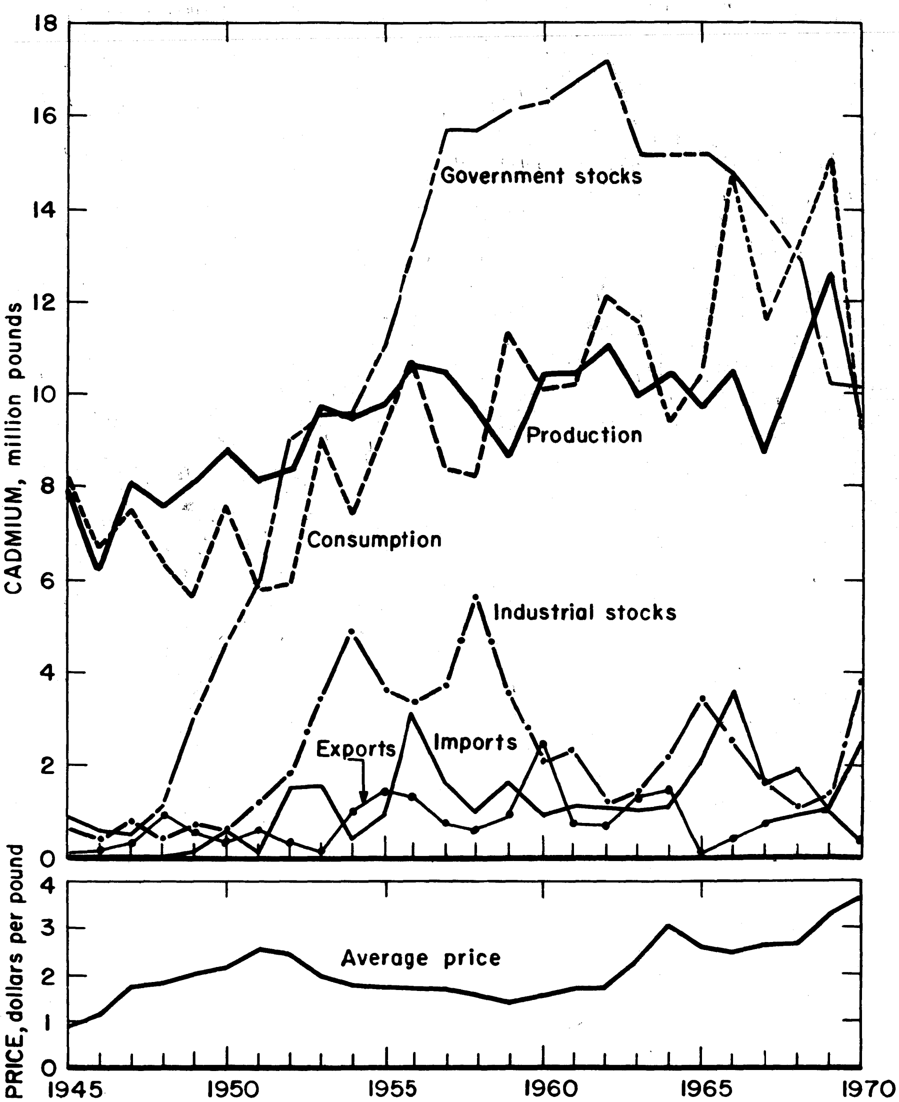

Figure 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in the United States.

for cadmium and is thought to account for 45 to 60 percent of annual demand. One industry source[2] estimated that platers consumed 5 million pounds in 1970, down from an estimated 6.5 million pounds in 1969.

Cadmium plating of parts used in motor vehicles, airplanes, and boats is important from a standpoint of resistance of the metal to corrosion and its attractive finish. Cadmium plating of small hardware parts, fasteners, and small home appliances constitutes a popular use.

Cadmium compounds, manufactured from the metal, have important uses as colorants and as stabilizing agents in the manufacture of vinyl plastics. Cadmium as a stabilizer has not been approved for plastics used in food packing, whereas tin and some other stabilizing agents are permitted.

Cadmium compounds used as colorants contribute bright yellow, red, and orange shades to plastics, printing inks, and pigments.

Cadmium is also used in the manufacture of primary batteries in both sealed and vented cells. Such batteries have a variety of uses as a source of power in aircraft, hand tools, and communication equipment.

Other requirements extend over a wide range including phosphors for television picture tubes and night-sighting devices. Small but important uses are also as an alloy for hardening copper, fusible alloys, solders, and as electrical contacts for switches and relays.

STOCKS

Yearend industry stocks of cadmium metal increased to 3.8 million pounds, a rise of 168 percent over like stocks at yearend 1969. Industry stocks of cadmium in compounds rose 9 percent. The greatest rise in metal stocks was found in the inventory of producers and distributors. Table 4 shows details of industry stocks held on December 31, 1969, and 1970.

Table 4.—Industry stocks, December 31

(Thousand pounds)

	1969		1970	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	708	W	3,325	W
Compound manufacturers	492	r 777	157	867
Distributors	r 232	r 45	354	33
Total	r 1,432	r 822	3,836	900

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Compound manufacturers."

PRICES

The 1969 yearend domestic price of cadmium in lots of 1 ton held steady at $4 per pound until August 7, 1970, when it was lowered to $3.25 per pound. A further price cut to $2.75 a pound occurred on October 6, because of soft European demand and a buildup of Japanese stocks; the combination of soft demand and growing stocks resulted in a substantial increase in the U.S. imports of free-market metal. As U.S. producer stocks and imports continued to rise in the fourth quarter of 1970, the price again decreased to $2.25 effective December 17. It was reported at yearend 1970 that free-market cadmium could be acquired at less than $2 per pound. There were few takers. The average price for the year was calculated at $3.75 per pound. Table 5 shows the 1970 domestic price range of cadmium to consumers.

On the London market, prices held at $3.95 per pound until about mid-August,

[2] Baker, Crosby. Cadmium. Eng. and Min. J. V. 172, No. 3, March 1971, p. 100.

when a decline to $3.23 was registered. In mid-October the price again fell to $2.76 per pound, which continued until yearend. The French price started the year at $4.43 per pound and declined steadily ending the year at $2.05 per pound. The price in Italy followed the same downward general trend, starting the year at $4.19 per pound and ending at $2.42 per pound in December.

Table 5.—Cadmium prices 1970
(Per pound)

Date	Producer to consumer: 1-ton lots	Producer to consumer: Less than 1-ton lots
Jan. 1	4.00	4.05
Aug. 7	3.25–4.00	3.30–4.05
Aug. 13	3.25	3.30
Oct. 6	2.75–3.25	2.80–3.30
Oct. 13	2.75	2.80
Dec. 17	2.25–2.75	2.30–2.80
Dec. 21	2.25	2.30

FOREIGN TRADE

Slack world demand for cadmium was reflected in the 66-percent decrease in U.S. exports during 1970. First quarter exports held well at 226,229 pounds, but declined rapidly to 29,214 pounds in the fourth quarter. Exports for the year totaled 373,000 pounds. The United Kingdom received 48 percent; Netherlands, 17 percent; West Germany, 16 percent; France, 8 percent; and Italy, 3 percent. The remaining 8 percent was distributed among 13 other countries.

Cadmium metal imports of 2.5 million pounds came from 18 countries. In terms of quantity, the chief sources of U.S. supply were as follows, in percentage of total imports: Japan, 37; Australia, 13; Peru, 12; Mexico, 10; Canada, 9. Imports from Japan at 932,000 pounds, increased over 500 percent compared with 1969.

Imports of 1.1 million pounds of cadmium-containing flue dust from Mexico were about equal to 1969 imports.

The import duty on cadmium metal was reduced from 2 cents per pound to 1 cent per pound effective January 1, 1970, in accord with decisions negotiated under the General Agreement on Tariff and Trade. Import of flue dusts continued duty free. Cadmium imports from Communist bloc countries, except Yugoslavia, were subject to a duty of 15 cents per pound.

Table 6 shows U.S. exports of cadmium for 1968–70. 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
1968	530	$1,400
1969	1,085	3,254
1970	373	997

Table 7.—U.S. imports for consumption [1] of cadmium metal and cadmium flue dust, by country
(Thousand pounds and thousand dollars)

Country	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Cadmium metal:				
Australia	186	$429	319	$854
Belgium-Luxembourg	1	3	165	522
Bulgaria	-----	-----	17	49
Canada	398	1,290	212	825
Ecuador	-----	-----	2	8
France	-----	-----	32	119
Germany, West	43	169	36	100
India	-----	-----	3	10
Italy	-----	-----	59	166
Japan	148	474	932	2,705
Mexico	43	183	259	996
Netherlands	-----	-----	46	158
Peru	173	389	303	948
South Africa, Republic of	72	211	56	201
Spain	-----	-----	11	21
United Kingdom	14	18	13	41
U.S.S.R	-----	-----	22	61
Yugoslavia	-----	-----	5	16
Total	1,078	3,166	2,492	7,800
Flue dust (cadmium content): Mexico	1,115	1,495	1,111	2,438
Grand total	2,193	4,661	3,603	10,238

[1] In 1969, general imports and imports for consumption were the same; in 1970, general imports were 2,503,081 pounds ($7,827,166) the difference was reflected in Japan.

WORLD REVIEW

World smelter output of cadmium in 1970 amounted to 35.2 million pounds, a 9-percent decrease from the revised total for 1969. The United States accounted for 27 percent of world production, followed by Japan, 15 percent, U.S.S.R., 15 percent, West Germany and Italy, 6 percent each, and Canada, 5 percent; the remaining 26 percent was produced by 20 other countries.

Apparent consumption of cadmium in the United States in 1970 was equivalent to about 26 percent of world production; this was a decided decrease from the 40 percent of world supply consumed in 1969.

World output of cadmium in terms of slab zinc produced averaged 8.0 pounds per ton of slab zinc in 1970 compared with 7.0 pounds per ton of slab zinc produced in 1969.

Table 8, showing world smelter production of cadmium, is not a true reflection of cadmium occurrence around the world. Not all countries producing cadmium in ores and flue dust produce refined metal, and many countries which produce cadmium in the metallic form recover it from imported cadmium-bearing material.

Table 8.—Cadmium: World smelter production, by country [1]

(Thousand pounds)

Country	1968	1969	1970 p
North America:			
Canada	r 2,114	p 2,124	e 1,870
United States [2]	10,651	12,646	9,465
Latin America:			
Mexico	446	462	e 470
Peru	378	371	e 375
Europe:			
Austria	r 44	55	e 55
Belgium	r 1,764	1,984	e 1,990
Bulgaria e	440	440	440
France	r 1,217	1,153	e 1,080
Germany, East e	26	26	26
Germany, West	754	1,746	e 2,080
Italy	551	930	e 1,000
Netherlands e	r 310	310	310
Norway	192	198	e 210
Poland e	915	925	990
Romania e	110	130	180
Spain	154	176	e 175
U.S.S.R. e	4,850	5,100	5,200
United Kingdom	r 452	541	701
Yugoslavia	r 436	375	e 400
Africa:			
Congo (Kinshasa)	705	e r 800	e 800
South-West Africa [3]	r 371	422	e 440
Zambia	25	14	e 15
Asia:			
India	90	130	e 70
Japan	4,839	6,096	e 5,313
Korea, North e	230	240	240
Oceania: Australia	r 1,041	1,259	e 1,350
Total	r 33,105	r 38,653	35,245

e Estimate. p Preliminary. r Revised.

[1] Table gives unwrought metal production from ores, concentrates, flue dusts, and other materials, both of domestic origin and imported. Sources generally do not indicate if secondary metal (recovery from scrap) is included or not; where known, this has been indicated by footnotes. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, London) and 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

Metadalic of Crawley (Sussex), of the Curzon Industrial Group, marketed a cadmium plating solution which was developed for use by the Dalic brush-plating process. Called cadmium 2022, the solution, according to claims, can be applied to high tensile steels without the risk of hydrogen embrittlement; the process also avoids strip down and heat treatment requirements that are normally needed after conventional bath plating.[3]

L. Domnikov described a method for cadmium-plating of parts in noncyanide baths.[4]

Reference to experimental work with cadmium is found in The Engineering Index, a monthly publication of Engineering Index, Inc., United Engineering Center, 345 East 47th St., New York, N.Y. 10017. Developments in cadmium technology are frequently referred to in Zinc Abstracts, published monthly by the Zinc Institute Inc., 292 Madison Avenue, New York, N.Y. 10017.

[3] Metal Bulletin (London). New Cadmium Solution. No. 5568, Jan. 22, 1971, p. 20.

[4] Domnikov, L. Plating From Non-Cyanide Cadmium Baths. Metal Finishing. V. 67, No. 11, November 1969, pp. 62–64.

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 four 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 four companies in Michigan recovered 632,000 tons of 75-percent-equivalent calcium-magnesium chloride valued at $15,225,000 from brine. Producers were: The Dow Chemical Co. at Ludington and Midland, Mich.; Wyandotte Chemicals Corp. at Wyandotte, 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.

The Calcium Chloride Inst., a national trade organization headquartered in Washington for the past 25 years was disbanded.

Wyandotte Chemicals Corp. discontinued production of calcium chloride at Wyandotte, Mich. in December 1970.

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, and straight calcium chloride below 10°F. Other important uses were as a deliquescent in dust control for roads, and as an accelerator for concrete.

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[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. Computed on a 75-percent-equivalent basis, the value of calcium-magnesium chloride f.o.b. plant in 1970, was $24 per ton. On the same basis, synthetic materials sold for $33 per ton.

Table 1.—Price quotations for calcium chloride in 1970

(Per short ton)

Grade	Jan. 5	Dec. 28
Flake or pellet, 94–97 percent [1]	$48.25	$52.50
Flake, 77–80 percent [1]	39.50	42.50
Powdered, 77 percent minimum [1]	46.00	51.00
Liquor, 40 percent [2]	16.00	16.50
Granulated, U.S.P.[3]	580.00	580.00

[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, 1970; v. 198, No. 26, Dec. 28, 1970.

FOREIGN TRADE

Total imports of calcium and various calcium compounds were 183,286 tons valued at $9,537,000 in 1970.

Eighty-two tons of calcium metal were imported from Ontario, Canada. The 8,280 tons of calcium chloride imported came principally from Canada, and Belgium, and were 10 percent less in quantity than in 1969.

Other imports included 52,420 tons of calcium nitrate from Norway, West Germany, Sweden, Canada, and Belgium; 33,164 tons of dicalcium phosphate from Belgium, Canada, and West Germany; 27,336 tons of calcium borate from Turkey; 18,649 tons of calcium carbide from Canada; 15,793 tons of calcium cyanide from Canada and Mexico; 13,658 tons of whiting from France, the United Kingdom, Belgium, Switzerland, and West Germany; 7,750 tons of calcium cyanamide; 1,714 tons of precipitated calcium carbonate; 922 tons of calcium hypochlorite; 15 tons of calcium sulfate; 10 tons of calcium tungstate; and 3,493 tons of miscellaneous calcium compounds.

Table 2.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value	Short tons	Value
1966	85,941	$72,176	2,499	$81,012
1967	423,631	370,407	4,385	157,570
1968	137,251	120,416	14,069	522,680
1969	r 662,200	r 619,000	9,226	349,998
1970	164,769	141,125	8,280	359,096

r Revised.

Table 3.—U.S. imports for consumption of calcium chloride, by countries

Country	Short tons	Value
Canada	6,233	$247,032
Belgium	1,438	45,375
United Kingdom	235	6,193
France	220	43,324
Japan	102	4,200
West Germany	52	12,972
Total	8,280	359,096

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.

Carbon Black

By Richard B. Smith [1]

Production of carbon black decreased slightly in 1970 from an alltime high point in 1969. Carbon black shipments were down 4.4 percent, and producers' stocks increased 42.3 percent at yearend to a 12-year high.

The trend of increasing percentages of furnace black production continued in 1970 when 96.1 percent of all carbon black production was by the furnace process. Channel black production decreased from 4.5 percent in 1969 to 3.9 percent of total carbon black production in 1970. Exports of carbon black declined 1.8 percent below 1969 levels; domestic sales decreased 4.6 percent.

The rubber industry continued as the leading user of carbon black in 1970. Sales for use in the manufacture of rubber accounted for 93.8 percent of total domestic sales. Preliminary data for passenger car tire production, which accounts for 87 percent of all tires produced, indicated an 8.9 percent drop from 180.6 million tires in 1969 to 164.6 million in 1970. Passenger car tire shipments decreased 4.9 percent to 168.6 million in 1970.

The carbon black industry produced at 78 percent of capacity in 1970, down from 81 percent in 1969. The principal changes in capacity occurred in Alabama and Ohio, where two new plants contributed to a net gain of 243,991 pounds per day in U.S. capacity. Total capacity of U.S. carbon black plants in 1970 was 10,282,630 pounds daily, an increase of 2.4 percent over capacity in 1969.

Yearend 1970 inventories increased 42.3 percent above 1969 levels as production exceeded shipments by 89 million pounds. Producers' stocks of furnace black led channel black 274 million pounds to 22 million pounds, respectively, at yearend. Total producers' stocks were 296 million pounds at the end of 1970. The average value of carbon black at the plant in 1970 was 7.58 cents per pound, up from 7.26 cents in 1969.

The volume of natural gas used in the manufacture of carbon black declined 12.6 percent below the 1969 level, whereas total production of carbon black declined only 1.1 percent. This reflects the trend toward production of smaller percentages of channel black, manufactured from natural gas, and larger percentages of furnace black, manufactured from liquid hydrocarbon. The amount of liquid hydrocarbon used in 1970 was down less than 0.1 percent from the amount in 1969.

Yields of carbon black produced from liquid hydrocarbons increased in 1970; yields from natural gas decreased. Each gallon of liquid hydrocarbon consumed yielded an average of 4.87 pounds of carbon black, up from 4.78 pounds in 1969. The yield from natural gas in 1970 was 6.20 pounds of carbon black per 1,000 cubic feet of gas consumed, compared with 6.28 pounds in 1969.

[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)

	1966	1967	1968	1969	1970
Production:					
Channel process	153,117	149,420	142,948	132,471	113,548
Furnace process	2,418,435	2,334,420	2,668,858	2,830,790	2,817,605
Total	2,571,552	2,483,840	2,811,806	2,963,261	2,931,153
Shipments:					
Domestic sales	2,277,595	2,216,145	2,588,402	2,777,949	2,649,521
Exports	297,281	236,035	263,122	196,203	192,636
Total	2,574,876	2,452,180	2,851,524	2,974,152	2,842,157
Losses	1,236	559	359	5,259	929
Producer stocks Dec. 31	233,145	264,247	224,170	208,020	296,087
Value:					
Production thousand dollars	$184,308	$178,158	$205,849	$215,120	$222,271
Average per pound cents	7.17	7.17	7.32	7.26	7.58

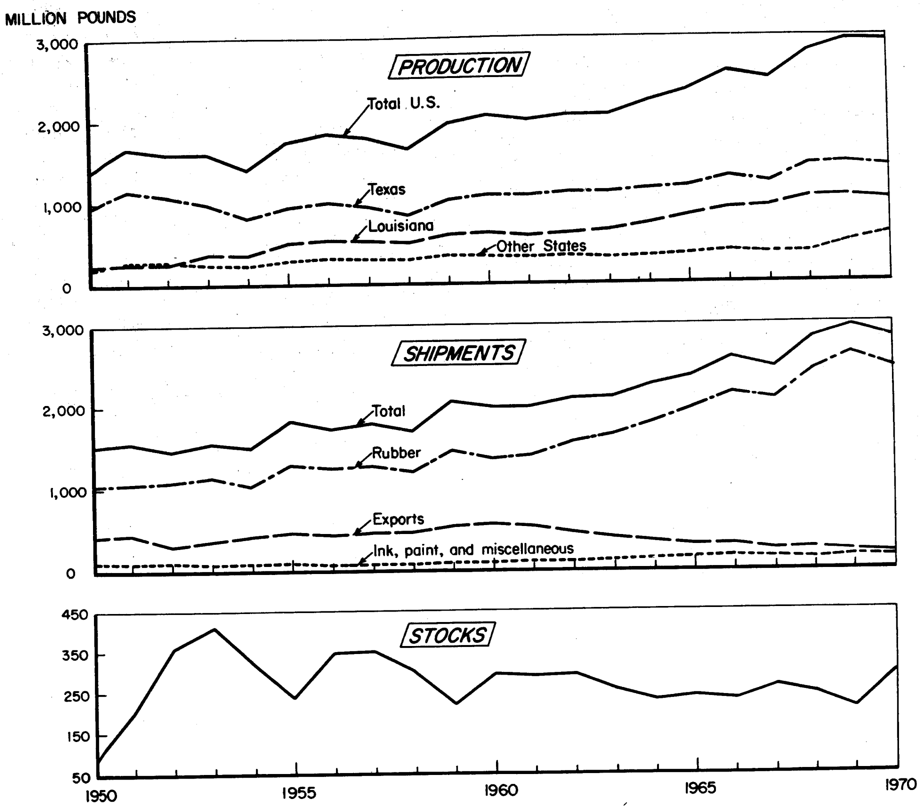

Figure 1.—Production by States, shipments by use, and exports, and stocks of carbon black.

PRODUCTION AND CAPACITY

Production by States.—Production of carbon black in 1970 totaled 2,931.2 million pounds, a decrease of 32.1 million or 1.1 percent below the 1969 level. Texas and Louisiana, which supply more than 80 percent of U.S. production, decreased their output 3.2 and 6.1 percent, respectively, from 1969 to 1970. This decrease was almost offset by a 16.3-percent increase in carbon black production from other States. Significant changes in production occurred in 1970 in Alabama and Ohio, where new carbon black plants became operational. West Virginia production was up 87.8 percent, and Kansas and New Mexico were down 18.9 and 21.3 percent, respectively.

Production by Grades and Types.—The seven major grades of carbon black produced by the furnace process, plus thermal black, comprised 96 percent of U.S. production in 1970. The balance was produced by the channel process, which continued its long-term trend by decreasing 14.3 percent below the 1969 level to 113.5 million pounds in 1970.

In the furnace category, high abrasion furnace (HAF) grade constituted the largest single grade produced in 1970 and accounted for 29 percent of total furnace black. Production of HAF grade increased from 595 million pounds in 1965 to 827 million pounds in 1970, an increase of 39 percent. Second in quantity produced is the intermediate abrasive furnace (ISAF) grade, which comprised 19.4 percent of furnace black production in 1970. During the interval 1965–70, output of ISAF grade increased from 504 million to 546 million pounds, or 8.2 percent. This growth rate was less than the 27.7-percent growth in the combined production of all grades of furnace black during the same period.

Production of channel blacks declined owing to reduced sales in its principal uses; inks, pigments, mechanical goods, natural rubber, off-the-road tires and other types of truck tires.

Number and Capacity of Plants.—Although the total number of carbon black plants decreased by one in 1970, the total capacity of all plants increased 2.4 percent, owing principally to the completion of new plants in Alabama and Ohio.

The capacity of carbon black plants in Texas decreased from 54 percent of the U.S. total in 1960 to 45 percent in 1970. During the same period plant capacity in Louisiana increased from 28 percent of the U.S. total to 34 percent. Plants in other States increased from 18 percent to 21 percent of U.S. capacity.

In 1960 there were 15 channel black plants and 27 furnace black plants in the United States. By 1970 there were only four plants using the channel process and 33 furnace plants. The 37 plants had a total capacity in 1970 of 10.3 million pounds per day, or 59.8 percent more capacity than the 42 plants had in 1960.

Materials Used and Yields.—In 1970 the amount of carbon black manufactured from liquid hydrocarbons was up 1.7 percent from the 1969 level of 2,507 million pounds. The consumption of natural gas for this purpose was down 12,367 million cubic feet, or 12.6 percent. Yields from liquid hydrocarbons in 1970 averaged 4.87 pounds of carbon black per gallon used, up from 4.78 pounds per gallon in 1969. Natural gas yielded 6.2 pounds per thousand cubic feet, a 1.3-percent decrease from 1969.

The average value of natural gas used to manufacture carbon black in 1970 was 2.65 cents per pound of black, or 76 percent more than the average cost of using liquid hydrocarbons.

CONSUMPTION AND USES

Domestic sales of carbon black decreased in 1970 by 128 million pounds, or 4.6 percent; exports decreased 3.6 million pounds, or 1.8 percent. Sales to the rubber industry, which represent 94 percent of domestic sales, were down 5 percent to 2,486 million pounds in 1970.

Sales of carbon black to the ink, paint, and paper industries also declined in 1970. Sales to manufacturers of ink decreased 0.3 percent, and sales to the paint industry dropped 18 percent. Carbon black sales to the paper industry continued its trend by declining 20 percent below the 1969 level, or 48 percent below the 1963 level of sales. Sales of carbon black to the plastics industry are included in table 7 under "Miscellaneous" sales, the only sales category which gained in 1970.

STOCKS

Inventories of carbon blacks increased 88 million pounds in 1970, with an increase of 4 million pounds of channel black and 84 million pounds of furnace black. Channel black stocks increased 19 percent over 1969 levels. Stocks of the general purpose furnace (GPF) type increased 26.8 million pounds, or 134 percent. Semireinforcing furnace (SRF) and thermal types increased 13.4 and 14.1 million pounds, respectively. The only grade having a decline in producers' stock in 1970 was high modulus furnace (HMF), which dropped 470 thousand pounds, or 18.7 percent.

FOREIGN TRADE

In 1970 carbon black exports totaled 192.6 million pounds, the lowest level since 1945. During the intervening 24 years exports grew in both quantity and value until a high level 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 65 percent and in value by 51 percent. The value of carbon black exports reached a low of $22.9 million in 1969, from which it increased 7 percent in 1970 to $24.5 million.

Exports of carbon black in 1970 consisted of 75 percent furnace black, up from 70 percent in 1969. Over the past 10 years furnace black has comprised 70 to 80 percent of total carbon black exports, the balance being channel black.

European countries are by far the best customers for U.S. exports of carbon black. They accounted for 58 percent of the quantity and 59 percent of the value of total exports in 1970. More than 84 percent of U.S. exports to Europe were received by five countries: France, the United Kingdom, West Germany, the Netherlands, and Italy. Canada uses 60 percent of all U.S. carbon black exported to Western Hemisphere countries.

In 1970 most of the carbon blacks imported into the United States were specialty blacks. About 5.2 million pounds of acetylene black was imported from Canada, and another 644,000 pounds came from East Germany. About 541,000 pounds of bone black was supplied by East and West Germany and the United Arab Republic. No lampblack was imported in 1970.

WORLD REVIEW

World production of carbon black increased in 1970 by 175.5 million pounds over the 1969 level, with 95 percent of the gain attributable to three countries. Japan accounted for 43 percent of the gain by producing 650.5 million pounds of carbon black in 1970, up 13.2 percent from the 1969 level of 574.5 million pounds. West Germany was responsible for 28 percent of the gain in world production from 1969 to 1970, and was the third highest producer after the United States and Japan. The third country responsible for the gain in world production, Italy, increased its output 18 percent to 272.4 million pounds in 1970, which represented 24 percent of the gain in world production. The largest increase in carbon black production during the period 1968–70 occurred in Japan, where, its 1970 production of 650,511,000 pounds was 35 percent higher than its output in 1968.

TECHNOLOGY

Carbon black, a petrochemical, is an extremely fine soot, primarily carbon (90 to 99 percent), which contains some oxygen and hydrogen. Oil furnace blacks may also contain small amounts of sulfur. The furnace process, which accounts for 96 out of every 100 pounds produced, breaks down into three different processes: Oil furnace, gas furnace, and thermal. Brief descriptions of these processes, and the channel process follow.

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 blacks 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.

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.

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 plants 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.

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 new process reportedly is being developed to convert old tires into carbon black. The process thermally decomposes tires and converts them at the rate of one-half ton of carbon black produced for every ton of old tires consumed. Road tests have been conducted on tires containing carbon black made by the process. Reportedly, tire wear is equal to that of tires containing ordinary carbon black.

The basic raw materials for carbon black are natural gas and oils; hence, most carbon black producing plants have been located near a fuel and raw material supply in southern Louisiana and in the Texas Panhandle. The carbon black is transported from there to the rubber plants. Recently, however, the carbon black industry has begun to change its policy by building new facilities near the largest customers, the rubber manufacturers.

Table 2.—Carbon black produced from natural gas and liquid hydrocarbons in the United States, by States

(Thousand pounds)

State	1966	1967	1968	1969	1970	Change from 1969 (percent)
Louisiana	899,178	923,286	1,031,349	1,045,902	982,416	−6.07
Texas	1,296,292	1,214,349	1,426,307	1,442,033	1,395,851	−3.20
Other States	376,082	346,205	354,150	475,326	552,886	+16.32
Total	2,571,552	2,483,840	2,811,806	2,963,261	2,931,153	−1.08

Table 3.—Production and shipments of carbon black in the United States in 1970, by months and grades of furnaces

(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	24,664	1,177	45,026	27,764	69,700	1,841	51,282	21,280	242,734	11,648	254,382
February	22,048	595	41,488	29,459	68,199	1,575	49,326	15,971	228,661	10,632	239,293
March	28,227	1,279	41,313	29,140	68,610	2,361	56,873	25,358	253,161	11,940	265,101
April	27,008	754	43,569	28,975	71,649	1,788	50,374	28,534	252,651	9,839	262,490
May	27,010	1,071	34,233	24,437	63,046	2,938	44,623	31,183	228,541	9,726	238,267
June	24,304	201	32,419	26,181	68,360	1,373	33,532	28,973	215,343	9,267	224,610
July	22,463	1,596	49,490	22,234	67,003	1,947	47,760	30,356	242,849	10,329	253,178
August	23,880	279	43,378	25,591	68,577	2,496	43,007	31,451	238,659	9,506	248,165
September	17,939	794	50,120	23,643	63,074	2,673	42,851	23,605	224,699	9,366	234,065
October	19,831	410	40,397	26,237	75,226	3,155	41,601	29,096	235,953	9,180	245,133
November	17,500	583	44,522	20,266	69,420	2,458	45,498	23,923	224,170	6,159	230,329
December	23,308	736	44,246	23,886	74,458	2,653	38,918	21,979	230,184	5,956	236,140
Total	278,182	9,475	510,201	307,813	827,322	27,258	545,645	311,709	2,817,605	113,548	2,931,153
SHIPMENTS (including exports) [9]											
January	24,606	770	45,740	30,797	71,999	1,855	55,160	23,570	254,497	12,299	266,796
February	23,223	936	42,156	29,010	67,315	1,691	52,072	23,757	240,160	10,821	250,981
March	26,135	1,235	41,451	29,610	67,582	2,510	54,028	27,678	250,229	13,241	263,470
April	24,066	618	38,532	27,317	69,168	2,243	50,634	31,068	243,646	10,555	254,201
May	20,528	935	27,904	19,786	62,879	1,734	35,667	29,809	199,242	7,800	207,042
June	21,716	822	36,348	24,688	61,823	2,348	37,208	27,974	212,927	9,100	222,027
July	20,585	708	44,615	26,230	71,226	2,034	44,864	26,513	236,775	9,467	246,242
August	19,414	643	39,999	23,130	63,937	2,358	38,873	22,082	210,436	7,665	218,101
September	20,296	988	43,591	23,608	66,753	2,374	42,549	23,311	223,470	7,397	230,867
October	20,858	873	43,375	25,327	69,524	2,533	43,899	21,678	228,067	8,602	236,669
November	21,501	495	36,884	20,715	68,511	1,041	39,480	18,775	207,402	6,062	213,464
December	21,857	922	42,758	25,078	71,224	3,605	39,410	21,419	226,273	6,953	233,226
Total	264,785	9,945	483,353	305,296	811,941	26,326	533,844	297,634	2,733,124	109,962	2,843,086

[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 1969 Channel	Number of plants 1969 Furnace	Number of plants 1970 Channel	Number of plants 1970 Furnace	Total daily capacity (pounds) 1969	Total daily capacity (pounds) 1970
Texas	Aransas	--	1	--	1	4,550,078	4,630,137
	Carson	1	--	1	--		
	Ector	1	--	1	--		
	Gaines	1	--	1	--		
	Gray	--	1	--	1		
	Harris	--	1	--	1		
	Howard	--	2	--	2		
	Hutchinson	1	4	--	2		
	Montgomery	--	1	--	1		
	Moore	--	1	--	1		
	Orange	--	1	--	1		
	Terry	--	1	--	1		
	Wheeler	--	1	--	1		
Total Texas		4	14	3	12	4,550,078	4,630,137
Louisiana	Avoyelles	--	1	--	1	3,568,055	3,492,574
	Calcasieu	--	1	--	1		
	Evangeline	--	1	--	1		
	Ouachita	--	2	--	2		
	St. Mary	--	3	--	3		
	West Baton Rouge	--	1	--	1		
Total Louisiana		--	9	--	9	3,568,055	3,492,574
Alabama	Russell	--	--	--	1	1,920,506	2,159,919
Arkansas	Union	--	1	--	1		
California	Contra Costa	--	1	--	1		
	Kern	--	2	--	2		
	Mojave (District)	--	1	--	1		
Kansas	Grant	--	1	--	1		
New Mexico	Lea	1	1	1	1		
Ohio	Lucas	--	--	--	1		
	Washington	--	1	--	1		
Oklahoma	Kay	--	1	--	1		
West Virginia	Pleasants	--	1	--	1		
Total other States		1	10	1	12	1,920,506	2,159,919
Total United States		5	33	4	33	10,038,639	10,282,630

Table 5.—Carbon black and the feedstocks used in its production, by States

	Louisiana	Texas	Other States[1]	Total
1969				
Carbon black production:				
Total ---- thousand pounds	1,045,902	1,442,033	475,326	2,963,261
Value ---- thousand dollars	$70,768	$110,816	$33,536	$215,120
Average value ---- cents per pound	6.77	7.68	7.06	7.26
Natural gas used:[2]				
Total ---- million cubic feet	27,834	55,199	15,218	98,251
Value ---- thousand dollars	$4,891	$7,549	$2,184	$14,624
Average value cents per thousand cubic feet	17.57	13.68	14.35	14.88
Carbon black produced[3] ---- thousand pounds	326,168	64,592	65,099	455,859
Liquid hydrocarbons used:				
Total ---- thousand gallons	152,891	292,293	79,186	524,370
Value ---- thousand dollars	$10,813	$21,195	$5,921	$37,929
Average value ---- cents per gallon	7.07	7.25	r 7.48	7.23
Carbon black produced ---- thousand pounds	719,734	1,377,441	410,227	2,507,402
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

r Revised.
[1] Arkansas, California, Kansas, New Mexico, Ohio, Oklahoma, and West Virginia.
[2] Includes natural gas used to enrich liquid hydrocarbons.
[3] Produced from natural gas used as feedstock.

Table 6.—Natural gas and liquid hydrocarbons used in manufacturing carbon black in the United States and average yield

	1966	1967	1968	1969	1970
Natural gas used[1] ---- million cubic feet	114,936	108,961	104,973	98,251	85,884
Average yield of carbon black per thousand cubic feet[2] ---- pounds	5.75	5.54	5.79	6.28	6.20
Average value of natural gas used per thousand cubic feet ---- cents	14.45	14.02	13.71	14.88	16.45
Liquid hydrocarbons used ---- thousand gallons	433,700	421,286	484,404	524,370	523,914
Average yield of carbon black per gallon ---- pounds	4.72	4.79	4.86	4.78	4.87
Average value of liquid hydrocarbons used per gallon ---- cents	7.09	7.07	7.11	7.23	7.35
Number of producers reporting	9	9	8	9	9
Number of plants	34	35	35	38	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	1966	1967	1968	1969	1970	Change from 1969 (percent)
Ink	63,682	63,963	67,721	73,077	72,824	−0.347
Paint	11,959	12,553	13,435	17,711	14,570	−17.73
Paper	6,108	5,658	4,710	5,668	4,527	−20.13
Plastics	21,945	20,907	26,863	(1)	(1)	-------
Rubber	2,131,169	2,072,543	2,445,550	2,616,166	2,486,146	−4.97
Miscellaneous[2]	42,732	40,521	30,123	65,327	71,454	+9.38
Total	2,277,595	2,216,145	2,588,402	2,777,949	2,649 521	−4.62

[1] Included in "Miscellaneous."
[2] Chemical, food, and plastics (1969, 1970) 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									Channel	Total
	SRF [1]	HMF [1]	GPF [1]	FEF [1]	HAF [1]	SAF [1]	ISAF [1]	Thermal	Total		
1966	35,479	5,570	15,709	21,411	53,344	4,925	43,801	9,615	189,854	43,291	233,145
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

[1] For explanation, see footnotes to table 3.

Table 9.—U.S. exports of carbon black, by countries

(Thousand pounds and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
North America:						
Canada	29,189	$2,455	26,454	$2,394	21,917	$2,195
Guatemala	3,042	250	1,132	98	1,186	113
Mexico	4,780	556	4,089	415	2,742	302
Other	3,085	279	1,037	98	1,766	178
Total	40,096	3,540	32,712	3,005	27,611	2,788
South America:						
Argentina	2,419	300	1,914	273	1,793	304
Brazil	4,800	465	2,865	301	5,343	565
Chile	627	79	455	50	357	58
Colombia	466	97	475	78	515	104
Peru	8,731	792	338	35	231	25
Venezuela	1,409	133	2,376	228	695	88
Other	844	88	393	57	202	24
Total	19,296	1,954	8,816	1,022	9,136	1,168
Europe:						
Belgium-Luxembourg	5,804	530	3,448	326	4,559	409
Denmark	2,135	322	1,105	154	1,355	273
Finland	1,044	156	314	39	412	69
France	36,523	3,822	33,236	3,625	35,603	3,751
Germany, West	23,871	2,258	15,041	1,647	15,338	1,766
Italy	22,425	2,695	10,934	1,384	12,055	1,657
Netherlands	3,793	479	2,470	320	13,484	2,047
Norway	1,145	101	934	72	1,052	84
Portugal	709	83	1,668	148	509	66
Spain	5,047	602	3,684	445	4,457	587
Sweden	6,075	515	2,380	217	3,392	338
Switzerland	2,504	210	1,511	150	1,271	145
U.S.S.R.	66	65	7,345	863	-------	-------
United Kingdom	24,597	3,675	17,117	2,782	16,638	3,032
Yugoslavia	436	43	72	12	147	38
Other	789	87	568	73	331	76
Total	136,963	15,643	101,827	12,257	110,603	14,338
Africa:						
Ghana	35	3	818	72	1,122	100
South Africa, Republic of	7,736	786	4,660	463	6,696	646
Other	1,427	122	498	57	427	94
Total	9,198	911	5,976	592	8,245	840
Asia:						
India	3,505	376	5,554	587	1,468	207
Indonesia	1,766	148	759	65	432	38
Iran	1,150	112	139	12	1,457	132
Israel	1,287	117	555	55	383	42
Japan	12,093	2,234	8,109	2,117	9,905	2,596
Korea, Republic of	11,026	1,041	13,779	1,375	3,481	354
Pakistan	206	17	1,794	173	3,159	292
Philippines	8,737	770	3,614	333	689	69
South Vietnam	352	44	800	79	1,368	144
Thailand	2,310	198	958	82	1,406	124
Turkey	935	96	428	47	1,798	160
Other	2,560	350	1,677	233	1,839	240
Total	45,927	5,503	38,166	5,158	27,385	4,398
Oceania:						
Australia	8,348	773	5,384	559	6,951	728
New Zealand	3,294	302	3,322	322	2,705	245
Total	11,642	1,075	8,706	881	9,656	973
Grand total	263,122	28,626	196,203	22,915	192,636	24,505

Table 10.—U.S. exports of carbon black in 1970, by months

(Thousand pounds and thousand dollars)

Month	Channel		Furnace		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
January	6,125	$1,389	11,942	$1,049	18,067	$2,438
February	4,093	924	11,022	970	15,115	1,894
March	6,194	1,321	10,948	967	17,142	2,288
April	3,602	840	17,030	1,471	20,632	2,311
May	3,135	765	17,199	1,566	20,334	2,331
June	2,728	621	13,155	1,111	15,883	1,732
July	6,534	1,711	15,514	1,420	22,048	3,131
August	2,538	732	8,914	877	11,452	1,609
September	3,147	769	9,014	828	12,161	1,597
October	2,280	637	9,447	847	11,727	1,484
November	5,611	1,222	10,147	921	15,758	2,143
December	2,569	673	9,748	874	12,317	1,547
Total	48,556	11,604	144,080	12,901	192,636	24,505

Table 11.—Carbon black: World production, by countries

(Thousand pounds)

Country [1]	1968	1969	1970 [p]
Argentina	48,444	52,911	[e] 55,000
Brazil	[r] 88,200	120,200	[2] 109,100
France	[r] 260,476	302,474	[e] 310,000
Germany, West	392,406	474,220	523,491
India [e]	[r] 55,000	55,000	55,000
Italy	[r] 205,585	231,038	272,401
Japan	[r] 482,289	574,531	650,511
Korea, Republic of	---------	1,001	7,374
Netherlands	[r] 169,976	179,456	189,377
Romania	[r] 120,974	124,411	159,778
South Africa, Republic of [e]	71,000	71,000	57,800
Spain [e]	[r] 55,000	66,000	66,000
Taiwan	[e r] 550	[e r] 550	584
United Kingdom	[r] 405,200	[r] 437,000	[e] 440,000
United States	2,811,806	2,963,261	2,931,153
Venezuela	16,204	16,001	16,200
Yugoslavia	[r] 19,700	34,240	[e] 35,000
Total	5,202,810	5,703,294	5,878,769

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Australia, Belgium, Canada, mainland China, Colombia, Mexico, Norway, Poland, Sweden, and the U.S.S.R. produce carbon black, but available information is insufficient to make reliable estimates of production levels.

[2] Partial figure. (Output of one of two reported producers, data for other producer not available.)

Cement

By Brinton C. Brown [1]

Portland cement shipments decreased in 1970 to 390,461,000 barrels, 19,365,000 barrels less than the alltime high shipments in 1969. High interest rates, shortage of mortgage money, and inflation problems in the first half of the year combined to reduce construction activity and the demand for cement. Easing of mortgage credit and the changing money market did not favorably affect cement shipments until December. Although production and shipments of cement from domestic plants declined, cement and clinker imported for consumption in the United States reached an alltime high, 43 percent above the previous record imports in 1969.

Despite price increases of 5 to 6 percent in some market areas, cement production and marketing costs rose about 10 percent.

For the past 3 years demand for coal has exceeded production, and as a result, in 1970 the price to the cement industry rose as much as 36 percent. Shortage of low-sulfur coal necessary to meet air pollution standards and higher costs impelled 30 percent of the plants using coal to change to natural gas and fuel oil.

Pollution control agencies adopted new standards and a proliferation of new regulations that had considerable impact on the cement industry. A combination of old age and pollution abatement regulations caused six companies to close 10 plants and three companies to permanently retire 20 additional kilns. This reduced annual clinker-producing capacity by approximately 25 million barrels. Virtually every plant in the country was modernizing and improving dust-collecting facilities. Investments for pollution control systems were expected to increase in the next few years not only to comply with regulations but to take advantage of the rapid amortization provisions of the Tax Reform Act of 1969.

Two new portland cement plants were placed in operation in 1970, with a reported combined annual capacity of 4.9 million barrels. Three companies added new kilns to their existing plants during the year, increasing the annual capacity another 4.5 million barrels. Two new plants under construction with an annual capacity of 4.3 million barrels were to be in operation in 1971. Two large kilns were to replace 14 older and smaller kilns when modernization programs were completed in 1971 at two plants. In addition, plant expansions announced by eight companies at 10 locations will further increase the Nation's annual capacity by about 7 million barrels within the next few years.

Concern for environmental quality was not limited to the United States. Landscaping a 6.4-million-barrel-per-year plant to fit in a national park was achieved by the Associated Portland Cement Manufacturers, Ltd., at its Hope, Derbyshire, England, works. The company's landscape architect, working with the Peak District National Park Planning Board devised a plan to fit the plant into the surrounding countryside and to landscape the plant so it is almost impossible to see from the surrounding villages. The shale quarry will be hidden by planted trees and the limestone quarry will be concealed by leaving a rock bank so that it will not disturb the skyline.

Two cement plants in Northampton, Pa., operated by Dragon Cement Co. Division of Martin Marietta Corp. and Universal Atlas Cement Division of United States Steel Corp. were recipients of the 1970 R. Emmet Doherty Award in recognition of their industry air pollution control leadership in the Lehigh Valley.

Legislation and Government Programs.—Public Law 91–605, an act to authorize the construction of certain highways in accordance with title 23 of the U.S. Code,

[1] Mining engineer, Division of Nonmetallic Minerals.

Table 1.—Salient cement statistics

	1966	1967	1968	1969	1970
United States:					
Production[1 2] thousand 376-pound barrels	393,824	377,885	403,349	407,944	395,347
Shipments from mills[1 2] do	389,856	381,824	405,863	418,284	396,844
Value[1 2 3] thousands	$1,226,806	$1,210,736	$1,294,533	$1,354,033	$1,336,255
Average value[1 2] per barrel	$3.15	$3.17	$3.19	$3.23	$3.37
Stocks Dec. 31 at mills[1 4] thousand 376-pound barrels	40,698	41,529	41,977	37,920	38,333
Exports do	1,069	980	942	589	847
Imports for consumption do	7,066	5,913	7,289	9,687	13,812
Consumption, apparent[5] do	395,853	386,757	412,210	427,382	[6] 404,163
World: Production do	2,722,068	2,812,729	3,021,620	3,179,863	3,350,142

1 Excludes Puerto Rico.
2 Includes portland, masonry, and slag cements (1966–69). Excludes slag cement (1970).
3 Value received, f.o.b. mill, excluding cost of containers.
4 Includes portland and slag cements only (1966–69).
5 Quantity shipped plus imports minus exports.
6 Adjusted to eliminate duplication of imports shipped by domestic cement manufacturers.

and for other purposes was passed on December 31, 1970. The National Environmental Policy Act (PL 91–190) was approved by the President in January to establish a Council on Environmental Quality. Under the Environmental Education Act (PL 91–516) approved in October, grants will be made supporting educational research and pilot projects dealing with environmental quality and ecological balance.

The Clean Air Act of 1970 (PL 91–604) provides for the establishment of ambient air quality standards; authorizes the administrator to monitor emission sources; and establishes penalties for violating air quality standards. An Office of Noise Abatement and Control was established within the Environmental Protection Agency to study noise and its effects on public health. The Secretary of Labor was empowered by the Occupational Safety and Health Act (PL 91–596) to inspect any factory or plant and enforce compliance with Federal standards.

Under the Tax Reform Act of 1969, deductions are allowed on domestic exploration expenditures. The act allows a 5-year amortization on air and water pollution abatement facilities added to plants in operation on December 31, 1968. Facilities must be certified to the Treasury Department as meeting performance standards and the rapid amortization deduction is limited to facilities in operation before January 1, 1975.

The Federal Trade Commission (FTC) Docket No. 8785 was still pending at yearend. The docket deals with a complaint against Ash Grove Cement Co. filed in July 1969 for alleged violation of section 7 of the Clayton Act by the company's acquisition of Fordyce Concrete, Inc., Lee's Summit Ready-Mixed Concrete and Materials Co., and Union Quarries. Also pending was FTC Docket 8783, which is a complaint against Missouri Portland Cement Co. filed in June 1969 for alleged violation of section 7 of the Clayton Act because of the company's acquisition of Botsford Ready Mix Co. In October 1970, the FTC ordered OKC Corp. to divest its interest in Jahncke Service, Inc., a ready-mixed concrete producer (Docket No. 8802).

DOMESTIC PRODUCTION

PORTLAND CEMENT

Although two new plants and three plant expansions added about 9.4 million barrels to the Nation's cement production capacity, 10 old plants were closed by yearend and an additional 20 old kilns were permanently shutdown, reducing the annual clinker-producing capacity almost 25 million barrels. One plant continued to produce cement from imported clinker after the kiln was shutdown, and another plant continued to grind clinker from a stockpile.

Public concern for the quality of the environment urged pollution control agencies to raise standards and enforce regulations. As a result most of the older plants and some new plants were modernizing and expanding their dust collecting facilities.

Some companies could not justify the expense of installing additional air-pollution control equipment in old marginal plants and elected to shut them down. More plants are expected to be closed in the future. Two new plants that were scheduled for operation in 1971 have a capacity of about 2.5 million barrels a year more than the old plants they will replace. Ten plant expansions to be completed in the next 3 years will add about 7 million barrels to the annual capacity.

In March, Maule Industries Inc. fired the first of its two wet-process, 10.5-foot- by 12-foot-diameter, 421-foot-long kilns at its new Pennsuco plant in Dade County, Fla. The 2.4-million-barrel-per-year plant is the first in the country to install electrostatic precipitators at both ends of the kilns. All cement produced was shipped in bulk because there was no bagging machinery installed at the plant. San Juan Cement Co., a newcomer in the industry, started operating its 2.5-million-barrel-per-year plant in the Barrio Espinosa area of Dorado near San Juan, P.R., in April 1970 and reached full production with the second kiln by late summer. Gifford-Hill Portland Cement Co. started operating its new kiln, 12 feet in diameter by 450 feet long, and grinding mills in June 1970 at its plant in Midlothian, Tex. The new facilities doubled the capacity to 3 million barrels a year. Lehigh Portland Cement Co. completed expansion of its Union Bridge, Md. plant in November 1970. By adding a fourth kiln, new raw and finish grinding mills, the capacity was increased from 3.5 to 5 million barrels a year. Medusa Portland Cement Co. increased the capacity of its Wampum, Pa., plant from 2.7 to 4.1 million barrels a year in 1970 with the addition of a 12-foot- by 14-foot-diameter, 390-foot-long kiln.

Lehigh Portland Cement permanently closed its 45-year-old plant at Buffalo, N.Y., in July. Three of the company's plants averaging 60 years in age were closed in the fourth quarter of 1970 at Birmingham, Ala., Fogelsville, Pa., and Iola, Kans. Alpha Portland Cement Co. permanently closed its 70-year-old plant in La Salle, Ill., and its 69-year-old plant at Ironton, Ohio, in September 1970 and the related terminals at Chicago and Cincinnati by yearend. Giant Portland Cement Co. closed its plant at Egypt, Pa., at the end of April 1970 because it was uneconomical to modify the old plant with eight kilns to comply with State air pollution control regulations. American Cement Corp., Peerless Division, closed its Jefferson Avenue plant in Detroit, Mich., at yearend. Wyandotte Chemical Corp. early in March, shut down the kiln at its plant near Detroit and imported clinker for its finish mills. Universal Atlas Cement shut down its No. 6 mill at Buffington, Ind., in August 1970 but continued to operate the other cement-producing facilities at the same location.

Ideal Basic Industries, Inc. shut down the four kilns at its Redwood City, Calif., plant in December mainly because of new State and local air and water pollution control regulations. When the present stockpile of clinker is ground, the storage facilities will continue to operate as a distribution terminal with cement supplied from the company's plant at Seattle. The terminal at Sacramento will be discontinued. The plant at San Juan Bautista, Calif., also scheduled to close because of air pollution abatement regulations, was permitted to operate under variances to alleviate a serious economic effect on the small community. Aetna Portland Cement Co. Division of Martin Marietta Corp. shut down four old kilns at its Essexville plant near Bay City, Mich., but continued production with a fifth, larger kiln. Production was augmented by purchasing clinker. Kosmos Portland Cement Co. shut down the six oldest of its 10 kilns at Louisville, Ky., to reduce dust output by 90 percent and will improve dust-collecting facilities for the other four kilns. The company completed planting 2,000 trees on three sides of the plant.

Dragon Cement Co. was constructing a new 2.5-million-barrel plant at Thomaston, Maine, to replace the 43-year-old facility. Completion was expected in mid-1971. Major equipment installed includes a 14.25-foot- by 17-foot-diameter by 520-foot-long kiln, a 4,500-horsepower (hp) grinding mill, and a glass bag house. Dragon Cement Co. gave 39 acres of land in Rockport, Maine, about 5 miles from Thomaston, for the site of the new Penobscot Bay Medical Center.

American Cement, Peerless Division's new 4-million-barrel cement plant near Detroit, Mich., was under construction and was scheduled to be in operation in 1971. At the company's Crestmore plant near

Riverside, Calif., two mills were converted to swing mills to grind either raw material or clinker, which added more than 1 million barrels of shipping capacity. One of two preheater kilns, inactive since 1965, at the Oro Grande, Calif., plant was reactivated. The kiln added about 750,000 barrels to the production capacity.

General Portland Cement Co. introduced a new tan-colored cement. The company acquired the Pacific Western Industries, Inc., 3.3-million-barrel plant at Los Robles, Calif. Plans were announced for expanding the company's Florida Portland Cement Division's facilities in Dade County, Fla., to increase capacity 20 percent. Plans were made to modernize facilities at the Paulding, Ohio, plant.

California Portland Cement Co. installed a new finish-grinding mill that increased grinding capacity at the Mojave, Calif., plant. The company's Arizona Portland Cement Co. Division increased its Rillito, Ariz., plant grinding capacity to 4.2 million barrels a year with the addition of a new finish mill. The company started expanding and modernizing the Rillito plant with the addition of a kiln, raw-grinding mill, crusher facilities, a 5-mile belt conveyor for transporting raw material from the quarry to the plant, and air pollution control equipment. It was expected to be completed by the end of July 1971.

Hawaiian Cement Co. started constructing a new 10-foot- by 12-foot-diameter by 240-foot-long kiln and dust-collection facilities at its plant in Ewa Beach, Oahu, to increase capacity to 2.5 million barrels a year. Louisville Cement Co. announced plans to install a new kiln with an annual capacity of 2 million barrels at its Speed, Ind., plant. This kiln is expected to be in operation by the end of 1973 and to replace three small, old kilns. Discussions were terminated on the proposed merger between Louisville Cement Co and Kaiser Cement & Gypsum Corp.

Marquette Cement Manufacturing Co. was installing a 15-foot- by 17-foot-diameter, 520-foot-long kiln to replace six old kilns and to increase annual production capacity by 450,000 barrels at its plant in Hagerstown, Md. A 3,000 hp raw-grinding mill replaced four old raw mills, and pollution control equipment was being installed to meet the Maryland Air Pollution Law requirements. Completion was expected in February 1971. Plans were announced to modernize the company's plant at Oglesby, Ill., by replacing eight kilns, all over 60 years old, with a 2.5-million-barrel kiln identical to the new one at Hagerstown; to install a 4,400 hp finish-grinding mill; and to erect pollution control equipment. At Trident, Mont., production capacity will be increased 12 percent when Ideal Basic replaces four small kilns with one large kiln and installs a new crusher and raw-grinding and dust-collecting facilities by mid-1973. Puerto Rican Cement Co. converted its white cement facilities at Ponce, P.R., to gray cement production to help alleviate the cement shortage on the island.

Calaveras Cement Co., Division of the Flintkote Co., was installing a 17.6-mile pipeline to convey slurry from its quarry to the plant at San Andreas, Calif. Construction of the crushing and grinding facilities were started in 1970. The facilities were to be completed in June 1971, at which time the slurry would be ground to 90 percent minus 200-mesh in two 11-foot by 33-foot, two-compartment raw mills and pumped through a 7-inch pipeline, assisted by gravity (1,500-foot vertical drop), to the kilns. Water was to be supplied by a 3.7-mile pipeline. Lone Star Cement Corp. installed a 3-mile covered conveyor from the quarry to the plant as part of a modernization program that will increase capacity of its Davenport, Calif., plant by 50 percent.

Penn-Dixie Cement Corp. completed modernization of its Clinchfield, Ga., plant with the addition of a finish mill and a cement cooler. A new finish mill was to be in operation early in 1971 at the Des Moines, Iowa, plant. Santee Portland Cement Co. started construction of a new finish mill that will increase the grinding capacity of its plant at Holly Hill, S.C. Diamond Portland Cement Co. was installing new shale crushing and drying facilities and an electrostatic precipitator at its plant in Middle Branch, Ohio. Kaiser Cement & Gypsum continued to modernize facilities including improvements of crushing operations at Lucerne Valley, Calif., and Waianae, Hawaii. Monarch Cement Co. was adding five storage silos and packing equipment at its plant in Humboldt, Kans.

New air pollution control equipment was installed by cement companies at the following plants: Ideal Basic at its Houston, Tex., plant; National Portland Cement Co's. plant at Brodhead, Pa.; and Universal Atlas Cement at plants in Hudson, N.Y., and Waco, Tex.

Other companies installing dust-collecting equipment were Capitol Cement Co., Division of Martin Marietta Corp. at its plant in Martinsburg, W. Va. Columbia Cement Co. Division of PPG Industries at Bellingham, Wash., Dewey Rocky Mountain Cement Co., Division of Martin Marietta Corp. at its new plant in Lyons, Colo., Ideal Basic plants at Knoxville, Tenn., and Okay, Ark.; and General Portland Cement Trinity Division at its Dallas, Tex., plant.

Electrostatic precipitators were installed or were being installed by the following companies: Alpha Portland Cement at its Birmingham, Ala., and Jamesville, N.Y., plants, General Portland Cement Co. at its Tampa, Fla. plant; Lone Star Cement at its Houston, Tex., and Bonner Springs, Kans., plants; Marquette Cement Manufacturing at its Rockmart, Ga. plant; Northwestern States Portland Cement Co. at its Mason City, Iowa, plant; Penn-Dixie Cement at its West Des Moines, Iowa, plant; and Puerto Rican Cement Co. at its San Juan, P.R., plant.

Dundee Cement Co. was to start construction in 1971 to add four electrostatic precipitators at its plant in Dundee, Mich. Monolith Portland Midwest Co. will install an electrostatic precipitator at its Laramie, Wyo., plant and Universal Atlas Cement plans to install another electrostatic precipitator at its plant in Duluth, Minn.

Universal Atlas replaced electrostatic precipitators with glass-bag dust collectors at its Northampton, Pa., plant.

Glass-bag dust collectors that were installed or were being installed by other cement companies include Lone Star Cement (at its Maryneal, Tex., plant) and Medusa Portland Cement (at the Toledo plant near Sylvania, Ohio).

Whitehall Cement Manufacturing Co. planned to replace the electrostatic precipitator in 1971 with new equipment including a glass-bag house to meet the more stringent air pollution requirements at its plant in Cementon, Pa. The company completed the conversion from coal to bunker C fuel oil for kiln-firing.

Plans were announced for installing additional air pollution control equipment in 1971 by the following companies: Missouri Portland Cement Co. at its plants in Joppa, Ill., and Kansas City, Mo.; Lone Star Cement at its plants in New Orleans, La., and Davenport, Calif.; Lehigh Portland Cement Co. at its plants in Union Bridge, Md., Mason City, Iowa, and Miami, Fla.; Kaiser Cement & Gypsum at its plants in Permanente, Calif., Lucerne Valley, Calif., and Waianae, Hawaii; and General Portland Cement at its plants in Chattanooga, Tenn., and Paulding, Ohio.

Huron Cement Co., Division of National Gypsum Co. was constructing a wastewater disposal system to comply with the State regulations at its plant in Superior, Wis.

ALUMINOUS CEMENT

Universal Atlas Cement started up its new calcium-aluminate refractory facilities at Buffington, Ind. (Chicago area). This will replace an old plant and double its capacity.

Lone Star Cement, Ciments Lafarge of Paris, and the Lafarge Organization Ltd. of London formed a new jointly owned company, Lone Star Lafarge Co., to market and distribute calcium-aluminate cement in the United States.

PRODUCTION CAPACITY

By the end of 1970, 64 kilns were permanently removed from production with the closing of 10 plants and partial shutdown of kilns at three plants. By yearend, 478 kilns were operating at 169 plants in 41 States and Puerto Rico with an estimated 24-hour-per-day clinker-producing capacity of 1,360,000 barrels. A kiln will not operate 365 days because some downtime is required to replace sections of refractory bricks and for mechanical maintenance. In 1970, kilns were reported down for an average of 38 days, indicating the apparent annual clinker-production capacity was about 445 million barrels.

In addition to 169 clinker-producing plants including eight white cement facilities, one plant was inactive and six plants had grinding mills only. The grinding plants were operating on imported, purchased, or interplant transfers of clinker with the exception of one that was grinding clinker from an existing stockpile. No information was collected on grinding capacity, but the total in the United States is estimated to be about 500 million barrels (or equivalent to 365 days of clinker-producing capacity).

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 Dec. 31, 1970

Barrels (376-pound) per 24-hour period	Number of plants [1]	Percent of total capacity
Less than 3,000	7	1.2
3,000 to 6,000	51	17.2
6,000 to 9,000	55	28.9
9,000 to 12,000	34	25.0
12,000 to 15,000	10	9.9
15,000 and over	12	17.8
Total	169	100.0

[1] Includes white cement-producing facilities.

TRANSPORTATION

Cost of rail and truck delivery of portland cement to customers increased 8 percent. At the National Association of Cement Shippers meeting in Chicago in November 1970, the problems of increased costs were discussed. Truckers were demanding pay increases ranging from 6 to 10 percent. In its 4 years of existence, the association has seen five general freight rate increases for the railroads amounting to 37 percent (assuming approval of a recent 15 percent boost).

Medusa Portland Cement proposes to convert a 550-foot ore boat, C. H. McCullough Jr., within 2 years, to a self-unloading cement carrier similar to the Medusa Challenger.

A 6,300-deadweight ton ship, the M.V. Orient, will be converted into a bulk cement carrier and chartered to Ryukyu Cement Co., Ltd., in 1971. Along with the M.V. Taipan, it will transport cement to Ryukyu Cement's markets in Guam and Australia. General Portland Cement will use ocean-going vessels to transport raw material (aragonite) from a deposit in the Caribbean to its plant in Tampa, Fla., which was to begin early in 1972. In 1970 four new barges were purchased by Missouri Portland Cement increasing the fleet to 30 cement barges to supply eight marine terminals.

Atlantic Cement Co. converted from coal to oil firing of its kilns, which required additional dock facilities for tankers. Dundee Cement Co. added 50 pressure-flow, 530-barrel tank cars to its fleet under lease. Cement can be transferred at the rate of 530 barrels per hour from the tank car to highway trailers. Calaveras Cement was building a bulk storage and distribution plant at Union City, Calif., to serve the Bay Area from its San Andreas plant. Ideal Basic started shipping cement from its new terminal at Anchorage, Alaska. A rail-truck transfer station was established at Fairbanks. Kaiser Cement & Gypsum expanded the capacity of its distribution facilities at Anchorage and Fairbanks.

The Associated Portland Cement Manufacturers Ltd., Blue Circle Group, built a new wharf at Northfleet, Kent, England, that will enable 90,000-ton ships to berth alongside the plant. Much of the cement is dispatched to Scotland in unit trains with bulk tankers carrying 79 tons each. In Holland, the Dutch cement industry was making 45 percent of its deliveries in waterborne tankers. Because railroads were unable to cope with the increased cement shipments in the Republic of South Africa, the Government granted permission for cement to be carried on highways.

CONSUMPTION AND USES

Shipments of cement into the various States are considered to be an index of consumption. Consumption of portland cement decreased nearly 5 percent below that of 1969. Only 12 States, Puerto Rico, southern California and western New York had an increase of shipments from that of the preceding year. The increase was small in Connecticut, Florida, Maine, Maryland, Massachusetts, New Jersey, Tennessee, Virginia, and southern California and Puerto Rico; however, the increase was about 10 percent or more above 1969 shipments in Arizona, Colorado, Idaho, North Dakota, and western New York. Shipments in all other States and regions decreased. The largest decreases in consumption of cement from that of the preceding year were in the following States: Illinois, Louisiana, Michigan, Ohio, Texas, Wisconsin, northern California, and eastern Pennsylvania. In each State the decrease was more than 1 million barrels less than consumption in 1969.

Producers of ready-mixed concrete were the primary customers of portland cement, accounting for about 62 percent of the total cement shipped. Concrete product manufacturers used about 15 percent of the cement shipments to make such items as precast concrete, prestressed concrete, concrete blocks, and concrete pipe. Nearly 12 percent of the shipments were sent directly to highway contractors or to Federal, State, or other government bodies. Building materials dealers received about 8 percent of the shipments. Approximately 3 percent of the shipments went to other construction contractors and for miscellaneous uses.

Ready-mixed concrete shipments decreased about 2 percent in 1970, showing the influence of the low volume of housing construction in the early part of 1970 and the decline of other building construction throughout the year. The U.S. Bureau of Labor Statistics wholesale price index for ready-mixed concrete rose 6 percent above the 1969 price. Despite a decrease in demand for concrete pipe in 1970, the price increased 2 percent. Similarly, shipments of concrete products such as prestressed and precast concrete declined moderately. Shipments of concrete blocks decreased 4 percent, but the price index rose about 5 percent, in part reflecting the higher prices for cement and aggregates.

Although residential construction was curtailed in the early part of 1970 by the impact of tight money, high interest rates, and inflation problems, the homebuilders responded quickly to the changing money market following a general easing of mortgage credit later in the year. The total number of new housing units started in 1970 was 2.2 percent less than in 1969 but was nearly 4 percent higher than the average of housing starts for the preceding 5-year period. Expenditures for new private nonresidential construction rose 5 percent despite a 7-percent decrease in expenditures for industrial buildings. Growing concern for the environment and pollution control accounted for increased expenditures for new sewer systems. Although expenditures for new public construction was at a record amount, it was only slightly more than in 1969. Highway construction expenditures were also at a record level but on a constant-dollar basis were down about 2 percent from that of the preceding year.

PRICES

The average mill value of portland cement was about $3.32 per barrel in 1970. Although prices rose about 5 to 6 percent for bulk gray cement in some market areas, the costs of producing and marketing the cement climbed 10 percent. The industry complained that profits suffered as a consequence. According to figures published in Engineering News-Record, some bulk mill prices remained unchanged throughout the year in certain areas such as parts of Alabama, Georgia, Indiana, Kansas, New York, Tennessee and Utah. Bulk mill price increases of 15 to 30 cents per barrel posted early in 1970 remained virtually unchanged for the rest of the year in other areas such as California, Louisiana, Missouri, Ohio, Oregon, Texas, Washington, Wisconsin, and parts of Pennsylvania. The Engineering News-Record shows the December bulk mill price range from a low of $3.40 a barrel in Northampton, Pa., to a high of $5.43 a barrel in Waianae, Hawaii, and $4.60 a barrel was reported at Lake Oswego, Oreg., and Seattle, Wash. Higher prices were subject to cash discounts.

Bag prices were $0.60 to $1.50 higher than the bulk prices. Base prices f.o.b. per barrel for portland cement in carload lots are reported in the Engineering News-Record for 20 cities across the United States. The December 1970 average for bulk cement was $4.29 per barrel, compared with $4.15 per barrel in December 1969. In the 20-city survey, the December 1970 prices ranged from a low of $3.80 a barrel in New York City, to a high of $5.07 a barrel in Cleveland, Ohio. Masonry cement averaged $4.68 per barrel in December 1970, compared with $4.58 per barrel in 1969, and ranged in price from $3.20 per barrel in New York City to $5.85 per barrel in Kansas City, Mo.

Increased fuel costs ranging from 14 to 36 percent for coal and as much as 70 percent for oil, along with electric power rate increases from 14 to 25 percent, forced many companies to announce price increases for 1971. In a large number of marketing areas, price increases were scheduled for January 1, 1971, ranging from 15 to 55 cents per barrel for bulk portland cement with an average of about 25 to 30 cents per barrel. In Puerto Rico the price was increased 40 cents per barrel in October, and a 60-cent-per-barrel price increase was announced for April 1971.

In 14 European countries the price increase was at least 3 percent higher in 1970, in Denmark, France, Germany, Iceland, Norway, Spain, and Sweden the increase was 5 percent or more compared with 1969 prices. In Japan there was a marginal decline in the portland cement price.

FOREIGN TRADE

Exports of cement from the United States in 1970 increased 44 percent above that of the preceding year, to 847,000 barrels (376-pound). Total value of these exports rose to $5.2 million, 63 percent above that of 1969. Although 74 countries received cement from the United States, Canada, the Leeward and Windward Islands, and the French West Indies received about 73 percent of the total exports.

Portland cement and clinker imported from 18 countries for consumption in the United States reached on alltime high of 13,812,000 barrels, surpassing the previous record set in 1969 by 43 percent. Imports were more than double that of any year during the period 1878–1967 with the exception of 1966. The importing and marketing of foreign cement in some areas was an important factor and, in effect, was equivalent to a large cement plant in the center of the market area. Imports from Canada nearly doubled those of the preceding year; cement shipments from Norway increased nearly 1 million barrels; and imports from Mexico increased more than 500,000 barrels. More than 85 percent of the cement imported came from three countries—Canada, the Bahamas, and Norway.

The rate of duty on white, nonstaining portland cement remained the same, at 2 cents per 100 pounds in 1970; however, the rate of duty for other hydraulic cement and clinker decreased to 0.9 cent per 100 pounds under the annual rate modifications resulting from 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.

WORLD REVIEW

Cement shortage in some countries and overcapacity in other countries continued to be a problem in the industry. For example, a cement shortage resulting from the tremendous building boom in the Transvaal caused the Republic of South Africa to import cement from Belgium, Spain, Denmark, Angola, and the United Kingdom. Although Yugoslavia imported from Greece, Hungary, and the United Arab Republic, it still experienced a cement shortage that curtailed housing construction. On the other hand, the Philippine cement producers experienced a depressed market that required curtailment of production to less than one-half of the industry's rated capacity. In 1970 Western European countries belonging to the CEMBUREAU put into operation 28 new kilns, representing a capacity increase of 9 million short tons. In 1971 another 34 kilns are expected to be in operation to produce an additional 13 million tons of clinker.

Algeria.—Construction was started at Meftah to erect a cement plant with an annual capacity of 1.1 million short tons. Completion was scheduled for 1972. The Algerian Construction Materials Agency contracted for a cement plant with a capacity of 550,000 tons at Ain-Cherchar near Constantine. A 550,000-ton-per-year plant was under construction at Hadjar-Soud.

Angola.—Companhia de Cimento Secil do Ultramar was expanding its Luanda plant capacity from 330,000 to 660,000 short tons per year. Completion was expected by mid-1971.

Argentina.—Compañía Argentina de Cemento Portland, a subsidiary of Lone Star Portland Cement Corp., increased the annual capacity of its Sierras Bayas plant to 4.6 million barrels per year by late 1970. This production and that of the plant at Parana give the company a total capacity of 5.6 million barrels.

Bolivia.—Compañía Boliviana de Cemento was constructing a cement plant about 40 kilometers from Cochabamba. Annual capacity was to be 110,000 short tons.

Brazil.—International Telephone and Telegraph Corp. (ITT) received the approval of the Brazilian Government to build a dry-process cement plant about 180 kilometers south of São Paulo. Capacity was to be 2,600 short tons per day. Operation was scheduled for 1972. Brazil's cement production capacity is expected to increase from 9.9 to 22 million short tons a year by 1975. The newest plant, which was built in Goiás, has an annual capacity of 220,000 tons. In 1971, Cia. Cimento Itau do Paraná, S.A. was to start building a cement plant with a 1,100-ton-per-day capacity in Rio Branco do Sul, State of Paraná. A new plant, which has a 2,200 ton perday capacity, was scheduled for construction in 1971, at Apai, near São Paulo. Empresa de Cimento Tocantins was building a cement plant in Brasilia; output capacity was to be 1,100 tons per day. Operations were expected to start late in 1971. Cia. Brasileira de Ligantes Hidraulicos planned to build a 2,600-ton-per-day plant at Macaé, Rio de Janerio which was to start operating in 1972. Other cement plants proposed include Cia. Carioca de Cimento Portland at Irajá, Guanabara, and Cia. de Cimento Portland, Alvorada at Cantagalo, Rio de Janerio. Cemento Aratú, a subsidiary of Lone Star Cement Corp., was expanding facilities at its Salvador plant to increase the annual capacity to 2.4 million barrels by mid-1971. Cimento Santa Rita, S.A., was adding grinding capacity to its plant in São Paulo.

Burma.—Industrial Development Corp., operator of the country's only cement plant at Thayetmyo, ordered equipment for a second plant, which was to be installed by 1972 in the Kyangin area in the upper Irrawaddy River region. Plant capacity was to be 880 short tons per day.

Cameroon.—At Bonaberi, near Douala, a new cement plant with 11,000-ton-permonth capacity was scheduled to start operating in January 1971. A second plant at Figuil was to be completed later in 1971 to serve north Cameroon.

Canada.—Canada Cement Co., Ltd. acquired control of Lafarge Cement of North America, Ltd. and changed its name to Canada Cement Lafarge Ltd. Canada Cement Lafarge Ltd. plans to phase out its Point Anne, Ontario, plant with the completion of a 1.1 million short ton plant at Bath, Ontario, in 1973. The new Lafarge plant 11 miles east of Kamloops started production in March. Its capacity is 230,000 tons per year.

Ceylon.—In March 1970 the State Cement Corp. plant at Puttalam started operation at an initial annual capacity of 240,000 short tons. Construction was continuing to increase the capacity to 435,000 tons per year. Ceylon Cement Corp. ordered equipment for a plant to be built at Colombo; the annual capacity will be 800,000 tons per year.

China, mainland.—Recovering from economic disruptions, cement production reached the level of 10 million metric tons per year in 1970. Numerous small local cement plants have been built recently in many provinces including Honan, Hunan, Heilungkiang, Anhwei (Anhui), Chekiang, and Fukien. More than 12 larger cement plants have been constructed since 1965. Towns, provinces, and estimation of capacity in million short tons (in parenthesis) are given as follows: Hantan (1.1 or more) south of Shihchiachuang in Hopeh; Yao Hsien (1.1) in Shensi; Huahsin or Huangshih (1.1) in Hupeh; Kwangchow (0.8) in Kwantung; Yungteng (0.7) in Kansu; Chungking (0.6) in Szechuan; Tatung (0.6) in Shansi; Mutanchiang (0.4) in Kirin; Tungfanghung or Nanking (0.4) in Kiangsu; Kunming (0.33) in Yunnan; Kweiyang (0.3) in Kweichow; Liuchow recently expanded to (0.3) in Kwangsi; Kaiyuan (0.3) in Yunnan; Nanping (0.1) in Fukien; Tungchiang (0.1) in Kirin and Nanchang (0.1) in Kiangsi. Fushun (originally 0.6) and Ch'ihsin (originally 0.4) have been expanded.

Congo (Kinshasa).—A cement plant with an annual capacity of 400,000 short tons was expected to be in operation by 1972 in Kinshasa bringing the total capacity for the western Congo to 1 million tons a year. Ciments et Materiaux de Construction du Katanga (CIMENKAT) began a modernization and expansion program which was to change from wet to dry process and increase production from 100,000 to 130,000 tons per year in 1971 and to 65,000 tons in 1973.

Cuba.—Two cement plants under construction, one by Czechoslovakia and one by the U.S.S.R., were expected to go into production in 1972. The country's total annual capacity for its five plants would then reach 2,668,000 short tons.

Ecuador.—Empresa Cemento Chimborazo, C.A., plans to install new facilities with a 550 short-ton-per-day capacity at San Juan Chico. The new facilities will more than triple the present plant capacity. A consortium of European companies plans to build a cement plant with a 830 tons-per-day capacity at Selva Alegre, about 90 kilometers from Quito. A Japanese company was interested in building a plant in the Rio Negro area.

Greece.—General Cement Co. S.A. was increasing the capacity of its Olympos plant at Volos from 3,900 to 6,400 short tons per day. In September 1970, a new 2,600-ton-per-day grinding mill was put into operation. A 2,200-ton-per-day rotary kiln was expected to be in operation late in 1971. Expansion and modernization of the company's Heracles plant at Drapetsona (Piraeus) is planned along with improvement of cement distribution centers at Thessaloniki, Rion, and Heraklion. Titan Cement Co. was expanding plant facilities at Thessaloniki to increase the capacity from 720,000 to 1.15 million tons per year. Completion was scheduled for July 1971. The company also plans to expand its facilities at Elefsis. Titan Cement purchased American Cement Corp.'s interest in Hellenic Cement Co. Hellenic planned to add a second kiln at the plant in Drepanon, Petras, which would raise the annual capacity from 390,000 to 770,000 tons by mid-1973. Chalkis Cement Co. started an expansion program to increase production from 720,000 to 1.7 million tons per year at its Avilis plant near Chalkis. Halyps S.A. planned to expand and modernize its plant at Skaramanga by 1973.

Guatemala.—Cemente, Norvello, S.A., Guatemala's only cement producer, plans to build a 1,000-ton-per-day plant at San Miguel.

Hungary.—The 1.1 million short ton-per-year cement plant under construction at Beremend near the Yugoslav border was scheduled for completion in August 1972. Construction of a cement plant with a capacity of 1.8 million tons was scheduled to start in 1971 at Hejöcsaba.

India.—Cement Corp. of India completed construction of a plant at Mandhar, Madhya Pradesh, and started constructing a new plant at Kurkunta, Mysore.

Indonesia.—Tjibinong Cement Co., a newly formed Indonesian corporation owned 76 percent by Kaiser Cement & Gypsum and P. T. Semen Gresik, Indonesia's largest cement company, which is government-owned, was to start construction of a 3-million-barrel-per-year cement plant at Tjibinong, 30 miles south of Djakarta in 1972. The cement plant near Padang was being modernized, and the capacity was being increased at the plant near Gresik. Toyo Menka Kaisha Ltd., of Japan in a joint venture with P. T. Gunung Ngadeg plans to build a cement plant. Singarise Ltd., of Singapore in a joint venture with P. T. Sumber Wangi plans to build a cement plant at Bahorok in north Sumatra. Both plans were pending government approval.

Iran.—Private investors plan to build a cement plant with a capacity of 1,100 tons per day. Operations were scheduled for mid-1972.

Iraq.—The Iraqi Government contracted for erection of a 220,000-ton-per-year, wet-process plant at Kufa, 100 miles from Baghdad. Plans were made to double the capacity of the Sarchinar plant in the north.

Italy.—Union Cementerie Marchino Emiliane e du Augusta S.p.A. was installing a kiln 5.6 meters in diameter by 85 meters long at its Guidonia plant to increase the capacity to 3,900 short tons per day. A 150-ton tube mill with an inside diameter of 5.0 meters and a length of 16.5 meters, the largest built by Kloeckner, Humboldt, Deutz was to be added to the grinding plant that was scheduled for operation in 1972. Cementerie Calabro Lucane S.p.A. announced plans for a cement plant at Castrovillari, Cosenza.

Japan.—Japanese cement production increased to 62.3 million short tons in 1970, an increase of 11 percent. New production capacity continued to rise with new kiln additions amounting to 8 million tons in 1970 and 7.5 million tons installed in 1969. UBE Cement Division of UBE Industries, Ltd. has bulk-loading-dock facilities at its UBE and Kanda plants. UBE maintains a fleet of 10 cement carriers with a total capacity of 79,000 tons to serve 22 packing facilities in Tokyo, Osaka, and other cities. In October 1970, Osaka Cement Co. signed a pollution prevention agreement with Prefecture and city governments to build a cement plant at Usuki City in Oita Prefecture. Construction was pending the outcome of court action filed by 16 fishermen from a nearby village of Kazanashi and the "Citizens Conference To Remove Pollution From Usuki." Onoda Cement Co. built a cement plant at Ofunato in Iwate Prefecture reported to be the largest in the world—a capacity of 3,600 metric tons per day.

Korea, Republic of.—Hyun Dai Construction Co. was doubling its annual capacity to 440,000 short tons per year. A 2,800-ton-per-day cement plant is planned for Chang-Sung by Fives-Lille-Cail of France and a consortium of other European companies.

Libya.—Plans were made to increase the present 390-ton-per-day output capacity of National Cement Co.'s new cement plant at Homs, about 120 kilometers east of Tripoli. Libyan Cement Co. was constructing a plant at Benghazi that has a 660-ton-per-day capacity. Operation was scheduled to begin in 1971.

Malawi.—Portland Cement Co. Ltd. (Malawi) was expanding facilities to double the plant output.

Malaysia.—A cement plant financed by German interests will be built on Pulau Langkawi, an island off Malaya's west coast.

Mexico.—Cementos California, S.A., started up its second plant with a capacity of 7,700 short tons per month near La Paz, Baja California. The company's other plant is in Ensenada, State of Baja California. Cementos Atolonilco, S.A., was doubling capacity at its plant in Hidalgo to 4,400 tons per day. Completion was expected in 1971. La Tolteca, Cia. de Cemento Portland, S.A. dedicated its plant at Zapotiltic, Jalisco. With the opening of its fourth plant, La Tolteca celebrated 60 years of operation in Mexico. Capacity of the new plant is 1,700 metric tons per day. La Tolteca was enlarging its white cement production facilities at Tolteca, Hidalgo, to 77,000 tons per year. Cementos Anáhuac has increased capacity at its Barrientos plant from 2,000 to 3,600 tons per day and expects to expand facilities to 5,800 tons per day within 4 years. The company's plant at Tamuin, San Luis Potosí, will have the capacity increased from 1,700 to 3,300 tons per day. Cementos Maya at Merida, the only producer in Yucatán, was to increase the capacity from 50,000 to 200,000 tons per year by mid-1971. Cementos Atoyac was expanding to 1,240 tons per day. Cementos Sinaloa, S.A., plans to expand the capacity of its El Fuerte plant in Sinaloa beyond the present capacity of 132,000 tons per year. Twenty-seven plants were operating in 1970.

New plants have been announced that are in the planning or construction stage. Both Cementos de Chihuahua and Cementos Mexicanos have plans for plants in Ciudad Juarez with 330- and 550-ton-per-day capacity, respectively. Trouyet scheduled construction of a 1,100-ton-per-day plant at Pajaritos, Veracruz. A 1,100-ton-per-day plant in the Tepuche area of Culiacán, Sinaloa, was proposed by Cementos de Guadalajara.

Cementos del Norte, S.A., was to expand plants at Monterrey and Torreon to double capacity, to 310,000 tons per year by mid-1971.

Nigeria.—The Commonwealth Development Corp. plans to reactivate the Nkalagu cement plant closed during the civil war. The Calabar Cement Co. was operating at about two-thirds of its 9,900-ton-per-month capacity because of unreliable electric power.

Paraguay.—The government-owned cement plant, at Vallemi which has been in operation for nearly 2 years, increased its annual production capacity to 110,000 short tons.

Philippines.—In June 1970, the Philippine cement industry changed from the 94-pound bags to 50-kilo (king-size) bags. The industry in the islands continued to expand production capacity 39 percent in 1970, despite a depressed market brought about in part by existing excess production capacity.

Island Cement a division of Martinduque

Mining & Industrial Corp. plant at Antipolo, Rizal, started up a second kiln to increase the annual capacity to 4.5 million barrels and make it the country's largest. Northern Cement Co. started production of its 3.75-million-barrel-per-year plant at Sison, Pangasinan, in 1970. Fortune Cement Corp. inaugurated its plant at Toysan, Batangos, in May 1970. This has an annual capacity of 2.25 million barrels. Four more plants, expected to be in operation in 1971, were under construction: Iligan Cement Co. at Iligan, Lanao, with a 2.25-million-barrels-per-year capacity; Midland (Quezon) at Tanay, Rizal with a 3-million-barrel-per-year capacity; Floro at Lugait, Misamis Oriental, with a 2.7-million-barrel-per-year capacity; and Continental at Norzagaray, Bulacan, with a 2.6-million-barrel-per-year capacity. Three other plants were reported in advance stage of planning and were to be completed in 1972 or 1973. These plants were Tayabas, at Calatrava, Negros Occidental; Builders, at Samboan, Cebu; and Mabuhay, at Montelban, Rizal. Twenty more proposed cement plants were registered with the Securities and Exchange Commission. Apo Cement Co. at Naga City, Cebu, the Philippines oldest cement plant, suspended operation in June 1970. Annual capacity of the plant was 600,000 barrels.

Romania.—A cement plant was under construction at Cîmpulung in Arges County; capacity was to be 2.2 million short tons per year.

Saudi Arabia.—Yamama Cement Co. was authorized to increase output from 110,000 to 390,000 tons per year. A 770-ton-per-day cement plant is planned for the Shaikhdom of Ras al-Khaimah and was scheduled for completion in 1973. Another plant of about the same size was planned for the Shaikhdom of Abu Dhabi.

South Africa, Republic of.—Cement plant output in the country will be increased 2.2 million short tons, or one-third of the 1969 output. White's South African Portland Cement Co., Ltd., was installing a new rotary kiln, 4.8 meters in diameter by 68 meters in length at its plant in Lichtenburg, on the highland of Transvaal near Witwatersrand, to increase capacity from 1.2 to 1.9 million tons per year by the end of 1971. Recent expansion at the Lichtenburg plant consisted of replacing three small wet-process kilns with a dry-process kiln 3.8 meters in diameter by 54 meters long, which nearly doubled the capacity. Anglo-Alpha Cement Ltd. was installing a second kiln at its Dudfield plant to increase output from 1,500 to 4,300 short tons per day. Completion was expected in late 1971. The No. 4 kiln at the company's Ulco works was put into operation in January 1970, increasing the output of that plant by about 660 tons per day. Durban Cement Co., Ltd., scheduled completion of its expansion program to triple output of the Bellair plant in October 1970 to 5 million barrels. Pretoria Portland Cement Co., Ltd., expanded capacity at Hercules and Jupiter by 610,000 tons per year. The company was building a new plant at Germiston with an annual capacity of 3 million barrels. Palcaso Ltd. was building a cement plant at Phalaborwa in the Eastern Transvaal. The plant was to have an annual capacity of 130,000 tons and was scheduled for completion in 1971.

Spain.—In 1971 Cementos de Liendo S.A. was to start building a cement plant at Liendo, between Santander and Bilbao, with an annual capacity of 1.1 million tons. Completion is expected in 1973.

Taiwan.—Cheng Tai Cement Corp. started construction to increase production from 110,000 to 550,000 short tons per year at its plant in Kaohsiung. Taiwan Cement Corp. virtually doubled capacity of its Suao plant to 580,000 tons with the addition of a fourth kiln. The company replaced three of the five kilns at its Kaohsiung plant with a new kiln rated at 1,600 tons per day. Asian Cement Corp. has installed a fourth kiln at its Hsinchu plant, which increases annual capacity to 1.9 million tons. Tung Nan Cement Co. installed a third kiln at its plant in Kaohsiung, which increased the capacity by 660 tons per day.

Tanzania.—Tanzania Portland Cement Co. Ltd. was increasing the annual capacity of its Wazo Hill plant from 180,000 short tons to 440,000 tons; completion was expected by late 1971.

Thailand.—Jalaprathan Cement Co., Ltd., was constructing a second plant at Cha-am with an annual capacity of 2.9 million barrels. Completion was scheduled for March 1971. A 550,000-short-ton-per-year plant was under construction for the Siam City Cement Co. at Tambol Tabkwang, off the Friendship Highway in Saraburi Province.

Togo.—Société des Ciements de l'Afrique de l'Ouest, (CIMAO) formed in 1969, was building a grinding plant in the Lomé area to produce annually 110,000 short tons of cement using imported clinker. Completion was scheduled for mid-1971. The organization was studying the feasibility of a 1.3-million-short-ton-per-year cement plant at Avéta.

Turkey.—Hostas cement plant was under construction at Ceyhan and was to have an annual capacity of 1.1 million short tons upon completion, which was expected in 1972.

Uganda.—Uganda Cement Industry Ltd. started to triple the capacity of its dry-process plant in Tororo, near Kasese to 990 tons per day. Completion is scheduled for early 1973. The country's second cement plant at Hima near Kasese in the Toro District was scheduled to start producing 330 tons per day in March 1971. Plans were made to double the capacity of this plant with an additional kiln.

United Arab Republic.—A new cement plant, which would have a capacity of 660,000 short tons per year, was planned for construction in upper Egypt. An expansion program at the Qusiyya plant will increase capacity to 660,000 tons per year.

U.S.S.R.—The Soviet Union continued to lead the world in cement production; a record 104.9 million short tons shipped in 1970. The Soviet Union has approximately 110 cement plants, and raw materials are supplied by 132 mines. The first rotary kiln of the Staryy Oskol cement plant in Kursk Oblast', which has an annual capacity of 660,000 tons, was put into operation in 1969. About 1.4 million tons of new cement production capacity was added at the Ust'-Kamenogorsk, Alekeyevsk, and other cement plants.

United Kingdom.—At Northfleet, Kent, the Associated Portland Cement Manufacturers Ltd., parent company of the Blue Circle Group, started production at what is believed to be the largest cement plant ever built. The first of six kilns was fired in the first half of 1970, and the remaining kilns will be brought into production at approximately 3-month intervals, with a total output capacity of 4.4 million short tons per year.

Associated Portland Cement Manufacturers Ltd., replaced five wet-process kilns with two large, dry-process kilns at its Hope plant in Derbyshire, raising the annual capacity to 1.3 million tons. The plant was designed and landscaped to fit in the surrounding area of the Peak District National Park.

Venezuela.—C. A. Venezolana de Cementos was to complete automation of its new 2,700-ton-per-day facilities in 1972.

West Indies.—Guadalupe and Martinique were to both have new grinding plants completed in 1971. Clinker purchased from elsewhere will be shipped by water.

Two separate groups announced intentions to build cement plants in the Dominican Republic. One plant would be constructed at Barahona by the Cementos Barahona C. por A. with a capacity of 22,000 barrels per day. The State-controlled Fabrica Dominicana de Cemento plans to expand its plant capacity, and Gulf & Western Industries, Inc., proposes to build a plant in Guayacanes. Distribution terminals were erected on many smaller islands including Barbados, Nassau, Curaçao, Aruba, Bermuda, Grenada, and St. Vincent.

Yugoslavia.—The new Prvoborac cement plant at Solin near Split was put into operation increasing the Yugoslav cement production capacity by 13 percent. The plant will have a capacity of 500,000 short tons per year. At Pljevlja, construction was started on a plant that is scheduled for completion in 1973. Construction was started in 1970 on a new slag cement plant in Kakanj, Bosnia, that will have an annual capacity of 720,000 tons when it is completed in 1974. A plant in Lukovac near Tuzla was under construction and was to have an annual capacity of 390,000 tons upon expected completion in 1972. Construction of a 1.2 million-ton-per-year plant at Usje near Skopje was scheduled for completion in 1972. Plans were announced for a 660,000-ton-per-year plant at Belgrade, a 440,000-ton-per-year plant in Kosjerić, Serbia, and a new nuit at the Podsused plant near Zagreb that will have the capacity increased by 660,000 short tons a year.

TECHNOLOGY

Millions of dollars were spent by the cement industry in 1970 to modernize and improve dust-collecting facilities and to increase the capacity and efficiency of pollution control systems to comply with existing and new pollution control standards and regulations. The cost of pollution abatement systems on new cement plants was reported to be about 20 percent of the capital investment. Electrostatic preceipitators continued to be the major dust collector installed on kilns; however, glass-bag dust collectors are becoming more important and in some instances have replaced the precipitators. Kaiser Cement & Gypsum installed glass-cloth bag houses with a design efficiency of 99.9 percent on the clinker coolers at its Permanente, Calif., plant. Maule Industries installed electrostatic precipitators at both ends of the kilns at its new plant in Dade County, Fla. This system has been used previously only in Australia. In Lund, Sweden, Mr. D. Romell patented an electro-scrubber dust collector using minute, electrically charged water drops instead of the large electrodes required for conventional electrostatic precipitators. The patent claims the ability to absorb sulphur dioxide, nitrous gases, and other gaseous impurities and particulate matter. Water drops are charged by electrostatic induction.

In addition to air and water pollution, there was increased attention given to noise pollution. According to the Portland Cement Association, Dragon Cement Co's. plant, under construction at Thomaston, Maine, will muffle noise from grinding mills with precast concrete enclosures. The control room and other monitoring stations will be soundproofed, and closed circuit television will be used to monitor the primary crusher and kiln flame to protect operators from the noise of those operations.

There was no indication of a change in the trend of manufacturing technology. Computer control is common in many plants with programs to cover most of the operations from preblending raw materials to calculating of heat consumption. The computer makes possible a greater degree of automation and the use of more sophisticated sensing and sampling techniques. One continuing trend in the industry is towards use of larger units of equipment. For example, Peerless Cement Co., a division of American Cement Corp., at its new plant under construction in Detroit, Mich., will install two ball mills 15 feet in diameter by 49 feet long driven by 7,000-horsepower motors. One of the largest rotary dryers in the world was put in operation at the Cement de Vicat S.A. plant in Crechy, France. The dryer, 17 meters long by 5.2 meters in diameter, has a rated capacity of 500 metric tons per hour, but a maximum of 700 tons per hour have been reached on material that has a mositure content of 15 to 18 percent.

Each year new improvements are announced for vertical shaft kilns used to produce clinker, and patents were granted in 1970. Output has been increased during the past 40 years to as much as 220 tons a day. Nevertheless, the capacity of the shaft kiln is very low, averaging about 60,000 tons per year compared with rotary kilns, which have capacities up to 1.25 million tons per year. Vertical kilns were not used to make cement in the United States but were common in many other countries.

According to the Portland Cement Association atomic-absorption spectroscopy is proving to be a reliable and time-saving tool in laboratory analytical work. Its growing acceptance in the cement industry is evidenced by its use by the Portland Cement Association, the Bureau of Public Roads, and many cement companies. Continuing work in several universities indicates the scanning electron microscope may also prove to be a useful device for investigation of the hydration process and other basic areas in cement and concrete research.

In July 1970 the National Bureau of Standards published the results of studies on the rate of stiffening of cement pastes and mortars in Building Science Series 28, "Exploratory Studies of Early Strength Development in Portland Cement Pastes and Mortars." The American Society for Testing and Materials (ASTM) published part 9 of the 1970 ASTM Standards containing 110 standards on cement, lime, and gypsum of which 20 percent are new, revised, or have changed in status since the 1969 edition was published.

The ASTM Committee C–1 on Cement is developing specifications for Types K, M, and S expansive cements that expand during the early hardening period after setting to produce shrinkage-compensating concrete. Concrete slabs poured with joint spacings more than 100 feet have not cracked during several years of exposure. Although applications are limited and usage is still relatively small, expansive cements are becoming increasingly important. The parking garage under construction at the Chicago O'Hare International Airport, one of the largest concrete structures in the world, uses the Type K expansive cement. Chemically Prestressed Concrete Corp. of Van Nuys, Calif. developed and holds the patent for the Type K expansive cement, sold under the trade name ChemComp. Ciments Lafarge of Paris, France, will produce and market ChemComp in France. Type K expansive cement comprises calcium silicates anhydrous calcium aluminosulfate, calcium sulfate, and free lime.

Limited quantities of controlled fast-setting cement have been produced. Although still in the experimental stage, the rapid-hardening hydraulic cement with very high early-strength development appears to offer promising applications in the manufacture of concrete products such as blocks, pipe, prestressed and precast forms; paving and resurfacing; underwater patching; and for slip form structures.

Research work at the Bureau of Mines Research Center in College Park, Md. on finding a use for waste silicofluorides produced during the sulfuric acid-superphosphate fertilizer process demonstrated that the fluorides act as byproduct mineralizers in lowering clinkering temperatures by as much as 150°C. In addition, retention time is reduced, fuel requirements are lowered, and the kiln refractory degradation is minimized.[2]

General Portland Cement Co., Trinity Division utilizing a new manufacturing process introduced a new tan-colored cement containing no color pigment additives to be used in high-quality architectural work. One of the first major applications was in the terminal building of the new Dallas-Fort Worth Airport. Universal Atlas Cement Division of United States Steel Corp. introduced a new oil well cement that mixes with sea water and remains pumpable without additives at depths to 16,000 feet. The company introduced an expansive cement comprizing portland cement, calcium aluminate cement and calcium sulfate designated Type M. Oregon Portland Cement introduced a new off-white cement. Ideal Basic Industries started marketing a Type S expansive cement composed of portland cement containing a large computed C_3A content and calcium sulfate in excess of the usual amount.

Various aspects of cement plant design and construction were discussed at the Sixth Cement Seminar in Chicago, Ill., December 6–9, 1970. Improvements in pyroprocessing, dust control, quarrying, and materials handling were the major topics covered in the seminar.

Raw materials used at the Dewey Rocky Mountain Cement Co's. new plant at Lyons, Colo., contain kerogen in the oil shale members of the shaley-limestone deposits. Kerogen, which vaporizes at 400 to 1,000° F, presented a problem of heat released at the feed end. A 12½-foot by 180-foot roaster was installed along with a 12½-foot by 45-foot dryer. Hot gases and unburned kerogens were utilized in the dryer and thereby eliminated the problems of high-backend temperatures in the kiln.

The British Standards Institution published BS4408, "Non-destructive Methods of Test for Concrete, Part 3 Gamma Radiography of Concrete," which described a method for radiographic inspection of hardened concrete up to 450 millimeters thick. This method is capable of diagnosing such faults as incomplete compaction or honeycombing, cavities in the grouting of prestressing wires, defects in joints between concrete units, and enables accurate determination of the position of reinforcing steel in concrete.

[2] Ampian, S. G. and Flint, E. P. The Effect of Silicofluorides on the Formation of Calcium Silicates, Aluminates, and Aluminoferrite. Paper to be presented at the 73rd Annual Meeting, The American Ceramic Society, Chicago, Ill. in April 1971.

Table 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by districts

District	Active plants		Production (thousand 376-pound barrels)		Shipments from mills						Stocks at mills Dec. 31 (thousand 376-pound barrels)	
					1969			1970				
						Value			Value			
	1969	1970	1969	1970	Thousand 376-pound barrels	Total (thousands)	Average per barrel	Thousand 376-pound barrels	Total (thousands)	Average per barrel	1969	1970
New York, Maine	11	11	27,555	27,518	29,423	$77,234	$2.62	28,402	$80,184	$2.82	2,374	1,978
Pennsylvania, eastern	17	17	31,453	31,357	32,940	89,096	2.70	30,909	89,782	2.90	2,387	1,972
Pennsylvania, western	5	5	11,651	10,295	11,953	37,845	3.17	9,999	31,319	3.13	1,688	1,753
Maryland, West Virginia	4	4	11,293	11,517	12,172	35,417	2.91	11,838	35,693	3.02	756	946
Ohio	9	9	14,698	11,898	15,100	50,071	3.32	11,752	39,997	3.40	1,824	1,989
Michigan	9	9	30,565	29,655	30,373	98,425	3.24	29,813	101,019	3.39	4,320	3,959
Indiana, Kentucky, Wisconsin	8	8	18,723	16,361	17,946	56,824	3.17	15,644	53,364	3.41	2,318	2,315
Illinois	4	4	8,872	7,400	8,720	29,996	3.44	7,946	25,252	3.18	1,765	1,030
Tennessee	6	6	8,813	8,534	9,159	29,403	3.21	8,878	29,832	3.36	799	834
Virginia, North Carolina, South Carolina	5	5	11,864	12,291	12,071	38,210	3.17	11,950	39,823	3.33	817	1,103
Georgia, Florida	6	7	14,520	15,856	15,108	51,260	3.40	15,456	51,566	3.34	776	1,246
Alabama	8	8	13,686	12,795	16,527	51,251	3.10	16,053	51,114	3.18	929	946
Louisiana, Mississippi	5	5	7,593	6,856	7,801	25,911	3.32	6,988	25,702	3.68	674	773
Minnesota, South Dakota, Nebraska	4	4	7,033	7,282	7,284	25,397	3.49	7,079	24,328	3.44	1,060	1,256
Iowa	5	5	13,633	13,421	14,084	47,265	3.36	12,744	45,432	3.56	1,157	1,873
Missouri	8	7	20,860	20,733	21,325	74,368	3.49	21,224	64,261	3.03	2,165	2,011
Kansas	6	6	9,737	8,973	9,764	29,365	3.01	9,197	28,177	3.06	1,483	1,120
Oklahoma, Arkansas	5	5	12,881	11,079	12,859	38,671	3.01	11,048	36,659	3.32	1,260	961
Texas	19	18	35,823	34,584	36,037	117,989	3.27	33,967	122,960	3.62	2,740	2,827
Wyoming, Montana, Idaho	4	4	4,680	4,494	5,099	17,727	3.48	4,518	16,127	3.57	696	718
Colorado, Arizona, Utah, New Mexico	7	8	12,037	13,820	12,408	44,868	3.62	13,553	52,972	3.91	899	1,203
Washington	5	4	6,323	6,670	6,356	22,724	3.58	6,495	24,832	3.82	1,004	1,005
Oregon, Nevada	3	3	3,497	3,935	3,689	14,127	3.83	3,944	15,231	3.86	805	254
California, northern	6	6	19,527	16,972	19,309	64,974	3.36	16,368	56,694	3.46	1,648	2,143
California, southern	8	8	31,238	33,100	31,301	105,638	3.37	33,131	116,432	3.51	1,928	1,831
Hawaii	2	2	2,102	2,271	2,075	10,544	5.08	2,105	9,968	4.74	133	287
Puerto Rico	2	3	8,945	9,523	8,943	27,920	3.12	9,460	29,515	3.12	154	217
Total	181	181	399,602	389,190	409,826	1,312,520	3.20	390,461	[2] 1,298,233	3.32	38,059	38,550

[1] Includes Puerto Rico.
[2] Data may not add to total shown because of independent rounding.

Table 3.—Portland cement shipped by plants in the United States,[1] by types

Type	1969 Quantity (thousand 376-pound barrels)	1969 Value (thousands)	1969 Average per barrel	1970 Quantity (thousand 376-pound barrels)	1970 Value (thousands)	1970 Average per barrel
General use and moderate heat (types I and II)	384,654	$1,216,626	$3.16	363,553	$1,191,215	$3.28
High-early-strength (type III)	13,485	47,065	3.49	14,171	50,086	3.53
Sulfate-resisting (type V)	2,033	7,452	3.67	3,155	11,652	3.69
Oil well	2,892	11,079	3.83	3,310	12,627	3.81
White	1,928	12,945	6.71	2,243	16,832	7.50
Portland-slag and portland pozzolan	386	1,187	3.08	410	1,418	3.46
Miscellaneous [2]	4,448	16,166	3.63	3,619	14,404	3.98
Total	409,826	1,312,520	3.20	390,461	[3] 1,298,233	3.32

[1] Includes Puerto Rico.
[2] Includes type IV, waterproof cements, and expansive cements.
[3] Data may not add to total shown because of independent rounding.

Table 4.—Destinations of shipments of all types of finished portland cement from mills in the United States, by States [1] [2]

(Thousand 376-pound barrels)

Destination	Finished portland 1969	Finished portland 1970
Alabama	6,043	5,314
Alaska [3]	W	W
Arizona	5,177	5,638
Arkansas	3,845	3,270
California, northern	17,733	15,176
California, southern	28,782	30,316
Colorado	4,817	5,535
Connecticut [3]	4,425	4,435
Delaware [3]	939	860
District of Columbia [3]	1,048	967
Florida	18,703	19,165
Georgia	10,880	10,125
Hawaii	2,584	2,447
Idaho	2,534	2,704
Illinois	19,581	17,595
Indiana	9,510	8,530
Iowa	8,865	8,488
Kansas	5,656	5,127
Kentucky	5,804	5,181
Louisiana	11,699	10,118
Maine	1,069	1,094
Maryland	7,230	7,709
Massachusetts [3]	6,952	7,198
Michigan	16,459	14,664
Minnesota	9,150	8,391
Mississippi	4,427	4,328
Missouri	9,577	9,291
Montana	2,077	1,699
Nebraska	4,525	4,437
Nevada	1,683	1,600
New Hampshire [3]	992	887
New Jersey [3]	10,963	10,995
New Mexico	2,273	2,282
New York, eastern	4,118	3,832
New York, western	4,521	5,020
New York, metropolitan [3]	8,987	9,016
North Carolina	8,526	8,099
North Dakota [3]	1,216	1,536
Ohio	20,242	17,176
Oklahoma	7,282	6,573
Oregon	3,645	3,423
Pennsylvania, eastern	12,460	11,144
Pennsylvania, western	7,357	6,115
Rhode Island [3]	1,031	1,001
South Carolina	4,297	4,163
South Dakota	1,341	1,289
Tennessee	7,231	7,320
Texas	30,051	28,792
Utah	2,441	2,228
Vermont [3]	692	575
Virginia	9,117	9,424
Washington	6,125	6,041
West Virginia	2,501	2,496
Wisconsin	9,611	8,138
Wyoming	915	989
Total United States	399,709	379,956
Other countries [4]	10,117	10,505
Total shipped from cement plants	409,826	390,461

W Withheld to avoid disclosing individual company confidential 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, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.

Table 5.—Clinker capacity and production in the United States,[1] by districts, as of Dec. 31, 1970

District	Active plants[2] Process used Wet	Active plants[2] Process used Dry	Active plants[2] Total	Total number of kilns	Daily capacity (376-pound barrels)	Average number of days for maintenance	Apparent annual capacity[3] (376-pound barrels)	Production[4] (376-pound barrels)	Percent utilized
New York, Maine	7	3	10	21	86,355	42	27,902,217	27,797,100	99.6
Pennsylvania, eastern	4	9	13	42	96,537	32	32,150,019	31,532,998	98.1
Pennsylvania, western	3	2	5	12	42,076	23	14,387,403	10,156,474	70.6
Maryland, West Virginia	2	2	4	14	38,665	36	12,705,095	11,543,884	90.9
Ohio	5	3	8	22	49,571	40	16,128,554	12,684,974	78.6
Michigan	6	1	7	30	90,929	40	29,538,903	28,786,853	97.5
Indiana, Kentucky, Wisconsin	3	5	8	19	67,169	46	21,422,818	16,637,876	77.7
Illinois	--	3	3	15	29,024	20	9,999,175	7,436,152	74.4
Tennessee	6	-	6	12	30,762	29	10,345,187	9,143,763	88.4
Virginia, North Carolina, South Carolina	4	1	5	15	38,786	49	12,254,214	12,555,879	102.5
Georgia, Florida	5	2	7	19	58,080	36	19,088,087	16,476,354	86.3
Alabama	4	3	7	18	39,213	49	12,373,215	12,859,751	103.9
Louisiana, Mississippi	5	-	5	13	29,377	49	9,276,880	6,844,951	73.8
Minnesota, South Dakota, Nebraska	3	1	4	13	25,400	49	8,035,768	6,906,521	85.9
Iowa	3	2	5	19	43,358	30	14,506,266	13,224,329	91.2
Missouri	5	2	7	12	71,426	68	21,228,957	20,601,374	97.0
Kansas	3	2	5	15	34,184	24	11,658,935	8,763,513	75.2
Oklahoma, Arkansas	3	2	5	11	43,041	53	13,448,626	11,395,125	84.7
Texas	14	4	18	46	129,805	30	43,423,863	35,543,830	81.9
Wyoming, Montana, Idaho	3	1	4	8	14,910	45	4,765,170	4,684,189	98.3
Colorado, Arizona, Utah, New Mexico	3	5	8	17	49,385	30	16,549,542	14,119,838	85.3
Washington	3	1	4	7	21,723	51	6,828,820	6,688,943	98.0
Oregon, Nevada	2	1	3	7	17,100	32	5,691,900	4,138,417	72.7
California, northern	3	2	5	25	53,641	37	17,601,722	17,992,428	102.2
California, southern	3	5	8	32	116,668	30	39,029,391	33,406,931	85.6
Hawaii	1	1	2	2	8,000	38	2,615,000	2,109,763	80.7
Puerto Rico	3	-	3	12	34,952	18	12,123,200	9,531,628	78.6
Total	106	63	169	478	1,360,137	38	445,078,927	393,563,838	88.4

[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 10 plants phased out; 2 new plants going on stream; and plants which added or shut down kilns during the year.

Table 6.—Clinker produced at mills in the United States,[1] by processes

Process	Number of plants		Production: Thousand 376-pound barrels		Production: Percent of total	
	1969	1970	1969	1970	1969	1970
Wet	113	112	245,235	237,542	61.0	60.4
Dry	r 66	67	157,040	156,022	39.9	39.6
Total	r 179	179	402,275	393,564	100.0	100.0

r Revised.
1 Includes Puerto Rico.

Table 7.—Raw materials used in producing portland cement in the United States [1]
(Thousand short tons)

Raw materials	1968	1969	1970
Cement rock	23,842	23,315	22,824
Limestone (including oystershell)	83,751	84,202	83,230
Marl	701	716	1,669
Clay and shale [2]	12,489	12,190	11,833
Blast-furnace slag	1,086	959	853
Gypsum	3,465	3,569	3,491
Sand and sandstone (including silica and quartz)	1,807	1,979	2,193
Iron materials [3]	652	783	777
Miscellaneous [4]	343	369	341
Total	128,136	128,082	127,211

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 8.—Finished portland cement produced and fuel consumed by the portland cement industry in the United States,[1] by processes

Year and process	Finished cement produced: Plants	Thousand 376-pound barrels	Percent of total	Fuel consumed: Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1969:						
Wet	[2] 113	245,344	61.4	5,553	5,093	139,337,469
Dry	68	154,258	38.6	3,630	981	61,957,351
Total	181	399,602	100.0	[3] 9,183	6,074	201,294,820
1970:						
Wet	112	235,278	60.5	4,347	7,486	143,262,418
Dry	[2] 69	153,912	39.5	3,619	2,542	68,550,508
Total	181	389,190	100.0	7,966	10,028	211,812,926

1 Includes Puerto Rico.
2 Includes two grinding plants that received clinker from other sources.
3 Comprises 212,522 tons of anthracite and 8,970,260 tons of bituminous coal.

Table 9.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	Finished cement produced: Plants	Finished cement produced: Thousand 376-pound barrels	Finished cement produced: Percent of total	Fuel consumed: Coal (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1969:						
Coal	60	[2] 129,950	32.5	6,191	-----	-----------
Oil	8	[2] 18,677	4.7	-----	3,338	-----------
Natural gas	[3] 48	[2] 101,714	25.5	-----	-----	111,505,526
Coal and oil	18	42,805	10.7	1,770	1,255	-----------
Coal and natural gas	21	44,309	11.1	986	-----	31,949,593
Oil and natural gas	18	42,894	10.7	-----	1,338	42,504,578
Coal, oil, natural gas	8	19,253	4.8	236	143	15,335,123
Total	181	399,602	100.0	[4] 9,183	6,074	201,294,820
1970:						
Coal	42	73,331	18.8	3,560	-----	-----------
Oil	11	24,946	6.4	-----	5,509	-----------
Natural gas	48	102,314	26.3	-----	-----	118,817,083
Coal and oil	[3] 19	49,860	12.8	1,762	1,356	-----------
Coal and natural gas	28	52,999	13.6	1,392	-----	30,628,839
Oil and natural gas	19	43,465	11.2	-----	1,909	40,526,094
Coal, oil, natural gas	14	42,275	10.9	1,252	1,254	21,840,910
Total	181	389,190	100.0	7,966	10,028	211,812,926

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows: Coal, 95.3 pounds; oil, 0.1783 barrel; and natural gas, 1,096 cubic feet.
[3] Includes two grinding plants that received clinker from other sources.
[4] Comprises 212,522 tons of anthracite and 8,970,260 tons of bituminous coal.

Table 10.—Electric energy at portland cement plants in the United States,[1] by processes

Year and process	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)
1969:								
Wet	9	265	109	5,508	5,773	59.3	245,344	23.5
Dry	r 14	r 836	r 67	r 3,126	3,962	40.7	154,258	25.7
Total	r 23	r 1,101	r 176	r 8,634	9,735	100.0	399,602	24.4
Percent of total electric energy used	--	r 11.3	---	r 88.7	100.0	-----	-------	----
1970:								
Wet	9	307	109	5,353	5,660	57.5	235,278	24.1
Dry	14	812	69	3,364	4,176	42.5	153,912	27.1
Total	23	1,119	178	8,717	9,836	100.0	389,190	25.3
Percent of total electric energy used	--	11.4	---	88.6	100.0	-----	-------	----

r Revised.
[1] Includes Puerto Rico.

Table 11.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers, by types of carriers in 1970

(Thousand 376-pound barrels)

Type of carrier	Shipments from plants to terminal		Shipments to ultimate consumer				Total shipments
			From terminal to consumer		From plant to consumer		
	In bulk	In containers	In bulk	In containers	In bulk	In containers	
Railroad	44,060	1,865	8,187	408	57,368	4,348	70,311
Truck	5,645	332	83,105	4,538	197,089	26,485	311,217
Barge and Boat	42,657	42	3,950	4	4,508	65	8,527
Unspecified [2]	-------	-------	35	-------	296	75	406
Total	92,362	2,239	95,277	4,950	259,261	30,973	[3] 390,461

[1] Includes Puerto Rico.
[2] Includes cement used at plant.
[3] Bulk shipments were 90.8 percent (354,538 barrels); container (bag) shipments were 9.2 percent (35,923 barrels).

Table 12.—Cement shipments by types of customers in 1970

(Quantities in thousand 376-pound barrels)

District	Building materials [1]		Highway contractors and government agencies [2]		Miscellaneous including own use		Total
	Quantity	Percent	Quantity	Percent	Quantity	Percent	
New York, Maine	25,953	91.4	1,257	4.4	1,192	4.2	28,402
Pennsylvania, eastern	28,862	93.3	1,532	5.0	515	1.7	30,909
Pennsylvania, western	8,582	85.8	1,170	11.7	247	2.5	9,999
Maryland, West Virginia	10,310	87.1	1,406	11.9	122	1.0	11,838
Ohio	10,232	87.1	1,217	10.3	303	2.6	11,752
Michigan	24,523	82.3	3,885	13.0	1,405	4.7	29,813
Indiana, Kentucky, Wisconsin	13,415	85.8	1,949	12.4	280	1.8	15,644
Illinois	7,290	91.7	467	5.9	189	2.4	7,946
Tennessee	7,868	88.6	879	9.9	131	1.5	8,878
Virginia, North Carolina, South Carolina	10,386	86.9	1,467	12.3	97	.8	11,950
Georgia, Florida	13,460	87.1	1,657	10.7	339	2.2	15,456
Alabama	14,036	87.4	1,794	11.2	223	1.4	16,053
Louisiana, Mississippi	5,363	76.7	1,040	14.9	585	8.4	6,988
Minnesota, South Dakota, Nebraska	5,150	72.8	1,843	26.0	86	1.2	7,079
Iowa	11,230	88.1	1,399	11.0	115	.9	12,744
Missouri	17,800	83.9	3,013	14.2	411	1.9	21,224
Kansas	7,182	78.1	1,511	16.4	504	5.5	9,197
Oklahoma, Arkansas	8,003	72.4	2,847	25.8	198	1.8	11,048
Texas	27,942	82.3	3,247	9.5	2,778	8.2	33,967
Wyoming, Montana, Idaho	3,109	68.8	1,064	23.6	345	7.6	4,518
Colorado, Arizona, Utah, New Mexico	11,338	83.7	1,829	13.5	386	2.8	13,553
Washington	5,125	78.9	1,259	19.4	111	1.7	6,495
Oregon, Nevada	3,500	88.8	439	11.1	5	.1	3,944
California northern	14,206	86.8	1,983	12.1	179	1.1	16,368
California, southern	26,948	81.3	5,616	17.0	567	1.7	33,131
Hawaii	2,005	95.2	58	2.8	42	2.0	2,105
Puerto Rico	8,822	93.3	1	--------	637	6.7	9,460
Total	332,640	85.2	45,829	11.7	11,992	3.1	390,461

[1] Includes dealers, concrete products manufacturers and ready-mixed concrete manufacturers.
[2] Includes Federal, State, and other government agencies.

Table 13.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand 280-pound barrels)		Shipments from mills					
					1969			1970		
						Value			Value	
	1969	1970	1969	1970	Thousand 280-pound barrels	Total (thousands)	Average per barrel [1]	Thousand 280-pound barrels	Total (thousands)	Average per barrel
New York, Maine	8	8	905	890	939	$2,335	$2.49	864	$2,260	$2.62
Pennsylvania, eastern	10	11	1,920	1,936	1,963	5,232	2.67	1,889	5,650	2.99
Pennsylvania, western	5	5	1,094	916	1,122	3,272	2.92	915	2,674	2.92
Maryland, West Virginia	4	4	947	811	930	2,468	2.66	788	2,082	2.64
Ohio	6	6	1,158	867	1,123	3,527	3.14	867	3,116	3.59
Michigan	4	4	1,903	1,431	1,904	5,473	2.87	1,519	5,253	3.46
Indiana, Kentucky, Wisconsin	5	5	3,015	2,814	2,983	8,009	2.68	2,781	8,165	2.94
Illinois	3	3	642	533	603	2,137	3.54	508	1,874	3.69
Tennessee	4	4	1,366	1,227	1,331	3,587	2.69	969	2,749	2.84
Virginia, North Carolina, South Carolina	5	5	2,222	2,125	2,182	7,238	3.32	2,098	7,711	3.68
Georgia, Florida	4	4	1,195	1,314	1,192	3,378	2.83	1,538	4,519	2.94
Alabama	9	8	2,395	2,090	2,600	8,520	3.28	2,402	7,601	3.16
Louisiana, Mississippi	4	4	297	295	380	1,018	2.68	337	974	2.89
Minnesota, South Dakota, Nebraska	4	4	188	201	227	740	3.25	193	699	3.62
Iowa	4	3	569	463	606	1,912	3.15	520	1,758	3.38
Missouri	6	6	416	401	427	1,319	3.09	402	1,234	3.07
Kansas	7	5	432	285	348	1,023	2.94	328	1,029	3.14
Oklahoma, Arkansas	5	5	621	546	582	1,789	3.07	550	1,735	3.15
Texas	12	12	1,137	1,102	1,110	3,873	3.49	1,006	3,769	3.75
Wyoming, Montana, Idaho	4	4	34	56	39	127	3.25	41	139	3.39
Colorado, Arizona, Utah, New Mexico	5	5	601	638	602	1,912	3.18	639	2,011	3.15
Washington	4	3	42	43	58	204	3.53	41	158	3.85
Oregon, Nevada	------	------	----------	----------	2	13	5.30	3	11	3.67
Hawaii	------	2	----------	72	----------	----------	----------	77	366	4.75
Total	122	120	23,099	21,056	23,253	69,106	2.97	21,275	67,537	3.17

[1] Computed prior to rounding.

Table 14.—Shipments of prepared masonry cement from mills in the United States, by States [1]

(Thousand 280-pound barrels)

Destination	Masonry cement 1969	Masonry cement 1970
Alabama	597	611
Alaska [2]	W	W
Arizona	W	W
Arkansas	343	316
California, northern [2]	----------	----------
California, southern [2]	----------	----------
Colorado	223	212
Connecticut [2]	145	132
Delaware [2]	59	53
District of Columbia [2]	257	200
Florida	1,703	1,710
Georgia	1,367	1,278
Hawaii	----------	77
Idaho	13	12
Illinois	805	698
Indiana	805	677
Iowa	188	173
Kansas	172	159
Kentucky	634	584
Louisiana	440	339
Maine	80	81
Maryland	687	627
Massachusetts [2]	315	328
Michigan	1,380	1,085
Minnesota	451	345
Mississippi	407	407
Missouri	229	225
Montana	14	13
Nebraska	74	73
Nevada [2]	W	----------
New Hampshire [2]	92	76
New Jersey [2]	600	580
New Mexico	73	74
New York, eastern	283	225
New York, western	263	239
New York, metropolitan [2]	326	324
North Carolina	1,544	1,458
North Dakota [2]	50	47
Ohio	1,632	1,313
Oklahoma	304	296
Oregon [2]	2	2
Pennsylvania, eastern	466	475
Pennsylvania, western	638	514
Rhode Island [2]	28	33
South Carolina	916	914
South Dakota	45	44
Tennessee	1,087	1,031
Texas	1,039	934
Utah [2]	5	5
Vermont [2]	43	38
Virginia	1,317	1,203
Washington	60	48
West Virginia	233	213
Wisconsin	469	392
Wyoming	15	12
Total United States	22,918	20,905
Other countries [3]	335	370
Total shipped from cement plants	23,253	21,275

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."
[1] Includes imported cement shipped by domestic producers only.
[2] Has no cement producing plants.
[3] Direct shipments by producers to other countries and to Alaska, Arizona, and Nevada.

Table 15.—Average mill value in bulk, of cement in the United States [1]

(Per barrel)

Year	Portland cement [2]	Slag cements [2]	Prepared masonry cement [3] [4]	All classes of cement [5]
1966	$3.12	$3.74	$2.83	$3.15
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

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 (1966–69).

Table 16.—U.S. exports of hydraulic cement by countries

(Thousand 376-pound barrels and thousand dollars)

Destination	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	9	$56	5	$215	27	$716
Bahamas	44	217	32	220	27	192
Belgium-Luxembourg	7	55	5	53	1	20
Bolivia	4	42	2	14	(1)	2
Brazil	(1)	4	3	43	2	12
Canada	222	1,117	200	980	460	2,235
Chile	3	40	5	79	3	26
Dominican Republic	3	17	1	21	1	30
Ecuador	1	13	3	25	13	103
France	1	10	1	13	2	22
French West Indies	349	660	79	146	75	130
Germany, West	4	80	4	84	2	85
Guatemala	(1)	1	1	5	1	8
Guyana	2	5	10	20	------	-------
Indonesia	16	149	10	91	2	15
Italy	2	16	1	5	2	21
Jamaica	5	28	5	42	4	26
Japan	11	197	11	228	12	309
Leeward and Windward Islands	130	271	130	266	88	171
Mexico	17	197	24	190	38	366
Mozambique	(1)	1	2	11	2	12
Netherlands	2	10	2	12	(1)	2
Netherlands Antilles	42	87	12	27	29	70
Nicaragua	10	67	4	33	11	83
Norway	3	12	3	13	4	20
Panama	1	16	1	20	1	17
Peru	6	42	1	15	1	15
Philippines	3	29	1	12	3	30
Spain	3	14	3	15	2	23
Sweden	1	22	2	19	2	31
Taiwan	1	20	------	------	2	25
United Kingdom	5	23	2	9	2	14
Venezuela	2	27	5	47	1	20
Vietnam, South	(1)	1	(1)	4	(1)	9
Western Africa, n.e.c	4	38	(1)	2	------	-------
Other	29	300	19	210	27	351
Total	942	3,884	589	3,189	847	5,211

[1] Less than ½ unit.

Table 17.—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
1968	6,922	$16,103	152	$242	215	$1,033	7,289	$17,378
1969	r 8,818	r 21,852	608	1,641	r 261	r 883	9,687	24,376
1970	11,437	28,596	2,136	4,320	239	1,260	13,812	34,176

r Revised.

Table 18.—U.S. imports for consumption of hydraulic cement in 1970, by countries and customs districts

(Thousand 376-pound barrels and thousand dollars)

	Quantity	Value
Country:		
Bahamas	3,848	$10,139
Belgium-Luxembourg	90	424
Canada	5,345	13,104
Colombia	496	932
Denmark	36	200
Dominican Republic	4	9
France	14	100
Germany, West	39	406
Jamaica	(1)	1
Japan	301	720
Korea, Republic of	(1)	3
Lebanon	(1)	1
Mexico	518	1,236
Norway	2,607	5,204
Spain	33	199
United Kingdom	460	1,383
Venezuela	8	17
Yugoslavia	13	98
Total	13,812	34,176
Customs district:		
Anchorage	283	864
Baltimore	18	39
Boston	125	289
Bridgeport	694	1,144
Buffalo	1,685	3,723
Customs district—Continued:		
Charleston	298	$665
Chicago	37	226
Detroit	1,178	2,316
El Paso	1	2
Galveston	32	190
Great Falls	9	36
Honolulu	242	481
Laredo	4	12
Los Angeles	17	106
Miami	1,831	4,567
Milwaukee	(1)	(1)
New Orleans	1	3
New York City	1,913	4,060
Norfolk	647	1,717
Ogdensburg	501	1,492
Pembina	116	445
Philadelphia	38	403
Portland, Maine	32	125
Portland, Oreg	1	5
St. Albans	352	1,401
San Juan	658	1,710
Savannah	4	54
Seattle	808	2,041
Tampa	2,287	6,060
Total	13,812	34,176

1 Less than ½ unit.

Table 19.—Hydraulic cement: World production, by countries

(Thousand 376-pound barrels)

Country	1968[1]	1969[1]	1970[p]
North America:			
Bahamas	4,000	4,764	4,887
Canada (sold or used by producers)	43,436	43,881	42,896
Costa Rica	774	926	1,050
Cuba	4,573	[e] 4,700	[e] 5,000
Dominican Republic	1,917	2,287	2,885
El Salvador	903	833	979
Guatemala	1,055	1,096	1,319
Haiti	246	293	369
Honduras	756	774	885
Jamaica	2,398	2,427	2,680
Mexico	35,919	39,795	41,782
Nicaragua	598	639	797
Panama	967	1,020	[e] 1,060
Trinidad and Tobago	1,231	1,425	[e] 1,490
United States (including Puerto Rico)	412,040	416,652	406,721
South America:			
Argentina	24,479	25,248	27,962
Bolivia	416	469	674
Brazil	42,691	45,869	52,782
Chile	7,259	8,414	7,910
Colombia	13,879	14,119	16,165
Ecuador	2,545	2,674	[e] 2,700
Paraguay	141	217	369
Peru	6,502	6,667	[e] 6,740
Uruguay	3,020	2,738	2,938
Venezuela	14,295	12,196	15,538
Europe:			
Albania	1,771	1,923	[e] 2,110
Austria	26,696	26,725	28,179
Belgium	33,656	36,757	39,455
Bulgaria	20,616	20,827	21,530
Czechoslovakia	38,071	39,478	43,395
Denmark	13,357	15,286	15,268
Finland	8,654	10,314	10,783
France	148,888	161,495	169,451
Germany, East	44,274	43,447	[e] 44,000
Germany, West	196,088	205,675	224,713
Greece	23,917	28,379	28,730
Hungary	16,423	15,034	16,247
Iceland	586	545	498
Ireland	7,927	7,464	5,042
Italy	172,764	184,684	194,241

See footnotes at end of table.

Table 19.—Hydraulic cement: World production, by countries—Continued

(Thousand 376-pound barrels)

Country	1968 [1]	1969 [1]	1970 p
Europe—Continued			
Luxembourg	1,120	1,214	1,437
Netherlands	20,147	19,326	22,457
Norway	13,468	14,611	15,450
Poland	68,015	69,364	71,416
Portugal	10,912	11,938	13,673
Romania	41,196	44,063	47,652
Spain (includes Canary Islands)	87,681	92,489	96,957
Sweden	22,937	23,207	23,418
Switzerland	25,336	26,584	28,127
U.S.S.R	513,114	526,178	558,192
United Kingdom	104,796	102,151	99,988
Yugoslavia	22,076	23,242	25,793
Africa:			
Algeria	5,078	5,570	e 5,900
Angola	1,829	2,246	2,639
Cape Verde Islands	53	e 60	e 60
Congo (Kinshasa)	1,724	1,888	2,252
Ethiopia	1,020	973	1,061
Ghana	1,349	2,392	2,474
Ivory Coast	1,935	2,275	e 2,350
Kenya	3,184	3,764	4,702
Liberia	293	410	e 410
Libya	----------	e 290	e 590
Malagasy Republic	399	440	440
Malawi	328	446	410
Morocco	5,840	5,429	6,831
Mozambique	1,689	1,788	2,257
Niger	135	147	205
Nigeria	3,366	3,319	3,495
Rhodesia, Southern	1,988	2,240	e 2,290
Senegal	1,184	1,214	1,413
Sierra Leone	258	e 211	e 211
South Africa, Republic of	25,857	29,241	33,720
Sudan	850	1,026	1,231
Tanzania	915	997	979
Tunisia	2,984	3,536	3,154
Uganda	909	1,014	1,120
United Arab Republic	18,452	21,184	21,612
Zambia	1,999	1,483	985
Asia:			
Afghanistan [2]	539	616	e 645
Burma	1,032	1,073	1,172
Cambodia e	350	350	350
Ceylon	1,301	1,659	1,911
China, mainland e	52,800	58,600	58,600
Cyprus	1,395	1,425	1,548
Hong Kong	2,199	2,216	3,096
India	70,009	77,748	79,407
Indonesia	2,404	3,166	3,242
Iran [2]	11,375	13,732	e 15,110
Iraq e	8,200	8,200	8,200
Israel	6,485	7,669	8,204
Japan	279,547	301,300	335,320
Jordan	2,814	2,234	2,345
Korea, North e	15,800	17,600	23,500
Korea, Republic of	20,944	28,525	34,078
Lebanon	5,312	7,347	7,593
Malaysia	5,494	5,705	6,039
Mongolia e	440	700	700
Pakistan	14,289	15,702	15,432
Philippines	15,034	17,297	14,371
Qatar	----------	e 300	e 600
Ryukyu Islands	1,466	e 1,500	e 1,500
Saudi Arabia	[3] 2,996	3,272	3,817
Singapore	3,325	3,653	4,257
Syrian Arab Republic	5,371	5,476	5,676
Taiwan	23,412	23,969	25,242
Thailand	13,867	14,090	14,500
Turkey	27,722	33,984	37,355
Vietnam, North e	2,900	2,900	2,900
Vietnam, South	850	1,448	1,677
Oceania:			
Australia	23,031	25,271	26,971
Fiji Islands	299	322	352
New Zealand	4,474	4,708	4,861
Total	r 3,021,620	r 3,179,863	3,350,142

e Estimate. p Preliminary. r Revised.

[1] Most entries revised slightly from data appearing in 1969 edition of this chapter owing to use of a different conversion factor from tons to barrels.

[2] Year beginning Mar. 21 of that stated.

[3] For the period Mar. 30, 1968 to Mar. 18, 1969.

Chromium

By John L. Morning [1]

Imports of chromite balanced domestic requirements for the first time since 1966, reflecting increased world production which established a new high. Metallurgical-grade chromite prices rose for the fourth successive year, continuing the trend initiated in 1967, primarily as a result of continued United Nations economic sanctions against Southern Rhodesia. Southern Rhodesia was formerly a leading supplier of chromite to the United States. Government stockpile sales of chromite were strong, particularly for chemical-grade chromite, of which the General Services Administration (GSA) sold 667,000 tons.

Legislation and Government Programs.—In August, the Office of Emergency Preparedness (OEP) found, as a result of an extensive investigation, that ferroalloys and related products were not being imported into the United States in such quantities or under such circumstances as to threaten the national security. This was in response to an application filed May 24, 1968, by a committee of producers of ferroalloys and related products under section 232 of the Trade Expansion Act of 1962. OEP concluded that, based on available information, the domestic ferroalloy capacity continues to be sufficient to meet emergency defense and civilian requirements.

New quantity stockpile objectives for chromite were established by OEP in March. OEP defines quantity objectives as the difference between the estimated essential requirements for defense production in an emergency period and the estimated supply that would be available. The new objectives lowered the basic objectives for both metallurgical-grade and refractory-grade chromite as well as subobjectives for metallurgical-grade chromite. The new objectives are shown in table 2.

GSA in July offered for sale, on a competitive bid basis, 803,527 long dry tons of metallurgical-grade chromite. This material was acquired under the Defense Production Act of the 1950's and stored at Nye, Mont. An announced sale of the material was defaulted, and the chromite was reoffered for sale in November, but no acceptable bid was received.

Congress on July 10 passed Public Law 91–328, authorizing the disposal of 826,900 short tons of refractory-grade chromite from the national stockpile. In December, GSA sold 21,840 short tons by competitive bidding to Kaiser Aluminum & Chemical Corp.

During the year, Government stockpiles were reduced by a total of 245,000 tons of which 161,000 tons was metallurgical-grade and 84,000 tons was chemical-grade. At yearend, 259,000 tons of metallurgical-grade, 589,000 tons of chemical-grade, and 21,000 tons of refractory-grade chromite were listed as sold but unshipped.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1966	1967	1968	1969	1970
United States:					
Exports	19	8	13	49	41
Reexports	173	157	126	150	73
Imports for consumption	1,864	1,240	1,084	1,106	1,405
Consumption	1,461	1,355	1,316	1,411	1,403
Stocks Dec. 31: Consumer	1,306	1,197	912	740	809
World: Production	4,843	5,041	5,444	5,896	6,527

Table 2.—U.S. Government chromium stockpile material inventories and objectives

(Thousand short tons)

Type of material	Objective	Inventory by program, Dec. 31, 1970: National stockpile	Defense Production Administration	Supplemental stockpile	Total
Chromite, chemical: Stockpile grade	260	559	600	----------	1,159
Chromite, refractory:					
Stockpile grade	368	1,047	----------	180	1,227
Nonstockpile grade	----------	(1)	----------	----------	(1)
Chromite, metallurgical:					
Stockpile grade	[2] 2,911	1,791	----------	323	2,114
Nonstockpile grade	----------	693	901	----------	1,594
Ferrochromium, high-carbon:					
Stockpile grade	71	125	----------	277	402
Nonstockpile grade	----------	1	----------	----------	1
Ferrochromium, low-carbon:	----------	128	----------	191	319
Ferrochromium-silicon	----------	26	----------	33	59
Chromium metal, electrolytic	4	1	----------	3	4
Chromium metal, aluminothermic	----------	----------	----------	4	4

[1] Less than ½ unit.
[2] 455,602 tons of chromium alloys included above, equivalent to 1,083,325 tons of chromite, credited to objective.

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 the world's leading chromite consumer 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:	
A. P. Green Refractory Co	Mexico, Mo.
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	Kearny, N.J. Painsville, Ohio.
Imperial Color & Chemical Department, Hercules, Inc	Glens Falls, N.Y.
PPG Industries, Inc	Corpus Christi, Tex.

CONSUMPTION AND USES

Domestic consumption of 1,403,000 tons of chromite ore and concentrate containing about 429,000 tons of chromium was about the same as in 1969. Of the total chromite consumed, the metallurgical industry used 65 percent, the refractory industry 20 percent, and the chemical industry 15 percent. The metallurgical industry consumed 912,000 tons of chromite containing 300,000 tons of chromium in producing 391,000 tons of chromium alloys and chromium metal. About 70 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 13 percent had a ratio of less than 2:1.

Producers of chromite-bearing refractories consumed 278,000 tons of ore containing 67,000 tons of chromium. The chemical industry consumed 213,000 tons of chromite containing 61,000 tons of chromium in producing 148,000 tons of chemicals (sodium bichromate equivalent).

Table 3.—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	Average Cr_2O_3 (percent)
1966	828	49.6	439	34.6	194	44.9	1,461	44.5
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	1,316	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

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1970

(Short tons)

Alloy	Production		Shipments	Producer stocks Dec. 31
	Gross weight	Chromium content		
Low-carbon ferrochromium	104,071	73,146	100,822	9,281
High-carbon ferrochromium	172,302	116,703	195,520	25,790
Ferrochromium silicon	99,108	39,364	101,327	12,703
Other [1]	15,504	12,238	15,562	2,505
Total	390,985	241,451	413,231	50,279

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Table 5.—U.S. consumption by end uses, and consumer stocks of chromium ferroalloys and metal in 1970

(Short tons)

End use	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Other [1]	Total
Steel:					
Carbon	1,934	5,356	W	W	7,290
Stainless and heat resisting	114,956	63,367	49,996	3,463	231,782
Alloy (excludes stainless and heat resisting)	16,780	33,706	6,443	3,369	60,298
Tool	589	1,955	259	W	2,803
Cast irons	1,315	6,465	67	576	8,423
Superalloys	10,977	1,218	745	1,942	14,882
Alloys (excludes alloy steel and superalloys):					
Cutting and wear-resistant materials	W	367	-------	W	367
Welding and alloy hard-facing rods and materials	569	927	W	296	1,792
Nonferrous alloys	W	W	-------	883	883
Other alloys [2]	1,196	62	W	158	1,416
Miscellaneous and unspecified	4,421	4,323	1,241	2,959	12,944
Total	152,737	117,746	58,751	13,646	342,880
Chromium content	105,073	76,746	23,841	8,535	214,195
Consumer stocks, Dec. 31, 1970	12,648	12,206	3,567	5,454	33,875

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."

[1] Includes chromium metal.

[2] Includes magnetic alloys.

STOCKS

Yearend stocks of chromite in the three consuming industries were mixed compared with the start of the year. Ending a 3-year drop, chromite stocks in the metallurgical industry rose 31 percent as a higher level of imports and Government stockpile releases contributed to supply. Stocks in the refractory industry showed little change during the year, while stocks in the chemical industry continued to decrease, dropping 22 percent.

Producer stocks of chromium alloys increased more than 5,600 tons compared with 1969, but the increase was offset by a similar quantity in drawdown of consumer inventory.

Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants increased from 8,279 tons in 1969 to 11,176 tons in 1970.

Table 6.—Consumers' stocks of chromite, Dec. 31

(Thousand short tons)

Industry	1966	1967	1968	1969	1970
Metallurgical	463	459	396	r 296	388
Refractory	578	486	309	r 301	310
Chemical	265	252	207	143	111
Total	1,306	1,197	912	r 740	809

r Revised.

PRICES

Published chromite ore prices were $5.50 to $13.00 per long ton higher at yearend than during the year. Yearend prices reflect delivery price for 1971 shipments. The metallurgical-grade chromite price advance continued the trend initiated in 1967 and reflects the continuation of United Nations economic sanctions on Southern Rhodesia, the limited available supply, and increased shipping costs.

The price of South African (Transvaal) chromite was increased in April and again in October, owing to strong consumer demand and increased shipping charges. This was the first substantial price movement in some years; throughout the 1960's the price ranged from $18 to $21 per long ton.

GSA sold both metallurgical-grade and refractory-grade chromite by competitive sealed bids and received $49.61 and $28.10 per short ton (equivalent to $54.57 and $30.91 per long ton), respectively. Chemical-grade chromite was sold by negotiation during the year at prices ranging from $14.50 to $17.50 per short ton (equivalent to $15.95 to $19.25 per long ton).

Chromium alloy prices continued to rise throughout the year with announcements made quarterly except for the second quarter. Selected chromium alloy prices published by Metals Week were as follows:

	Oct. 1, 1969	Jan. 12, 1970	Jan. 2, 1971
	Cents per pound chromium		
High-carbon ferrochromium	21.7	23.7	28.7
Low-carbon ferrochromium (0.025 percent carbon)	28.6	31.5	39.5
Charge chromium	18.0	20.0	25.0
Blocking chromium (10–14 percent silicon)	20.6	22.6	27.6
	Cents per pound product		
Ferrochromium-silicon (40–43 percent grade)	14.35	15.65	(1)
Electrolytic chromium metal	101.0	101.0	115
Aluminothermic chromium metal	99.0	99.0	115

1 Pricing base changed to per pound chromium plus per pound silicon.

Table 7.—Price quotations for various grades of foreign chromite in 1970

Source	Cr_2O_3 (percent)	Chromium-iron ratio	Price per long ton, Jan. 1 [1]	Price per ton Dec. 31 [1,2]
South Africa, Republic of (Transvaal)	44	------------	$19.00–$21.50	$25.00–$27.00
Turkey	48	3:1	47.50– 48.50	55.00– 56.00
U.S.S.R.	48	4:1	50.00– 52.00	[3] 64.00
U.S.S.R.	54–56	4:1	55.20– 59.20	[3] 70.00
Iran	48	4:1	------------	[4] 54.00– 55.00

1 Dry basis, subiect to penalties if guarantees are not met, f.o.b. cars Atlantic ports.
2 For 1971 delivery.
3 Estimated. Actual quotations per metric ton f.o.b. loading point.
4 F.o.b. Iranian ports.

Source: Metals Week.

FOREIGN TRADE

Exports of chromite were approximately the same as in 1969, while reexports decreased 51 percent and were the lowest since 1964. Canada received 88 percent and Mexico 12 percent of the reexports. Chromite was exported to nine countries, with Canada, Mexico, and Japan accounting for 90 percent of the total.

Ferrochromium exports were 15 percent higher than in 1969, totaling 28,373 tons valued at over $8 million.. Of the 24 countries receiving shipments, West Germany, the United Kingdom, and Canada were leading recipients, accounting for 80 percent of the total.

Chromium and chromium alloys (wrought and unwrought) and waste and scrap exports totaled 225 tons valued at $400,000. Canada received 30 percent of the shipments, and the balance was well dispersed among 23 other countries.

Exports of non-pigment-grade chromium chemicals totaled 1,031 tons valued at $517,561. Mexico, Canada, Hong Kong, and Australia were the principal recipients, although 30 countries received shipments. Exports of pigment-grade chromium chemicals totaled 156 tons valued at $227,433. Of the 17 countries receiving shipments, Canada accounted for 60 percent, South Vietnam 15 percent, and Iran 12 percent.

Exports of sodium chromate and bichromate totaled 4,890 tons valued at $1,224,438. Canada received 78 percent of the shipments.

Imports of chromite increased significantly in 1970 compared with 1969 as shipments from the U.S.S.R. and Turkey increased 47 and 50 percent, respectively. Both low-carbon and high-carbon ferrochromium imports for consumption decreased substantially compared with those of 1969. Low-carbon ferrochromium imports were the lowest since 1964.

Imports of chromium-containing pigments were as follows: Chrome green, 164 tons; chromium yellow, 5,319 tons; chromium oxide green, 1,034 tons; hydrated chromium oxide green, 240 tons; molybdenum orange, 95 tons; and zinc yellow, 1,353 tons. Total value of these products was $3.9 million, 50 percent higher than in 1969. Chrome yellow accounted for 64 percent of total value, of which Japan supplied 87 percent.

Imports of sodium bichromate and dichromate totaled 3,606 tons valued at $655,245, a decrease of 44 percent compared with 1969. The Republic of South Africa, Italy, Japan, and West Germany were the leading suppliers. Potassium chromate and dichromate imports totaled 80 tons valued at $12,711.

At yearend, the fourth stage of tariff reductions became effective under the 1967 "Kennedy round" of tariff negotiations. Import duties as of January 1971 are shown in table 11.

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
1968	13	$517	126	$5,351
1969	49	1,915	150	5,806
1970	41	2,582	73	2,572

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	
1969						
Australia	--	--	--	587	417	$80
France	475	348	$134	--	--	--
Finland	--	--	--	2,254	1,303	239
Germany, West	r 3,113	r 2,374	r 901	1,924	1,285	336
Italy	--	--	--	1,102	716	179
Japan	661	445	164	2,498	1,674	391
Mozambique	560	380	135	--	--	--
Norway	3,044	2,118	788	r 883	630	169
South Africa, Republic of	19,794	12,192	4,973	r 8,992	r 4,823	r 933
Sweden	3,800	2,865	1,098	--	--	--
Turkey	4,947	3,456	1,213	--	--	--
United Kingdom	(1)	(1)	1	--	--	--
Western Africa, n.e.c	r 2,256	1,514	530	--	--	--
Western Portuguese Africa, n.e.c	539	366	130	--	--	--
Total r	39,189	26,058	10,067	18,240	10,848	2,327
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	11,658	4,517	560	322	71
Sweden	2,933	2,192	1,146	--	--	--
Total	28,972	18,353	7,746	12,333	7,592	1,874

r Revised.
1 Less than ½ unit.

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
1969												
Albania	--------	--------	--------	12	5	$257	--------	--------	--------	12	5	$257
Iran	--------	--------	--------	--------	--------	--------	13	6	$253	13	6	253
Philippines	192	64	$3,388	--------	--------	--------	--------	--------	--------	192	64	3,388
South Africa, Republic of	30	12	303	227	100	2,624	143	70	1,638	400	182	4,565
Turkey	33	13	471	64	29	1,360	74	35	1,929	171	77	3,760
U.S.S.R	19	7	331	--------	--------	--------	299	165	7,476	318	172	7,807
Total	274	96	4,493	303	134	4,241	529	276	11,296	1,106	506	20,030
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

Table 11.—U.S. import duties

Tariff classification	Articles	Rate of duty, Jan. 1, 1971 [1]
	CHROMIUM ORES AND METAL PRODUCTS	
601.15	Chromium ore	Free.
607.30	Ferrochromium, less than 3 percent carbon	5 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]	6 percent ad valorem.
	CHROMIUM CHEMICALS AND RELATED PRODUCTS	
420.08	Potassium chromate and dichromate	1.35 cents per pound.
420.98	Sodium chromate and dichromate	1.05 cents per pound.
422.92	Chromium carbide	7 percent ad valorem.
	CHROMIUM PIGMENTS	
473.10	Chrome green	6 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

Albania.—Chromite production in Albania has increased steadily since the first production was recorded in 1938, rising to over 300,000 tons by 1963. Official production in 1968 was 428,000 tons. Most of the production was from near the Albanian-Yugoslovia border. A typical analysis of the chromite is 43 percent Cr_2O_3, 10 percent SiO_2, 8 percent FeO, and 22 percent Al_2O_3 with a chromium to iron ratio of 3–1. Historical exports through 1964 indicate most of the chromite was shipped to Communist-bloc nations, with an ever increasing quantity being exported to mainland China. In 1970, a trade agreement was reached with Yugoslavia for 94,000 tons.

India.—The total recoverable chromite reserves of India remain unknown; however, during 1969, the Geological Survey of India completed a reassessment of portions of the minable reserves in Orissa and Mysore, the country's leading chromite-producing States. Published findings represent an increase of about 1.82 million tons over earlier estimates. In Orissa proven ore reserves totaled 1.34 million tons and probable ore totaled 2.90 million tons, while in Mysore proven ore totaled 1.64 million tons and probable ore 1.33 million tons, for a combined total for the two States of 7.22 million tons.

Pakistan.—Although chromite production failed to reach the goal of 60,000 tons for the year, target goals for 1974–75 were established at 80,000 tons.

Table 12. Chromite: World production, by countries
(Short tons)

Country [1]	1968	1969	1970 [p]
Albania	[r] 428,000	473,000	[e] 500,000
Brazil	[r] 18,775	17,379	30,442
Cyprus	[r] 27,673	26,368	36,165
Finland	39,899	78,623	132,838
Greece	[r] 14,410	66,811	58,710
India	[r] 226,700	249,195	293,000
Iran [e]	99,000	154,000	132,000
Japan	[r] 30,746	32,829	12,007
Malagasy Republic	----------	[p] 88,000	155,000
Pakistan	28,683	24,922	[2] 39,412
Philippines	[r] 483,441	517,765	634,730
Rhodesia, Southern [e]	420,000	400,000	400,000
South Africa, Republic of	1,270,667	1,320,203	1,573,282
Sudan	[r] 24,346	28,895	29,393
Turkey	[r] 461,653	500,342	[e 3] 526,200
U.S.S.R. [e 4]	1,820,000	1,874,000	1,929,000
Yugoslavia	[r] 49,892	43,468	44,715
Total	[r] 5,443,885	5,895,800	6,526,894

[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] Exports.
[3] Based on crude ore production of 768,167 short tons.
[4] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

Philippines. — Production of chromite increased 23 percent compared with that of 1969; 83 percent was classified as refractory-grade and 17 percent as metallurgical-grade chromite. Exports of refractory-grade chromite totaled 482,751 tons. The United States received 53 percent, the United Kingdom 16 percent, and Japan 11 percent, and the balance was shipped to eight other countries. Japan received all of the 109,000 tons of metallurgical-grade chromite exported.

In 1969 Acoje Mining Co., Inc., the sole metallurgical-grade chromite producer, mined 307,710 tons of crude ore, processed 307,209 tons, and recovered 127,534 tons of concentrate. Shipments of chromite concentrate totaled 142,220 tons. Mine development and exploration work continued, and at yearend the ore reserve exceeded 2 million tons.

Also in 1969, Consolidated Mines, Inc., a refractory-grade chromite producer, mined and processed 278,488 tons of chromite from the Coto area, from which 11,766 tons of lump ore was recovered. A fines plant recovered 101,185 tons of plus 10-mesh, 159,537 tons of minus 10-mesh, and 7,888 tons of minus 65-mesh chromite concentrate. A total of 262,117 tons of refractory-grade chromite products mined from the Coto area were sold. Operations of the Zambales Mineral Reservation included mining and processing of 236,747 tons of ore in producing 73,512 tons of lump ore and 15,048 tons of plus 10-mesh, 32,954 tons of minus 10-mesh, and 6,004 tons of minus 65-mesh chromite concentrates. Sales of Zambales chromite products totaled 140,606 tons. Chromite ore reserves at the beginning of 1970 totaled 8.5 million tons in the combined Coto and Zambales ore bodies. Exploration and development programs were continued, as was acquisition of adjoining properties in an effort to increase the ore reserve.

Romania.—Airco Alloys and Carbide Division, Air Reduction Co. Inc., signed a contract to sell 61,000 tons of ferroalloys, including low-carbon ferrochromium, to Metalimport, the Romanian state trading organization. Deliveries call for 7,000 tons in 1970 and 54,000 tons over a 4-year period beginning in 1971.

South Africa, Republic of.—South African chromite production increased 19 percent compared with that of 1969, reaching a record high of over 1.6 million tons. Of the total, 364,000 tons was sold locally and 1,079,000 tons was exported.

Rand Mines Ltd. (RM), through its various subsidiaries, continued to be a leading chromite producer as sales exceeded 300,000 tons. Although most of the chromite was exported unconverted, a considerable tonnage was utilized by Middleburgh Steel and Alloy (Pty.) Ltd. (MSA). MSA was formed in 1968 and acquired the entire capital of RMB Alloys (Pty.) Ltd. and The Southern Cross Steel Co. (Pty.) Ltd. (SCSC). In 1969 Palimet Chrome Corp. (Pty.) Ltd. (PCC) was added to the group. In 1970, PCC produced 15,000 tons of chromium contained in low-carbon ferrochromium and 4,000 tons of chromium contained in charge chromium. SCSC produced 29,000 tons of chromium. Output of ferrochromium by both subsidiaries of MSA totaled 78,500 tons. Both PCC and SCSC installed additional furnace capacity during 1970; SCSC planned to construct a 24-kilovolt-ampere furnace for production of charge chromium, with startup scheduled for 1972.

Zeerust Chrome Mines Ltd. (ZCM) planned to install additional mining and milling equipment to raise production by 300 percent over the next 5 years. ZCM, a subsidiary of Associated Ore & Metal Corporation Limited, formerly exported the bulk of its production as concentrate. Beginning in 1971, Feroalloys, Ltd., a subsidiary of Associated Manganese Mines of South Africa Ltd., will start producing ferrochromium at a new plant at Mochadadorp. ZCM will furnish the chromium ore requirements.

Turkey.—The Andizlik-Zimparalik area in southwest Turkey produces about 85,000 tons of metallurgical-grade chromite annually. A geological study was conducted which provided structural, petrographic, and chemical evidence bearing on the origin of the chromite ores of the area.[2]

Negotiations were carried out between Etibank and Nippon Heavy Chemical Industries through Mitsubishi Shoji Kaishi, Ltd. for three electric furnaces and technical guidance in setting up a 50,000-ton-per-year ferrochromium plant in Turkey.

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[2] Engin, T., and D. M. Hirst. The Alpine Chrome Ores of the Andizlik-Zimparalik area, Fethiye, Southwest Turkey. Inst. Min. and Met. Trans., Sec. B (London), v. 79, No. 759, February 1970, pp. B16–B29.

TECHNOLOGY

Results of beneficiation tests on low-grade chromite from the Baramya district in Egypt indicate that chromite containing 36 to 38 percent Cr_2O_3 with chromium-to-iron ratios of 1.3 to 1.9 can be upgraded to 47 to 55 percent Cr_2O_3 and chromium-to-iron ratios of 2.5 to 3.5 by tabling and magnetic separation.[3] The investigation studied upgrading effects of feed rate, water flow, motor speed, stroke length, and particle sizes during tabling tests and upgrading effects of feed rate, magnetic field strength, and particle size during magnetic separation studies.

The use of chromium ore briquets in the manufacture of ferrochromium-silicon was described at the 28th annual American Institute of Mining Engineers (AIME) Electric Steel Furnace Conference held in Pittsburgh, Pa. Owing to limited availability of high-quality metallurgical-grade lumpy chromite ores, Globe Metallurgical Division of Interlake Inc. conducted laboratory and plant-scale tests using chromium ore briquets as a replacement for natural lump ore. Although improvement in furnace productivity was noted, it was concluded that the use of chromite briquets as a replacement for regular ore was neither superior nor inferior, but fulfilled the goal desired.

Owing to the high price of tin, considerable research and development have been undertaken in recent years on processes to produce a tin-free steel coating for container use, particularly for beer and carbonated beverage usage. Since late in 1966, National Steel Corp. has employed a modified Japanese process in producing a chromium-plated steel suitable for these applications. Equipment, design, and construction materials were described.[4] Since initial startup, numerous changes have been made in operations which have improved the economics of the process. Coating weight was reduced 40 percent; plating solution temperature was reduced 10° F to 110° F; posttreatment solution temperature was reduced 20° F to 120° F; efficiency of the plating operation was increased 26 percent; and plating solution concentration was reduced from 280 to 150 grams per liter.

A chromium-plated gold color was added to the family of chromium-plated colors of black, sky blue, gun metal gray, and blue gray, by the Corrilium Corp. (CC). CC holds patents for five color processes which have been described as a major breakthrough in the science of electroplating. The process was described as electrolytic chromium plating over other metals in which the chromium metal appears in one of the characteristic colors of the metal itself. The colors are not obtained by placing a dye in the electrolytic bath, nor by dipping the plated article.

Some correlations between the loss of appearance and the nature of the underlying metal systems for decorative chromium plating were described.[5]

A new type of refractory grain was developed by prereacting high-purity magnesium oxide and low-silica chromium ore concentrate for use in manufacture of high-performance refractory brick. The microstructure and physical properties of the new material were described and compared with those of other magnesia-chromium-type refractories.[6]

Patent activity concerned upgrading chromite by acid leaching, production of sodium chromate, and production of chromium chloride.[7]

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[3] Yousef, A. A., T. R. Boulous, G. A. Kolta, and O. Abdel Aal. Concentration of Low-Grade Chromite Ores for Metallurgical and Chemical Purposes. J. Mines, Metals and Fuels (Calcutta), January 1970, pp. 12–18.

[4] Allen, James E. Tin Line Conversion to Chrome. Iron and Steel Eng., v. 47, No. 5, May 1970, pp. 88–92.

[5] Kubach, G. Corrosion Problems in Decorative Chromium Plating. J. Electrochem. Soc., v. 117, No. 7, July 1970, pp. 965–975.

[6] Neely, J. E., W. H. Boyer, and C. A. Martinek, Jr. Sintered Magnesia-Chrome Grains For New Type of Refractories. Am. Ceramic Soc. Bull., v. 49, No. 8, August 1970, pp. 710–713.

[7] Bruner, H. K. (assigned to Foote Mineral Co.). Beneficiation of Chromium Ore to Reduce the Iron Content. U.S. Pat. 3,508,906, Apr. 28, 1970.

Schafer, H. (assigned to Farbenfabriken Bayer A.G.). Alkali Treatment of Chromium Ores. U.S. Pat. 3,510,256, May 5, 1970.

Uno, T., and H. Kiyata (assigned to Kiyoshi Miyozaki). Process For Producing Chlorides of Chromium and Iron From Chrome Ore. U.S. Pat. 3,527,561, Sept. 8, 1970.

Clays

By Samuel A. Gustavson [1]

In 1970 clays in one or more of the customary classification categories (kaolin, ball clay, fire clay, bentonite, fuller's earth, or common clay and shale) were produced commercially in 48 States and Puerto Rico; no significant production of clays was recorded in Alaska, the District of Columbia, or Rhode Island. Leading in quantity of output were Georgia, 5.7 million tons; Texas, 4.1 million; and Ohio, 3.9 million; followed in order by North Carolina, California, and Alabama. Georgia also led in total value of clays output with $110.1 million, and Wyoming was second with $18.8 million. Compared with 1969 figures, production increased in 11 States in terms of tonnage and in 20 States in terms of total value. However, declines in tonnage and value were notably in the majority. Although the total quantity of all clays sold or used by domestic producers in 1970 was approximately 7 percent less in tonnage than in 1969, the corresponding total value figure increased by 1 percent to an alltime high. Moderately higher per-ton values were reported for bentonite and fire clay, but the factor chiefly responsible for the 1970 overall increase was the sharply higher unit value of the kaolin output, which was 9 percent above the figure for 1969.

Table 1.—Salient clay and clay products statistics in the United States
(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
Domestic clays sold or used by producers	56,713	54,664	57,348	58,694	54,853
Value	$221,714	$223,987	$246,938	$264,415	$267,912
Exports	1,074	1,149	1,519	1,574	2,076
Value	$31,135	$32,432	$44,134	$45,767	$66,116
Imports for consumption	139	108	97	82	87
Value	$2,883	$2,235	$1,951	$1,750	$1,802
Clay refractories, shipments (value)	$243,516	$225,116	$229,660	$257,507	$256,384
Clay construction products, shipments (value)	$554,667	$538,110	$590,776	$608,982	$548,528

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Kaolin produced from domestic sources in 1970 increased 4 percent in quantity over that of 1969 and total value, as reported by producers, increased 14 percent. The larger increase in value was due to some companies reporting a higher unit value for their product and because a large portion of the production increase was in the higher value kaolin used for paper filler and coating. Kaolin production was reported from mines in 11 States. Output in 1970 from Alabama, Arkansas, Florida, Georgia, Idaho, Pennsylvania, and Texas was greater than in the previous year, more than offsetting declines in production from California, North Carolina, South Carolina, and Utah. Mines in Georgia accounted for 76 percent of the domestic production. South Carolina ranked second with about 11 percent, and was followed in order by Alabama and Arkansas.

There were no changes in prices quoted for kaolin in trade journals during 1970. Oil, Paint and Drug Reporter, December 28, 1970, quoted kaolin prices as follows:

[1] Former physical science administrator, Division of Nonmetallic Minerals (retired).

Water washed, fully calcined, bulk carload lots, f.o.b. Georgia, per ton	$60.00
Partially calcined, same basis, per ton	50.00
Paper-grade, uncalcined, same basis, per ton:	
No. 1 coating	38.00–38.50
No. 2 coating	30.00–30.50
No. 3 coating	29.00–29.50
Filler, general purpose, same basis, per ton	17.50–18.00
Delaminated, water washed, uncalcined, paint-grade, 1-micron average, same basis, per ton	62.00
Dry-ground, airfloated, soft, same basis, per ton	12.50
National Formulary, powder, 50-pound bags, 5,000-pound lots, works, per pound	0.06–.75
National Formulary, colloidal, 150-pound drums, works, per pound	0.16–.50

Exports of kaolin, as reported by the U.S. Department of Commerce, amounted to 816,284 short tons, a 71 percent increase over that of 1969. Technical advances in processing, new production capacity, and cost reductions gave domestic producers a more competitive position in the world market. These factors, along with the combination of a dock strike and adverse weather conditions in the United Kingdom, normally a major world supplier of kaolin (china clay), all contributed to the exceptional increase in U.S. kaolin exports.

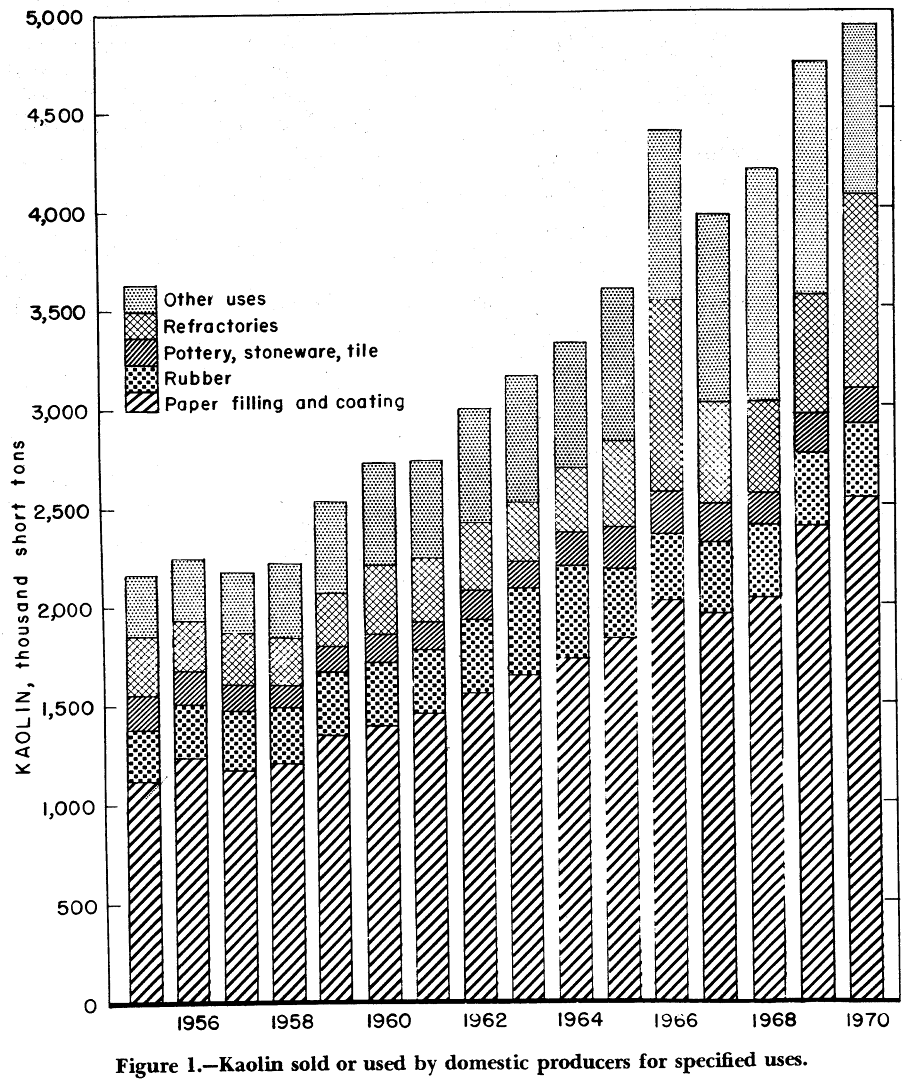

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

The exported material went to destinations in 53 countries, among which the Netherlands, Canada, Italy, Japan, and West Germany, in order of rank, were the principal countries of destination. Collectively, they accounted for 81 percent of the exports and 84 percent of the overall increase from 1969, even though exports to Canada declined slightly. Exports to West Germany and to the Netherlands were four times those of 1969. Exports to France, Japan, and Italy increased 81 percent, 70 percent, and 56 percent, respectively, over those of the previous year. Reports also indicated that exports to 19 other countries more than doubled.

Although kaolin imports have been declining for a number of years, imports in 1970 amounted to 65,335 short tons, valued at $1,246,155, about the same as in 1969. The United Kingdom supplied 91 percent; West Germany, 6 percent; Canada, 3 percent; and Japan, the Republic of South Africa, and Australia together supplied about 0.1 percent.

BALL CLAY

Production and value reported for domestically mined ball clay in 1970 indicate an increase of 4 percent over that of 1969. Most of this increase represents a change in classification of production by one operation in Texas from miscellaneous clay in 1969, to ball clay in 1970. California output also increased in tonnage (12 percent) and value (8 percent), but all other producing States recorded declines. Tennessee mines provided 58 percent of the Nation's output, followed in order of output by Kentucky, Texas, Mississippi, Maryland, and California.

Oil, Paint and Drug Reporter, December 28, 1970, 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	49.50–50.75
Imported, lump, bulk, Atlantic ports, per ton	31.50–37.50

Ball clay exports in 1970 amounted to 21,914 short tons, valued at $613,000. These figures are not comparable with those for 1969 and previous years when ball clay export data were not reported as a separate item. In 1970, clay exports in the "not elsewhere classified" category amounted to about 538,000 short tons, valued at $20.6 million, compared with 395,000 tons and $15.3 million in 1969.

U.S. imports of common blue clay or ball clay, beneficiated and unbeneficiated, totaled 17,318 short tons, valued at $287,000 in 1970, an increase of 35 and 26 percent, respectively, over that of 1969 and reversing the decline of about 25 percent from 1968 to 1969.

FIRE CLAY

Fire clay and stoneware clay sold or used by domestic producers in 1970 declined 11 and 9 percent in tonnage and value, respectively, from that of 1969. This decrease reflects a continuation of an industry trend from the conventional refractories based on fire clay to more custom-designed refractories using higher alumina clays or other refractory materials.

Fire clay production was reported in 1970 from mines in 23 States. The first five States in rank—Ohio, Pennsylvania, Missouri, California, and Alabama—accounted for 75 percent of the total domestic output. Among the 10 leading States, California and West Virginia had slight gains in output, Pennsylvania was unchanged, and the seven other States recorded decreases.

Exports of fire clay in 1970 totaled 167,000 tons, valued at $3.5 million, compared with 163,000 tons and $2.6 million in 1969. Countries of destination totaled 45. Canada was the leading recipient (51 percent), followed by Mexico (37 percent), Japan (4 percent), and all other nations (8 percent). No imports of fire clay were reported.

There are no price quotations in domestic journals for fire clay.

BENTONITE

Bentonite production in 1970, although down about 4 percent in tonnage and 2 percent in total value from the 1969 figures, was still greater than in any other previous year. A business decline in the first half of 1970 and a lower level of domestic exploration for oil and gas were the principal factors effecting the decline. Also, producers reported lower sales for most other uses. The 14-percent increase in sales for use in pelletizing iron ore and concentrates was a notable exception.

Bentonite production was reported by operators in 13 States in 1970, compared with 15 in 1969. Lower output was reported from all producing States except Montana and Oregon. The sodium, high-swelling bentonite is produced chiefly in Wyoming, Montana, and South Dakota. The calcium, low-swelling bentonite is the product of the other States. During 1970, Federal Ore and Mineral Corp. and Youghioheny & Ohio Coal Co. formed the Federal Bentonite Co., which took over the Wyoming Oil Co., Inc. Additional air pollution control equipment was being installed by Dresser Industrial Minerals Division and by Wyo-Ben Products, Inc., at their bentonite plants near Greybull.

Oil, Paint and Drug Reporter, December 28, 1970, 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. Quotations in the December 29, 1969, issue were $14 and $91 respectively. The average unit value reported by producers of domestic bentonite sold or used in 1970 was $10.07, a slight increase from the $9.82 average in the previous year. Per-ton values reported in the various producing States ranged from $5 to $18, but as in 1969, the average value reported by the larger producers was near the Wyoming average figure of $9.83.

Exports of bentonite in 1970 totaled about 496,000 tons, valued at $12.6 million. Tonnage exported was about 1 percent less than in 1969, but the dollar value was 9 percent greater; unit value increased an average of $2.38 per ton. Countries of des-

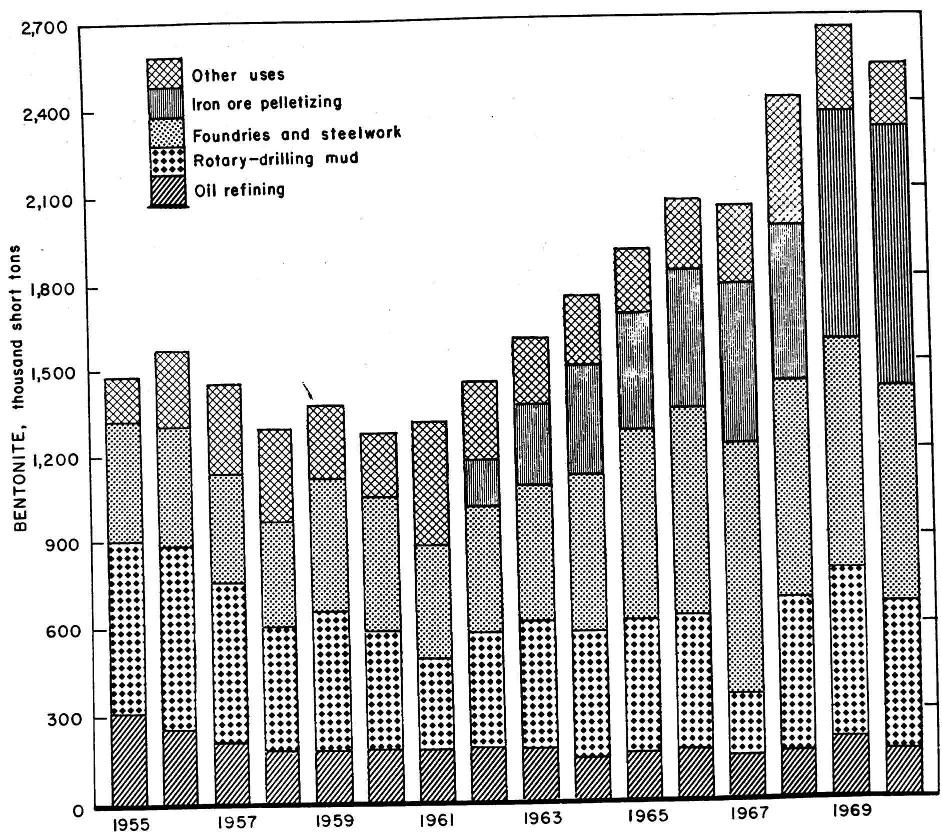

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

tination for exports of bentonite totaled 77.

Imports of bentonite, chiefly special-purpose material, were from Canada (60 tons) and Italy (123 tons).

FULLER'S EARTH

Production of fuller's earth in 1970 was nearly the same in quantity as in 1969, but total value was about 6 percent lower because some producers in Florida and Georgia assigned lower unit values to their output. Unit values reported by producers operating in other States were unchanged from 1969.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate oil decolorizing and purifying properties.

Production from the region that takes in Attapulgus (Decatur County), Ga., and Quincy (Gadsden County), Fla., is predominantly the mineral attapulgite. Most of the fuller's earth produced in other areas in these and other States is predominantly montmorillonite.

Declines in output were reported for Florida, Mississippi, Missouri, and Utah. Increases were reported for Georgia, Illinois, Tennessee, and Texas.

Utilization of fuller's earth for rotary-drilling mud decreased 27 percent, and minor declines in filtering, decolorizing, and clarifying, and miscellaneous other uses were slightly greater than increases recorded for absorbent and filler uses.

Prices for fuller's earth were not publicly quoted in 1970, but the per-ton values reported by producers ranged from $14 to about $29. The average was $24.35, compared with $25.77 in 1969.

Exports of fuller's earth were the same in tonnage and value as in the previous year, but the countries of destination totaled 37, compared with 30 in 1969. Canada was again the principal recipient, but Canadian purchases in 1970 represented only 38 percent of the total U.S. exports of fuller's earth, compared with 46 percent in 1969. In contrast, exports to the United Kingdom, the second ranking country of destination, amounted to 27 percent of the 1970 total, compared with 19 percent in 1969.

Fuller's earth imports in 1970, all from the United Kingdom, totaled 66 short tons, valued at $4,928, about the same as in 1969.

COMMON CLAY

Common clay in the collective designation applied in this report to the miscellaneous clay and shale materials of diverse types that are used in the manufacture of structural clay products, portland and other cements, and lightweight aggregate. Other clays of various types that, either because of differing mineral content or lack of identifying data, cannot be placed appropriately in one of the preceding categories are also included in this classification.

In 1970 the reported domestic production of common (or miscellaneous) clay totaled about 39.2 million short tons, valued at $57.7 million. Thus, common clays represented 72 percent of the quantity and 22 percent of the value of all the clays and shales produced in the United States during the year. In addition, Puerto Rican production was reported at 428,885 short tons, valued at $486,285. Following the general business and construction decline in the first part of the year, output was 7 percent less than in the previous year.

Most of the common clays and shales are used by the producer in the fabrication of a product. Less than 4 percent of the output in 1970 was sold in the crude state, and the unit values reported by producers are, therefore, chiefly company estimates rather than values based on actual sales of crude clay. The average unit value for all common clay produced in the United States in 1970 was $1.47 per short ton, $0.02 less than in the previous year. The range in unit value reported for the bulk of the output was from $1 to $2 per ton.

Exports of clays that were not separately classified as to type totaled about 538,000 tons, valued at $20.6 million, compared with 395,000 tons and $15.3 million in 1969. The totals represented a 36-percent increase in tonnage and a 35-percent increase in value. As in previous years, the high unit value ($38.33 per ton in 1970) is evidence that all of the material belonged to grades of a higher order than the common clays normally produced for use in structural products. Most countries, furthermore, have deposits of local clays suitable for manufacture of common brick and

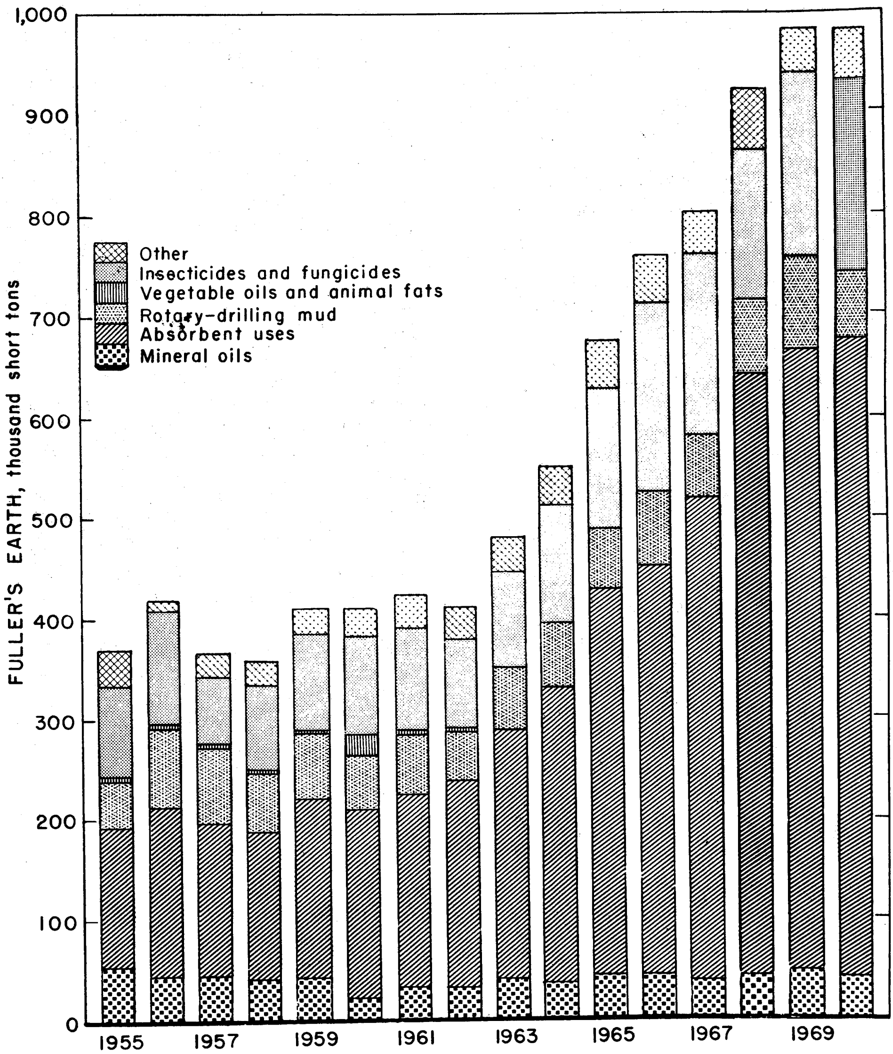

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

tile and cement and thus have no need to import such materials.

Imports of clays not elsewhere classified (n.e.c.), beneficiated and not beneficiated, totaled 1,577 tons with a value of $92,144, and imports of clays artifically activated with acid totaled 2,061 tons, valued at $162,534. The unit values of another nation's shipments of clays n.e.c. to the United States ranged from about $50 to $140 per ton, evidence that these materials also belong to grades of a higher order.

CONSUMPTION AND USES

Heavy Clay Products.—Manufacture of heavy clay products (building brick, drain tile, vitrified sewer pipe, and other structural clay products), portland and masonry cements, and lightweight aggregate consumed 99 percent of all the common (or miscellaneous) clays and shales produced domestically in 1970, as well as smaller percentages of the outputs of fire clay, ball clay, kaolin, and bentonite. In summary, 76 percent by weight of all clays produced was consumed in the manufacture of these clay-based construction materials. Every use classification of these products recorded a decline from 1969, and the quantity of slate expanded for lightweight aggregate represented a comparable decrease. Utilization of clays in heavy clay products decreased 8 percent; in portland and other cements, 9 percent; in lightweight aggregate, 2 percent; and in building and structural products as a whole, 7 percent, reflecting a general slowdown in the construction industry.

Refractories.—Utilization of clays in refractories also recorded an overall decline of 6 percent in 1970. All classes of clays, with the exception of fuller's earth, were used for this purpose, accounting for more than half of the year's output of fire clay, 17 percent of the kaolin, and minor tonnages of bentonite, ball clay, and common clay and shale. The total tonnage used in refractories amounted to about 9 percent of that of all clays produced.

There was an evident trend toward use of refractories custom-designed for specific needs and toward utilization of higher cost materials in their manufacture. Supporting this statement is the fact that kaolin, a relatively high-cost, high-alumina clay, was the only type of clay used in refractories that showed an increase over that of 1969.

Filler.—All clays are used to some extent as fillers in one or more areas of use. In 1970, consumption in this end-use classification increased about 3 percent over that of 1969. Utilization of high-unit-value clay products, chiefly kaolin for paper filling and coating, increased 6 percent, more than offsetting slight declines in other filler uses. Filler uses, in general, accounted for about 6 percent of the tonnage of all clays sold or used by producers during the year and about 28 percent of the corresponding total value (as determined from the average unit value for each type of clay used). Kaolin was the principal clay filler consumed in each major use division with the exception of insecticides, in which 85 percent of the clay used was fuller's earth. Kaolin sold or used as paper filler or coating alone, using the reported average unit value of $23.57, amounted to about $60 million, or over 22 percent of the value of all clays produced.

Absorbent Uses.—Absorbent uses for clays consumed about 1 percent of the production, representing about 6 percent of the total value in 1970. Demand increased about 12 percent. Clays used were fuller's earth, bentonite, and clays not classified by the producer. Substantially more than half of the fuller's earth produced was used as absorbent. Animal litter and floor-sweeping compound were made almost exclusively from fuller's earth.

Drilling Mud.—Demand for clay for rotary-drilling mud declined about 13 percent in 1970. Swelling-type bentonite is the principal clay used in drilling-mud mixes, although fuller's earth or nonswelling bentonite is also used in some cases to obtain a desired physical property or to reduce the need for the higher cost swelling bentonite. Since swelling bentonite deposits are principally located in Wyoming, Montana, and South Dakota, freight costs for shipping bentonite to the drilling site are frequently much more than the purchase price. For this reason, there is continuing search for other deposits and also for methods to economically refine or process suitable substitutes.

Floor and Wall Tile.—Clays used in the manufacture of floor and wall tile are principally of the kaolinic type, fire clay, ball clay, common (or miscellaneous) clay, and kaolin, in order of demand. Demand increased approximately one-sixth from that of 1969.

Pelletizing Iron Ore.—Bentonite is used as a binder in forming strong pellets of iron ore and of some other mineral materials. Demand, following a general trend for several years, increased about 14 percent in 1970. Of the total bentonite produced, about 35 percent, nearly all rated as swelling bentonite, was consumed for this purpose. Demand is worldwide, and the U.S. deposits are currently the principal source.

Pottery.—Pottery, whiteware, and related products utilize kaolinic clays, especially those clays that have excellent plastic properties and usually are classed as ball clays. Total demand for all types of clays decreased about 13 percent in 1970, but consumption of kaolin in pottery and stoneware was slightly higher than in 1969.

Filtering.—Consumption of clay, principally bentonite and fuller's earth, for the filtering, decolorizing, and clarifying of oils and greases was about 17 percent less than in 1969.

WORLD REVIEW

Australia.—Production of refractory brick from local raw materials was started at a new $4 million manufacturing plant at Port Kembla, New South Wales, the second such facility built in that area by Kaiser Refractories Division of Kaiser Aluminum & Chemical Corp. of Oakland, Calif. Although construction of the new factory was chiefly in response to rapid growth in demand for refractories by Australia's domestic minerals-processing industry, plans include eventual expansion to sustain a substantial volume of export trade throughout the western Pacific region.

Greece.—Bentonite and kaolin are important items in this nation's export trade. Shipments of these two types of clays in 1968, the last full year reported, totaled about 175,000 tons, valued at nearly $2 million, and went to destinations in at least 10 countries.

New Zealand.—An outstanding advantage that warrants a bright future for New Zealand's newly launched steel industry is the close-by availability of an ample supply of the essential raw materials. Immense resources of ironsand occur within 12 miles of the recently completed Glenbrook smelting complex, there are adequate deposits of coal and limestone within 120 miles, and even high-quality bentonite suitable for iron ore pelletizing is found in abundance within easy shipping distance at Coalgate. To date, approximately $500,000 has been spent in developing this deposit of special-purpose clay, and a processing plant has been constructed that will provide 25,000 tons per year of pelletizing bentonite for consumption at Glenbrook and for export, particularly for the steel mills of Australia and Japan.

Poland.—Polish metallurgists have developed two separate processes for the extraction of alumina from clays. A plant with an annual capacity of 330,000 tons that is being constructed between Glogov and Lobin will apply an acid method for the treatment of unspecified clays, and a 100,000-ton-per-year plant under construction near Kielce will make use of a sintering-leaching process to produce alumina and cement simultaneously from a mill feed consisting of coal schists and aluminous marl.[2]

Spain.—In Catalonia, a modern brick-making plant recently inaugurated in the city of Igualada, about 35 miles from Barcelona, has now been in operation long enough to provide a striking contrast to the results obtained at an adjacent older facility that is still in production. Details of the equipment and procedures in use at the new installation, as well as the improved performance that they make possible, were discussed briefly in an industrial journal.[3]

Sweden.—Expanded aggregates produced from clays are being field tested as road-building material by the Swedish State Board Institute and the city of Avesta (northwest of Stockholm). Experimental stretches of highway that incorporate beds of expanded material in an asphalt bond and surfaced with conventional black top have been built over terrain that is subject to severe frost-thaw disturbance. Preliminary studies have indicated that under varying burdens of actual traffic this type of construction provides a smooth-riding surface with a superior rating for stability.

United Kingdom.—Plans for the disposal by pipeline out-to-sea of slurried processing residues from china clay operations in Cornwall have generated much discussion and acrimony. This proposed solution to a long-standing problem is being bitterly opposed by the people of the village of Gorran Haven, in the path of the projected

[2] Metals Week. Aluminum. V. 41, No. 18, May 4, 1970, p. 6.

[3] Svec, J. J. Ceramic Casanovas Produces 150/T Tile With 21 Men. Brick & Clay Record, v. 156, No. 2, February 1970, p. 36.

pipeline, and by the fishermen who customarily draw their livelihood from the adjacent coastal waters that may be affected.

Fuller's earth is produced at present from deposits in Surrey, Somerset, and Bedfordshire at a rate of about 125,000 tons per year. A potentially valuable addition to the United Kingdom's known resources of this useful clay material resulted from a routine mapping program being conducted by the Institute of Geological Sciences in Berkshire. Engineers of the Institute reported the discovery of "important new deposits of fuller's earth at shallow depths," and exploration is being carried out by drilling to explore and delineate the extent of the mineral body.

TECHNOLOGY

An industrial journal, continuing an annual feature, published an informative listing of ceramics-oriented research projects that are in progress throughout the United States. More than 1,300 studies were cataloged by project titles and by names of the organizations and personnel involved.[4]

The Bureau of Mines classifies six individual mineral materials as distinct types of clays. For three members of that group, kaolin, bentonite, and fuller's earth, production figures recorded during the last 20 years indicate growth rates significantly greater than that of the national economy, ball clay also promises to move into the high-growth class in the seventies. A rationale for the notable prosperity of these special-purpose clays, based on a technological analysis of the applications in which they serve, was delineated, together with some projections of clays end-use patterns in the future, in a paper presented at the 1970 annual meeting of a professional society.[5]

Production of metallurgical-grade alumina from unconventional starting materials such as kaolin or other specified aluminous substances is the objective of a process for which a patent was issued. This method differs from others proposed for a similar purpose in that the raw mineral (kaolin, for example) is "opened up" by being heated and then dissolved in a fused mixture of calcium fluoride and calcium or sodium chloride, a step that is said to accomplish a selective solubilization of the ore's alumina content.[6] The increasingly earnest consideration being given to new technologies for providing an important share of future aluminum-smelter feeds was exemplified by the announcement that Reynolds Metals Co., second largest domestic aluminum producer, has purchased patent rights and accessory procedural information pertaining to a number of processes developed by Allied Chemical Corp. for the production of alumina from clay.[7]

The modern machinery, with its sophisticated central-control system, and the innovative operating procedures that make it possible for one plant to produce more than 6 million tons per year of bentonite-bonded taconite pellets for steelmaking were described in an industrial journal. Consumption of bentonite at this Minnesota facility is currently at the rate of about 200 tons per 24 hours.[8] A magazine article provided a detailed account of the up-to-date automated equipment and novel handling methods in use in the $1.5 million bentonite-processing plant recently placed in operation by International Minerals & Chemical Corp. (IMC) in Mississippi.[9]

The year 1970 was fruitful in significant studies dealing with the theoretical and practical aspects of the manufacture and utilization of refractories, those extraordinarily versatile mineral materials that make it possible to produce and control violent extremes of temperature and thus force them to serve the needs of mankind. Two journal articles relating to refractories technology were especially deserving of

[4] Ceramic Bulletin. Current Ceramic Research. V. 49, No. 2, February 1970, pp. 231–242, 245–250, 252–260, 263–264.

[5] Cooper, James D. The Demand Picture for High Quality Clays. Paper Presented at the Annual Meeting of AIME, Denver, Colo., February 1970, Preprint No. 70–H–100.

[6] Slatin, H. L. (assigned to Timax Associates.) Alumina From Low-Grade Aluminiferous Ores and Minerals. U.S. Pat. 3,489,514, Jan. 13, 1970.

[7] Oil, Paint and Drug Reporter. Alumina From Clays: Reynolds, Allied Deal. V. 198, No. 3, July 20, 1970, pp. 4, 50.

[8] Erickson, Donald V. Minntac Story—Agglomeration. Skillings' Min. Rev., v. 59. No. 17, Apr. 25, 1970, pp. 1, 12–14.

[9] Pit & Quarry. IMC's Aberdeen Plant on Stream. V. 63, No. 2, August 1970, pp. 110–115.

mention.[10] A sound and color film, "Fahrenheit 3300," made available for free loan by the Bureau of Mines and sponsored by Kaiser Refractories Division of Kaiser Aluminum & Chemical Corp. presented a survey of the technology of up-to-date refractories practice, emphasing the indispensable role of refractories somewhere in the course of the production of almost everything that is bought and sold, used and consumed, in virtually every phase of modern living.[11] The Bureau of Mines issued a publication on the rapidly evolving technology and utilization of all types of refractories in modern high-temperature processing of metallic and nonmetallic materials.[12]

By making a change in which part of the crushing equipment does double duty, a Massachusetts lightweight-aggregate producer increased plant capacity by approximately one-half. An article in a trade magazine reported details of this original bottleneck bypass and details of other efficiency-promoting practices. The application of the new practices enabled this Massachusetts facility to turn out expanded clay aggregate in excess of 900 tons per day with a work force, including sales and management personnel, of only 27 employees.[13] The largest Dwight-Lloyd, traveling-grate sintering unit ever built for the purpose of expanding clays to make lightweight aggregate has been placed in service at a site about midway between Grand Haven and Grand Rapids, Mich. This giant machine, with a processing grate 8 feet wide and 108 feet long, gives the plant a rated capacity of 1,200 tons per day of finished product. Details of the operation of this out-sized facility and of the testing program that led up to its construction were discussed in a magazine article.[14]

Different starting materials for the manufacture of lightweight aggregate differ markedly in their burning characteristics and present no less variability in the dust-collection problems to which their treatment gives rise. Some of the difficulties that have been encountered in practice and some of the ideas that have been successful in coping with them were described in an article.[15] Cosponsored by the Bureau of Mines, a Mineral Waste Utilization Symposium was held March 18–19, 1970, at the Illinois Institute of Technology Research Institute (IITRI), in Chicago. Potentially profitable applications proposed for burdensome and otherwise useless coal-mine gangue, metallurgical slags, phosphate rock residues, powerplant fly ash, and kaolin-processing wastes included utilization as soil conditioners, cement additives, and components in rotary-drilling mud mixtures or as semiprocessed materials for the manufacture of refractories, ceramics, glass, and a range of building materials, especially lightweight aggregate. A general review of this symposium was published in an industrial magazine.[16] Another journal article contained a further account of current technology that is changing fly ash from the status of a costly nuisance to that of an increasingly valuable source of revenue as a useful manufacturing intermediate. Consumption in the making of lightweight aggregate is the only end use known at present that is potentially capable of keeping abreast of fly-ash production in the United States.[17]

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[10] Jeffers, P. E. Refractories Blast-Off for the 70's Brick & Clay Record, v. 156, No. 1, January 1970, pp. 33–37 and 40–44.
Spieckerman, J. A. Trends and Developments in Refractories. Minerals Processing, v. 11, No. 3, March 1970, pp. 11–13.

[11] Prospective borrowers, who must have available a 16-millimeter projector and an experienced operator, should address applications for short-time loans as follows:
Motion Pictures
Bureau of Mines
U.S. Department of the Interior
4800 Forbes Avenue
Pittsburgh, Pa. 15213

[12] Kusler, David J., and Robert G. Clarke. Impact of Changing Technology on Refractories Consumption. BuMines Inf. Circ. 8494, 1970, 68 pp.

[13] Svec, J. J. Masslite Streamlines Operations to Save Labor. Brick & Clay Record, v. 156, No. 2, February 1970, pp. 33–35.

[14] Milas, James E. Sintering Machine Expands Clay at 50-TPH Rate. Rock Products, v. 73, No. 6, June 1970, pp. 48–51, 96.

[15] McElrath, A., Jr. High-Efficiency Dust Collecting for Lightweight Aggregate Production. Rock Products, v. 73, No. 6, pp. 56–59.

[16] Stearn, Enid W. Solid Mineral Wastes—Blight or Bonanza? Rock Products, v. 73, No. 6, June 1970, pp. 78–79, 96.

[17] Environmental Science & Technology. Fly Ash Utilization Climbing Steadily. V. 4, No. 3, March 1970, pp. 187–189.

Table 2.—Value of clays produced in the United States, by States

(Thousand dollars)

	1969	1970	Kind of clay produced in 1970					
			Kaolin	Ball clay	Fire clay	Benton-ite	Fuller's earth	Common clay
Alabama	$7,083	$8,213	X		X	x		X
Alaska	-------	-------						
Arizona	394	454			x	x		x
Arkansas	2,426	2,902	X					X
California	7,443	6,506	x	x	X	x		X
Colorado	1,619	[1] 1,503			X	x		x
Connecticut	341	386						x
Delaware	11	11						x
Florida	13,627	12,661	x				X	x
Georgia	98,462	110,149	X				X	X
Hawaii	9	11						x
Idaho	[2 3] 51	[2 3] 28	x		x			x
Illinois	[4] 4,321	[4] 3,862			X		X	X
Indiana	2,264	2,139			x			X
Iowa	1,660	1,823						X
Kansas	[2] 1,070	[2] 946			x			X
Kentucky	[5] 2,076	[5] 1,793		X	x			x
Louisiana	2,943	1,575						X
Maine	[2] 56	[2] 56			x			x
Maryland	[2 5] 1,369	[2 5] 1,433		x	x			X
Massachusetts	624	582						x
Michigan	3,037	2,887						X
Minnesota	[2] 412	335						x
Mississippi	8,660	8,062		X	x	X	X	X
Missouri	[1 4] 6,405	[4] 6,480			X		x	X
Montana	[1] 63	[1] 71				X		x
Nebraska	223	147						x
Nevada	W	W				x		x
New Hampshire	40	32						x
New Jersey	1,123	990			x			x
New Mexico	89	91			x			x
New York	1,783	1,897						X
North Carolina	[3] 2,610	[3] 3,102	x					X
North Dakota	W	W						x
Ohio	11,693	10,100			X			X
Oklahoma	[1] 1,182	[1] 1,120			x	x		X
Oregon	[2] 321	[2] 180			x	x		x
Pennsylvania	[3] 19,637	[3] 15,845	x		X			X
Rhode Island	-------	-------						
South Carolina	10,911	9,878	X					X
South Dakota	1,171	946				x		x
Tennessee	[4] 7,064	[4] 7,123		X			x	X
Texas	8,664	9,587	x	X	X	x	x	X
Utah	1,286	1,237	x		x	x	x	x
Vermont	W	W						x
Virginia	1,504	1,672						X
Washington	[2] 434	[2] 436			x			x
West Virginia	[2] 348	[2] 238			X			x
Wisconsin	24	14						x
Wyoming	18,970	18,829				X		x
Other [6]	8,910	9,580						
Total [7]	264,415	267,912						
Puerto Rico	454	486						

W Withheld to avoid disclosing individual company confidential data.
X Major producing States which account for over 90 percent of production. x Other producing States.
[1] Value of bentonite included with "Other" to avoid disclosing individual company confidential data.
[2] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.
[3] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.
[4] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.
[5] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.
[6] Includes Nevada, North Dakota, Vermont, and values indicated by footnotes 1 through 5.
[7] Data may not add to totals shown because of independent rounding.

Table 3.—Kaolin sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Sold by producers	Used by producers	Total [1]	
	Quantity	Quantity	Quantity	Value
1966	3,664	721	4,385	$81,984
1967	3,336	637	3,973	81,321
1968	3,579	622	4,201	92,486
1969:				
California	W	W	W	268
Georgia	3,310	366	3,676	87,956
South Carolina	481	115	596	8,884
Other States [2]	154	313	467	5,154
Total [1]	3,944	794	4,739	102,262
1970:				
Arkansas	W	W	203	1,840
California	W	W	13	187
Georgia	3,508	241	3,749	100,278
South Carolina	443	77	519	8,011
Other States [2]	247	410	441	5,792
Total [1]	4,198	728	4,926	116,109

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes Alabama, Arkansas (1969), Florida, Idaho, North Carolina, Pennsylvania, Texas, Utah, and data indicated by symbol W.

Table 4.—Georgia koalin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China clay, paper clay, other	Refractory uses	Total		
	Quantity	Quantity	Quantity	Value	Average value per ton
1966	2,719	487	3,206	$67,156	$20.95
1967	2,708	301	3,009	69,327	23.04
1968	2,947	218	3,165	79,061	24.98
1969	3,358	318	3,676	87,956	23.93
1970	3,355	394	3,749	100,278	26.75

Table 5.—Ball clay sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1966	571	$7,322
1967	559	7,446
1968	630	8,351
1969	682	9,720
1970	710	10,149

Table 6.—Fire clay, including stoneware clay, sold or used by producers in the United States, by States

Year and State	Sold by producers	Used by producers	Total	
	Short tons	Short tons	Short tons	Value (thousands)
1966	2,596,470	6,181,695	8,778,165	$42,179
1967	2,512,411	5,460,002	7,972,413	42,157
1968	2,547,878	5,506,074	8,053,952	42,094
1969:				
Alabama	W	W	462,820	1,994
Arizona	----------	15	15	(1)
Colorado	154,188	133,975	288,163	1,073
Illinois	W	W	215,176	1,618
Indiana	W	W	165,847	314
Kentucky	66,195	131,976	198,171	1,054
Missouri	69,843	970,521	1,040,364	4,968
New Jersey	W	W	81,764	575
New Mexico	W	W	2,432	12
Ohio	1,106,711	924,888	2,031,599	6,731
Oklahoma	----------	381	381	4
Pennsylvania	382,930	823,531	1,206,461	12,921
Texas	W	W	635,102	1,669
Other States [2]	922,377	1,573,619	932,855	4,842
Total	2,702,244	4,558,906	7,261,150	37,775
1970:				
Alabama	W	W	395,609	2,636
Arizona	----------	10	10	(1)
California	W	W	399,924	1,276
Colorado	151,612	87,157	238,769	951
Illinois	W	W	182,079	1,503
Indiana	W	W	75,403	202
Kentucky	W	W	160,085	916
Missouri	128,668	798,002	926,670	4,854
New Jersey	W	W	W	518
Ohio	889,499	999,584	1,889,083	6,055
Oklahoma	----------	405	405	4
Pennsylvania	392,853	816,134	1,208,987	10,544
Texas	W	W	351,231	1,334
Utah	W	W	7,109	24
Other States [2]	749,866	1,444,721	623,147	3,694
Total	2,312,498	4,146,013	6,458,511	34,511

W Withheld to avoid disclosing individual company confidential data; included with "Other States".
[1] Less than ½ unit.
[2] Includes Arkansas (1969), California (1969), Idaho, Kansas, Maine, Maryland, Minnesota (1969), Mississippi, Nevada (1969), New Mexico (1970), Oregon, Utah (1969), Washington, West Virginia, Wyoming (1969), and data indicated by symbol W.

Table 7.—Bentonite sold or used by producers in the United States, by States

Year and State	Short tons	Value (thousands)	Year and State	Short tons	Value (thousands)
1966	2,060,616	$22,010	1970:		
1967	2,042,841	20,490	Mississippi	261,949	$3,124
1968	2,437,526	23,970	Oregon	697	8
			Texas	73,531	839
1969:			Wyoming	1,905,844	18,725
Colorado	1,428	7	Other States [1]	290,824	2,818
Mississippi	299,123	3,525			
Oregon	604	7	Total	2,532,845	25,514
Texas	99,828	655			
Wyoming	1,952,174	18,871			
Other States [1]	287,055	2,859			
Total	2,640,212	25,924			

[1] Alabama, Arizona, California, Colorado (1970), Missouri (1969), Montana, Nevada, North Dakota (1969), Oklahoma, South Dakota, and Utah.

Table 8.—Fuller's earth sold or used by producers in the United States, by States

Year and State	Short tons	Value (thousands)	Year and State	Short tons	Value (thousands)
1966	759,638	$18,354	1970:		
1967	803,919	20,539	Florida	422,150	$11,657
1968	921,550	23,176	Georgia	334,426	7,675
			Utah	2,586	47
1969:			Other States [1]	222,728	4,529
Florida and Georgia	778,175	21,123			
Utah	2,834	51	Total	981,890	[2] 23,907
Other States [1]	203,603	4,199			
Total	984,612	25,373			

[1] Includes Illinois, Mississippi, Missouri, Tennessee, and Texas.
[2] Data may not add to totals shown because of independent rounding.

Table 9.—Common clay and shale sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Sold by producers	Used by producers	Total [1]	
	Quantity	Quantity	Quantity	Value
1966	1,156	39,005	40,161	$49,865
1967	1,054	38,259	39,312	52,035
1968	1,456	39,647	41,104	56,863
1969:				
Alabama	294	2,144	2,438	3,335
Arkansas		833	833	1,091
California	836	1,737	2,573	5,876
Colorado	W	W	442	539
Connecticut		197	197	341
Delaware		11	11	11
Georgia	W	W	1,663	2,001
Hawaii		2	2	9
Idaho	W	W	23	51
Illinois	W	W	1,648	2,703
Indiana	W	W	1,317	1,950
Iowa		1,199	1,199	1,660
Kansas	W	W	797	1,070
Kentucky	W	W	1,034	1,022
Louisiana		1,078	1,078	2,943
Maine		42	42	56
Maryland	W	W	1,152	1,369
Massachusetts		332	332	625
Michigan		2,667	2,667	3,037
Minnesota		275	275	412
Mississippi	W	W	1,099	1,136
Missouri		1,211	1,211	1,437
Montana	W	W	34	63
Nebraska	W	W	149	223
New Hampshire		44	44	40
New Jersey	W	W	245	547
New Mexico	W	W	67	77
New York	W	W	1,623	1,783
North Carolina	W	W	3,342	2,610
Ohio	215	2,340	2,555	4,962
Oklahoma		802	802	1,178
Oregon	W	W	215	314
Pennsylvania	90	1,430	1,520	6,716
South Carolina		1,848	1,848	2,026
Tennessee	W	W	1,265	1,130
Texas	W	W	3,593	5,402
Virginia		1,677	1,677	1,504
Washington	25	205	230	434
West Virginia	W	W	247	348
Wisconsin		12	12	24
Wyoming		40	40	99
Other States [2]	1,032	19,770	845	1,208
Total [1]	2,493	39,894	42,387	63,361

See footnotes at end of table.

Table 9.—Common clay and shale sold or used by producers in the United States, by States—Continued

(Thousand short tons and thousand dollars)

Year and State	Sold by producers	Used by producers	Total [1]	
	Quantity	Quantity	Quantity	Value
1970:				
Alabama	W	W	2,046	$2,780
Arkansas	----------	812	812	1,063
California	210	2,187	2,397	4,821
Colorado	W	W	398	552
Connecticut	----------	171	171	386
Delaware	----------	11	11	11
Georgia	W	W	1,601	2,196
Hawaii	----------	2	2	11
Idaho	W	W	13	28
Illinois	----------	1,494	1,494	2,359
Indiana	W	W	1,259	1,936
Iowa	----------	1,181	1,181	1,823
Kansas	W	W	713	946
Kentucky	W	W	860	877
Louisiana	----------	1,080	1,080	1,575
Maine	----------	41	41	55
Maryland	W	W	1,129	1,433
Massachusetts	----------	284	284	582
Michigan	----------	2,480	2,480	2,887
Minnesota	----------	227	227	335
Mississippi	W	W	974	1,008
Missouri	----------	1,201	1,201	1,626
Montana	W	W	41	71
Nebraska	W	W	90	147
New Hampshire	----------	40	40	32
New Jersey	----------	W	W	472
New York	W	W	1,707	1,897
North Carolina	W	W	3,318	3,102
Ohio	185	1,846	2,031	4,045
Oklahoma	----------	769	769	1,116
Oregon	W	W	134	172
Pennsylvania	105	1,350	1,456	5,301
South Carolina	12	1,443	1,455	1,867
Tennessee	----------	991	991	1,461
Texas	W	W	3,550	4,945
Virginia	----------	1,633	1,633	1,672
Washington	24	216	240	436
West Virginia	W	W	191	238
Wisconsin	----------	8	8	14
Wyoming	----------	44	44	104
Other States [2]	839	18,358	1,175	1,340
Total [1]	1,375	37,869	39,244	57,721

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.
[2] Includes Arizona, Florida, Nevada, New Mexico (1970), North Dakota, South Dakota, Utah, Vermont, and data indicated by symbol W.

Table 10.—Clay sold or used by producers in the United States in 1970, by kinds [1]

(Thousand short tons)

Use	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Common clay and shale	Total
Pottery and stoneware:							
Whiteware	120	297	W	W	-------	W	428
Other	45	20	53	-------	-------	38	156
Total	165	317	W	W	-------	38	584
Floor and wall tile	15	109	207	-------	-------	98	429
Refractories:							
Firebrick and block	692	12	2,428	-------	-------	W	W
Foundries, steelworks (bulk)	W	W	545	745	-------	9	1,431
High-alumina brick (minimum 50 percent Al_2O_3)	W	-------	48	-------	-------	-------	W
Mortar	W	W	61	-------	-------	W	70
Saggers, pins, stilts, and wads	W	W	W	-------	-------	-------	W
Other	W	W	76	W	-------	11	110
Total	821	W	W	W	-------	24	5,001
Heavy clay products:							
Building brick	83	141	2,151	W	-------	15,882	W
Drain tile	-------	-------	W	-------	-------	846	W
Vitrified sewer pipe	W	-------	495	-------	-------	1,384	W
Other	W	-------	50	-------	-------	181	W
Total	W	141	W	W	-------	18,293	21,226
Lightweight aggregate	-------	-------	W	-------	W	9,605	9,606
Filler:							
Paper coating and filling	2,535	W	-------	W	W	W	W
Rubber	371	-------	-------	W	-------	W	W
Plastics	W	-------	-------	W	W	W	W
Paint	107	-------	-------	W	W	W	110
Fertilizers	81	-------	-------	-------	W	W	100
Insecticides and fungicides	26	W	W	2	192	W	225
Other	86	-------	W	W	W	W	106
Total	W	W	W	W	W	W	3,520
Portland and other cements	67	-------	18	1	-------	10,903	10,990
Absorbent uses:							
Animal litter	-------	-------	-------	W	240	W	W
Floor sweeping compound	-------	-------	-------	-------	330	W	W
Other	-------	-------	-------	W	W	-------	W
Total	-------	-------	-------	W	W	W	712
Miscellaneous:							
Filtering, decolorizing, and clarifying	-------	-------	-------	162	41	-------	202
Rotary-drilling mud	W	W	6	509	67	W	586
Chemicals	63	-------	W	W	W	W	W
Catalysts (oil refining)	65	W	-------	-------	3	W	W
Pelletizing (iron ore)	-------	-------	-------	898	-------	-------	898
Other	392	W	96	186	28	191	W
Total	W	W	W	W	W	W	2,783
Grand total:							
1970	4,926	710	6,459	2,533	982	39,244	54,853
1969	4,739	682	7,261	2,640	985	42,387	58,694

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

Table 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments 1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
CLAY REFRACTORIES					
Fire clay (including semisilica) brick and shapes, except superduty.	1,000 9-inch equivalent	269,751	$56,852	224,857	$51,078
Superduty fire-clay brick and shapes	----do------	75,189	26,268	78,177	27,867
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	----do------	r 65,240	r 37,236	66,416	40,673
Insulating firebrick and shapes	----do------	r 60,926	r 18,026	55,285	17,368
Ladle brick	----do------	205,850	27,386	193,567	28,130
Sleeves, nozzles, runner brick and tuyeres	----do------	r 54,080	15,545	49,873	15,803
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks.[1 2]					
Hot-top refractories	Short tons	37,350	3,134	29,717	2,352
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.	------------	NA	r 10,363	NA	9,060
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short tons	r 78,041	r 10,432	69,507	9,681
Refractory bonding mortars, except air-setting types.[3]	----do------	r 15,970	r 1,972	12,106	1,529
Plastic refractories and ramming mixes [3]	----do------	r 171,130	r 15,355	170,624	15,579
Castable refractories (hydraulic-setting)	----do------	r 178,498	r 20,155	178,987	21,766
Insulating castable refractories (hydraulic-setting).	----do------	r 41,168	6,168	44,576	6,819
Other clay refractory materials sold in lump or ground form.[4 5]	----do------	345,227	r 8,615	330,835	8,679
Total clay refractories		XX	r 257,507	XX	256,384
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent	68,668	r 17,480	45,395	15,251
Magnesite and magnesite-chrome brick and shapes (magnesite predominating) (excluding molten cast and fused magnesia).	----do------	103,642	112,601	92,912	108,126
Chrome and chrome-magnesite brick and shapes (chrome predominating) (excluding molten cast).	----do------	21,637	20,816	16,850	17,831
Graphite crucibles, retorts, stopper heads, and other shaped refractories containing natural graphite.	Short tons	r 16,418	r 15,058	15,957	14,732
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten-cast).	1,000 9-inch equivalent	r 6,153	r 10,128	6,106	10,879
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten cast).	----do------	r 3,580	r 9,343	3,171	9,207
Silicon carbide brick and shapes made predominantly of silicon carbide (including kiln furniture).	----do------	r 3,793	r 13,526	3,589	13,745
Zircon and zirconia brick and shapes made predominantly of either of these materials.	----do------	r 2,310	r 6,983	1,788	6,614
Forsterite, pyrophyllite, molten-cast, dolomite, dolomite-magnesite, and other nonclay brick and shapes including carbon refractories except those containing natural graphite.	----do------	r 25,645	r 48,575	25,032	49,323
Mortars:					
Basic bonding mortars (magnesite or chrome ore predominating).	Short tons	r 95,305	r 8,534	90,283	8,803
Other nonclay refractory mortars	----do------	r 25,068	r 4,591	25,282	4,888
Nonclay refractory castables (hydraulic-setting)	----do------	r 38,293	r 9,192	41,769	10,358
Plastic refractories and ramming mixes (wet and dry types):					
Basic (magnesite, dolomite, or chrome ore predominating).	----do------	168,474	24,503	147,321	23,014
Other nonclay plastic refractories and ramming mixes.	----do------	r 64,316	r 13,708	73,004	15,614

See footnotes at end of table.

Table 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	Shipments 1969 Quantity	Shipments 1969 Value (thousands)	Shipments 1970 Quantity	Shipments 1970 Value (thousands)
NONCLAY REFRACTORIES—Continued					
Dead-burned magnesia or magnesite	Short tons	r 117,326	r $8,016	159,883	$12,571
Nonclay gunning mixes	do	249,573	26,209	219,580	24,440
Other nonclay refractory materials sold in lump or ground form.[4]	do	r 256,303	r 10,506	255,141	9,580
Total nonclay refractories		XX	r 359,769	XX	354,976
Grand total refractories		XX	r 617,276	XX	611,360

r Revised. 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 12.—Shipments of principal structural clay products in the United States

Product	1966	1967	1968	1969	1970
Unglazed brick (buildings) 1,000 standard brick	7,606,237	7,117,353	7,556,809	7,289,669	6,495,995
Value thousands	$292,914	$285,630	$318,365	$318,892	$287,131
Unglazed structural tile short tons	267,431	234,517	191,067	241,509	---
Value thousands	$5,317	$4,900	$4,169	$6,875	---
Vitrified clay sewer pipe and fittings short tons	1,610,318	1,572,167	1,705,528	1,783,546	1,622,339
Value thousands	$96,707	$97,330	$109,465	$120,420	$119,048
Facing tile, ceramic glazed, including glazed brick 1,000-brick equivalent	292,525	230,064	211,223	200,074	167,070
Value thousands	$25,179	$21,274	$19,708	$19,188	$15,661
Facing tile, unglazed and salt glazed 1,000-tile, 8- by 5- by 12-inch, equivalent	5,207	3,352	3,032	2,965	1,915
Value thousands	$1,284	$837	$750	$729	$469
Clay floor and wall tile and accessories, including quarry tile 1,000 square feet	272,688	257,532	274,512	284,780	250,405
Value thousands	$133,266	$128,139	$138,319	$142,878	$126,219
Total value thousands	$554,667	$538,110	$590,776	$608,982	$548,528

Table 13.—U.S. exports of clay by countries and class in 1970

(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	54	$1,383	(1)	$47	1	$24	10	$362	(1)	$20	22	$1,249	87	$3,085
Brazil	8	350	(1)	15	(1)	8	3	124	(1)	12	5	353	16	862
Canada	242	4,470	86	1,069	14	674	168	4,298	4	69	187	5,094	701	15,674
Finland	4	149	(1)	6	(1)	8	29	967	------	------	7	273	40	1,403
France	17	425	(1)	31	2	129	33	1,318	1	89	19	1,062	72	3,054
Germany, West	55	1,197	(1)	35	3	127	84	4,004	(1)	6	31	1,123	173	6,492
Italy	4	195	3	212	2	112	133	4,219	(1)	6	30	1,447	172	6,191
Japan	1	288	6	593	(1)	12	97	4,385	(1)	11	75	2,953	179	8,242
Mexico	1	41	62	869	(1)	7	25	939	10	164	30	557	128	2,577
Netherlands	10	195	(1)	11	1	49	175	4,447	2	74	14	648	202	5,424
Sweden	3	151	(1)	(1)	(1)	4	22	718	(1)	3	12	468	37	1,344
United Kingdom	48	1,449	2	77	10	319	5	123	(1)	20	14	853	79	2,841
Venezuela	16	498	(1)	20	------	------	9	324	1	20	8	218	34	1,080
Other	33	1,769	8	479	4	90	23	1,066	4	119	84	4,324	156	7,847
Total	496	12,560	167	3,464	37	1,563	816	27,294	22	613	538	20,622	2,076	66,116

[1] Less than ½ unit.

Table 14.—U.S. imports for consumption of clay in 1970

(Short tons and thousand dollars)

Kind	Quantity	Value
China clay or kaolin, whether or not beneficiated:		
Australia	1	(1)
Canada	1,982	$29
Germany, West	3,699	49
Japan	55	11
South Africa, Republic of	25	1
United Kingdom	59,573	1,156
Total	65,335	1,246
Fuller's earth: United Kingdom	66	5
Bentonite:		
Canada	60	3
Italy	123	6
Total	183	9
Common blue and other ball clay, not beneficiated:		
Canada	1,654	24
Germany, West	2,755	40
United Kingdom	9,522	132
Total	13,931	196
Common blue clay or ball clay, wholly or partly beneficiated:		
Argentina	55	4
Netherlands	62	1
United Kingdom	3,270	86
Total	3,387	91
Clays, n.e.c., not beneficiated:		
Canada	54	3
Germany, West	22	1
Total	76	4
Clays, n.e.c., wholly or partly beneficiated:		
Canada	49	7
Germany, West	253	18
United Kingdom	1,199	63
Total	1,501	88
Clays artificially activated with acid:		
Canada	1,193	51
Germany, West	518	45
Japan	340	66
Mexico	10	1
Total	2,061	163
Grand total	86,540	1,802

1 Less than ½ unit.

Table 15.—China clay: World production, by countries

(Thousand short tons)

Country [1]	1968	1969	1970 p
North America:			
Mexico	83	99	87
United States [2]	4,201	4,739	4,926
South America:			
Argentina	r 81	89	e 89
Chile	29	49	53
Colombia	93	97	102
Ecuador	1	(3)	e 1
Peru	1	2	e 2
Europe:			
Austria (marketable)	106	107	e 106
Belgium e	110	110	110
Bulgaria	140	134	138
Czechoslovakia	376	378	386
Denmark e	20	20	20
France [4]	r 485	e 518	e 529
Germany, West (marketable)	451	480	493
Greece	r 87	e 66	e 58
Hungary	r 69	66	79
Italy:			
Crude	90	104	111
Kaolinitic earth	r 21	e 22	e 22
Portugal	r 46	49	55
Romania e	55	55	55
Spain (marketable)	250	302	e 330
Sweden	31	32	e 32
U.S.S.R.e	1,900	2,000	2,000
United Kingdom	r 3,115	3,368	3,509
Africa:			
Angola	10	1	2
Ethiopia	14	14	12
Kenya	1	2	2
Malagasy Republic	1	e 1	1
Mozambique	r 1	1	2
Nigeria	(3)	1	1
South Africa, Republic of	36	37	41
Swaziland	2	2	2
Tanzania	1	1	1
United Arab Republic	r 120	86	e 88
Asia:			
Ceylon	3	3	2
Hong Kong	6	5	4
India: [5]			
Salable crude	172	200	222
Processed	113	113	113
Indonesia (kaolin powder)	8	e 3	e 10
Iran [6]	35	p 37	e 39
Japan	187	214	239
Korea, Republic of	133	149	215
Malaysia	2	2	4
Pakistan [7]	3	4	e 10
South Vietnam	1	e 1	e 1
Taiwan e [8]	11	12	11
Thailand	(9)	(9)	3
Oceania: Australia [10]	66	72	e 72
Total	r 12,767	13,847	14,390

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, Brazil, mainland China, East Germany, Israel, Lebanon, Southern Rhodesia, and Yugoslavia also produces kaolin, but information is inadequate to make reliable estimates of output levels. In addition, Morocco and Paraguay 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] Series revised to show total salable product; figures in previous editions of this chapter were total crude production. Processed kaolin listed was derived from so-called nonsalable crude production, which was as follows in thousand short tons: 1968, 386; 1969, 413; and 1970, 371.

[6] Year beginning March 21 of that stated.

[7] 1968 and 1969 data are officially reported figures but totals may be higher owing to unreported production from West Pakistan.

[8] 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.

[9] Production unreported but small if any.

[10] Includes ball clay.

Coal—Bituminous and Lignite

By L. W. Westerstrom [1]

Production of bituminous coal and lignite increased substantially in 1970. The output of 602.9 million tons, an increase of 42.4 million tons over production in 1969, was surpassed in only two previous years, 1944 and 1947. The gain was attributed to expanded consumption by the electric utilities, a greater use at coke ovens, a substantial increase in exports, and a rebuilding of depleted stockpiles.

The big increase in demand for coal, caused serious shortages in the first half of the year. Production, although hampered by some wildcat strikes and railway car shortages during the first half of the year, improved steadily during the second half as strikes dwindled and the car supply improved. As a result, production was able to nearly match demand.

Despite the 42-billion-ton increase in bituminous coal and lignite production in 1970, underground production in all major coal-producing states was less than that of 1969. As a result, coal produced from strip mines in 1970 accounted for 40 percent of the total production, compared with 35 percent in 1969. In Kentucky alone, coal output from strip mines increased 15.3 million tons—9.8 million tons in East Kentucky and 5.5 million tons in West Kentucky. In West Virginia, strip-mine production increased 7.4 million tons, and in Ohio, production increased 4.8 million tons.

The shortage of coal, the increased cost of production, the passage of a comprehensive Federal mine safety law, and local and national antipollution measures drove coal prices to an unprecedented high. The average U.S. f.o.b. mine price increased from $4.99 per ton in 1969 to $6.26 per ton in 1970.

In developments affecting underground coal mining, the most significant event was the implementation of the Federal Coal Mine Health and Safety Act of 1969. Definite changes were required in most mine operations to achieve respirable dust control, to increase general ventilation requirements, to make appropriate equipment changes and modifications, and to comply with manpower training and certification criteria. These measures, as would be expected, increased mining costs considerably.

Exports in 1970 gained 14.7 million tons, raising the total for the year to 70.9 million tons. Shipments of coal to Canada and exports of coal to Japan and the European Coal and Steel Community increased significantly.

In transportation, a new coal pipeline running from a mine in northeastern Arizona to a powerplant in Nevada began operation. Unit-train shipments continued to grow. The rail cost of transporting coal increased during the year. Despite increased unit-train shipments of coal, two general freight rate increases raised the average rail freight charge from $3.10 per ton in 1969 to $3.41 per ton in 1970.

This chapter includes all bituminous coal and lignite produced in the United States except Texas lignite and bituminous coal and lignite from mines that produced less than 1,000 tons per year. 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 statuary authority to require such reports. Thus, complete coverage of all mines producing 1,000 tons per year or more is reported.

[1] Industry economist, Division of Fossil Fuels.

The annual coal production canvass does not include information on employment. The information, which shows the average number of men working daily, days worked, man-days worked, and tons per man per day, was obtained from the Office of Accident Analysis of the Bureau of Mines.

The monthly and weekly estimates of production, summarized in tables 4 and 5, are based upon railroad carloadings of coal reported daily and weekly by railroads, shipments on the Allegheny and Monongahela Rivers reported by the U.S. Army Corps of Engineers, direct reeports from mining companies, and monthly production statements compiled by certain local operators' associations and State mine departments.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1966	1967	1968	1969	1970
Production thousand short tons	533,881	552,626	545,245	560,505	602,932
Value thousands	$2,421,293	$2,555,378	$2,546,340	$2,795,509	$3,772,662
Consumption thousand short tons	486,266	480,416	498,830	507,275	517,158
Stocks at end of year:					
Industrial consumers and retail yards do	74,466	93,128	85,525	80,482	92,275
Stocks on upper lake docks do	2,342	2,280	1,937	1,484	1,468
Exports [1] do	49,302	49,528	50,637	56,234	70,944
Imports [1] do	178	227	224	109	36
Price indicators, average per net ton:					
Cost of coking coal at merchant coke ovens	$9.81	$10.33	$10.58	$10.75	$12.28
Railroad freight charge [2]	$3.01	$3.00	$3.01	$3.10	$3.41
Value f.o.b. mines (sold in open market)	$4.24	$4.34	$4.38	$4.65	$5.89
Value f.o.b. mines	$4.54	$4.62	$4.67	$4.99	$6.26
Method of mining:					
Hand-loaded underground thousand short tons	28,243	19,219	14,755	11,700	9,599
Mechanically loaded underground do	310,281	329,914	329,387	335,430	329,189
Percentage mechanically loaded	91.7	94.5	95.7	96.6	97.2
Percentage cut by machine	51.0	49.1	48.4	46.2	46.1
Mined by stripping thousand short tons	180,058	187,134	185,836	197,023	244,117
Percentage mined by stripping	33.7	33.9	34.1	35.2	40.5
Mined at auger mines thousand short tons	15,299	16,360	15,267	16,350	20,027
Percentage mined at auger mines	2.9	2.9	2.8	2.9	3.3
Mechanically cleaned thousand short tons	340,626	349,402	340,923	334,761	323,452
Percentage mechanically cleaned	63.8	63.2	62.5	59.7	53.6
Number of mines	6,749	5,873	5,327	5,118	5,601
Capacity at 280 days thousand short tons	683,000	707,000	694,000	694,000	740,000
Average number of men working daily: [3]					
Underground mines	107,614	107,432	102,940	99,269	107,808
Strip mines	21,752	21,439	22,358	22,323	28,395
Auger mines	2,386	2,652	2,596	2,940	3,937
Total	131,752	131,523	127,894	124,532	140,140
Average number of days worked: [3]					
Underground mines	215	216	217	224	229
Strip mines	247	248	243	247	236
Auger mines	144	133	145	139	148
Total	219	219	220	226	228
Production per man per day:					
Underground mines short tons	14.64	15.07	15.40	15.61	13.75
Strip mines do	33.57	35.17	34.24	35.71	35.96
Auger mines do	44.43	46.48	40.46	39.88	34.26
Total do	18.52	19.17	19.37	19.90	18.84

[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.

DISTRIBUTION AND SHIPMENTS

Shipments of bituminous coal and lignite, summarized by district of origin, State of destination, type of consumer use, and method of transportation, show the participation of the bituminous coal and lignite industry in the local and national markets of the United States.

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 in 1970 increased 6.8 percent from those of 1969, and most geographic divisions shared in the increase. The largest increases were in the East North Central region, followed by the East South Central and West North Central regions. Of the total 38.1-million-ton net increase in 1970, shipments to electric utilities were up 27.4 million tons. Coke and gas plants increased their receipts of coal by 4.4 million tons, and overseas exports increased 12.4 million tons. Shipments to retail dealers and all other industrial markets decreased 0.9 and 4.5 million tons, respectively. Miscellaneous items such as railroad fuel, mine fuel, Canadian and U.S. Great Lakes dock storage accounts, U.S. tidewater dock storage accounts, and net changes in mine inventory decreased 0.7 million tons.

The quantitative changes in total tons shipped, expressed in indices, that took place throughout the country, by geographic division, State of destination, and consumer use, are shown for the years 1957 and 1966 through 1970 in table 40. To indicate the size of the bituminous coal and lignite market in each geographic division, State, and consumer use category, the 1957 total tons shipped are shown in lieu of the index numbers of 100, which each tonnage figure represents (except those otherwise noted).

These distribution data 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 per year. 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]

TRANSPORTATION

Unit trains continued to increase their share of coal traffic, particularly at new mines. Innovations in coal loading were made. At some mines, where space was available, track loops that permitted smooth, continuous loading of cars were installed. Coal loading and car movement was also enhanced by the incorporation of facilities that automatically moved cars of various sizes and capacities by the loading point.

Car utilization improved substantially by the issuance of new regulations by the Interstate Commerce Commission, which accelerated the return of empty hopper cars to owning railroads. The regulations prohibited major coal carriers from loading cars foreign to their lines and required them to return cars to the owner.

Car shortages were further eased, when in mid-year, the N & W and the C & O – B & O railroads began a permit system for the movement of export coal to their Hampton Roads, Va., port facilities. Under the system, exporters or transshippers need a permit from the rialroad for the number of cars they require, based on the expected arrival and availability of ships. The purpose of this system was to free more cars for movement of coal to domestic utilities and steel plants.

In the fall of 1970, commercial operation of the 273-mile Black Mesa slurry line from Peabody Coal Co.'s Kayenta mine in

[2] U.S. Bureau of Mines. Bureau of Mines Bituminous Coal and Lignite Distribution, Calendar Year 1970. Miner. Ind. Survey, Mar. 23, 1971, 39 pp.

northeastern Arizona, to the Mohawk powerplant at Davis Dam, Nev. began. The delivery capacity of 660 tons per hour enables the pipeline to deliver the equivalent of one and one-half unit-train loads every day.

FOREIGN TRADE

In 1970 the United States exported 70.9 million tons of coal, an increase of 14.7 million tons over the amount exported in 1969 and only 5.5 million tons short of the record year of 1957. The increased demand for U.S. coal stemmed from an unprecedented rise in world steel production, a depletion of large coal stockpiles, and a reduction in coal mining capacity.

After World II, bituminous coal exports became an important item of foreign trade, contributing significantly to our international balance of payments. In 1970 the total value of coal exported was $951 million and represented 2.3 percent of the total national export value (excluding shipments for defense). Nearly 96 percent of U.S. exports in 1970 were shipped to Japan, Canada, and Europe. The bulk of the remaining 4 percent went to Brazil and Chile.

Shipments of coal to the Iron Curtain countries during 1970 amounted to 466,000 tons, all destined for East Germany and Romania; 1969 exports to these Eastern Bloc countries totaled 159,000 tons.

Exports of coal fluctuated widely prior to 1961 because of various emergencies abroad; since then, with no major fuel emergencies, exports have increased considerably. There is reason to believe that because of its high quality and competitive price, U.S. coal will continue to provide an important part of the coal supply in Canada, Japan, and Western Europe.

Imports of bituminous coal and lignite are very small, totalling only 36,400 tons in 1970.

WORLD REVIEW

World production of coal totaled 3,288 million tons in 1970, an increase of 3.7 percent over the total of 1969. The United States supplied nearly 613 million tons of bituminous coal, anthracite, and lignite, or 19 percent of the world output in 1970.

North America's contribution to world output increased 8.2 percent from the 1969 level. Production increased in Europe, Africa, and Oceania, and declined in South America.

Production in the U.S.S.R., the largest coal-producing country in the world, was estimated at 688 million tons in 1970, an increase of 2.7 percent from the 1969 tonnage.

TECHNOLOGY

Improvements were made in the area of electric power distribution and utilization since the passage of the Federal Coal Mine Health and Safety Act of 1969. Trailing cables on face equipment with regard to the number of temporary splices permitted by the new law caused some operating difficulties in 1970. However, equipment and techniques to make permanent cable splices were perfected in 1970.

With the passage of the new safety act, the control of duct and methane assumed a position of great importance in coal mining. Dust control methods involved water infusion, use of water sprays, and improved ventilation. More mines adopted bulk rock-dusting systems, which includes surface storage tanks that deliver rock dust through boreholes to pressurized cars or tanks for delivery to the working faces as needed.

Production from surface mines and highwall coal-recovery augers reached new highs in 1970. In area stripping, large shovels and draglines accounted for most of the production; the 220-yard dragline continued to be the largest operating machine. At large mines, where the overburden was thick, shovels and draglines in sizes of 100 to 120 yards were most often used. At mines where large machines could not be used, such as in mountainous terrain where equipment followed the outcrop, mining companies used a wide range of machines to remove overburden. Those most widely used were diesel-powered shovels and draglines, front-end loaders, and large bulldozers. These units are easily moved from mine to mine and provide flexibility in stacking overburden. In hauling coal at contour operations, end-dump trucks carried nearly all of the output. Tractor-trailer combinations were most often used over relatively level terrain from the loading shovel to the preparation plant or to stockpiles at the power plant.

Substantial research was conducted in coal utilization by the Bureau of Mines. The coal gasification process, designated the "Synthane" process, was further developed and tested in a pilot plant for converting coal to pipeline-quality gas. The economic and operational feasibility of the gasification process were judged attractive by an outside engineering firm. Design of a prototype plant is underway. The process is capable of gasifying caking as well as non-caking coals. Other advantages of the process are that more than one-half of the ultimate methane is produced in the gasifier and that it includes an efficient and novel methanator for upgrading the coal gases to pipeline quality.

In a second program, successful pilot plant tests at the Morgantown Energy Research Center demonstrated that strongly caking coal can be gasified in a fixed-bed unit if mechanical stirring is employed to break up agglomeration in the fuel bed. The tendency of coals to agglomerate when heated has hampered the gasification of coals from the Eastern United States, the locale in which the largest potential markets for synthetic gas are located. Although the Bureau's fixed-bed operation requires the use of screened coal, it is attractive for large-scale application, because it offers high throughput and economy of operation.

The Bureau demonstrated that slurries of coal in high-temperature tar can be hydrogenated to an oil over fixed beds of pelleted cobalt molybdate catalyst.

Hydrogenation of a 30-weight-percent coal slurry at 425° C and 4,000 psi resulted in 91 percent of the moisture and ash-free coal being converted to liquids and gases; the yield of liquid products amounted to 96 percent of the paste feed. Sulfur content of the oil was as low as 0.2 percent. These results confirm the technical feasibility of converting coal to low-sulfur utility fuels compatible with air pollution regulations.

Coke research during 1970 continued to emphasize the use of coals not presently used in coke-making, coals of marginal coking quality, and western coals for making metallurgical-grade cokes. At the Grand Forks Coal Research Laboratory, five high-volatile western coals presently used in commercial coke-making are being investigated. All five coals require the addition of low- and medium-volatile coals to produce a metallurgical-grade coke. Studies completed on two of these coals show that char produced from the parent coal is in some cases an acceptable substitute for expensive blending coals. At Pittsburgh, the addition of coal breeze to a coal-char mixture resulted in a stronger coke than that produced from a blend containing low-volatile coal.

During the year, plans were completed between the Bureau of Mines and a major American coal-producing company to restore a coal mine refuse dump using techniques developed at the Morgantown Energy Research Center. The site chosen for the cooperative project is near Cassville, Monongalia County, W. Va. Flyash, itself a major waste product, is used to neutralize the acidic components in the soil and to act as a soil conditioner as well.

Table 2.—Coal reserves of the United States, January 1, 1970, by States

(Million short tons)

State	Date of publication of estimate	Estimated original reserves: Bituminous coal	Sub-bituminous coal	Lignite	Anthracite and semi-anthracite	Total	Reserves depleted to Jan. 1, 1970: Production [1]	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, 1955–1970 [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	15,001	12,440	517,158	12,708	12,290

[1] Prior to 1970, the average heat content of the annual output of bituminous coal and lignite was measured at 13,100 Btu per pound. This value was based on an estimate made in 1949. (Wynn, Jr., George J. Average Heating Values of American Coals by Rank and by States. BuMines Inf. Circ. 7538, 1949. 11 pp.) 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, in 1970, by States, with estimates by months [1]

(Thousand short tons)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Alabama	1,759	1,571	1,577	1,658	1,546	1,729	1,163	1,712	1,961	1,899	1,994	1,991	20,560
Alaska	61	54	58	62	64	51	17	38	44	46	31	23	549
Arizona	------	------	------	------	------	------	------	------	9	36	42	45	132
Arkansas	21	19	38	37	17	18	16	24	21	17	19	21	268
Colorado	569	496	482	448	503	447	329	496	533	562	556	604	6,025
Illinois	5,513	5,437	5,801	5,469	5,232	4,848	4,446	5,509	5,661	5,783	5,344	6,076	65,119
Indiana	1,607	1,533	1,739	1,831	1,848	1,957	1,734	1,929	1,991	2,069	1,956	2,069	22,263
Iowa	74	86	76	109	79	74	79	80	74	81	76	99	987
Kansas	130	136	144	147	130	140	115	145	148	142	124	126	1,627
Kentucky:													
Eastern	4,753	4,719	5,816	5,925	5,905	6,135	5,871	7,029	6,765	6,845	6,311	6,424	[2] 72,502
Western	4,106	4,227	4,740	4,339	4,150	4,135	3,789	4,691	4,760	4,710	4,609	4,551	[2] 52,803
Total	8,859	8,946	10,556	10,264	10,055	10,270	9,660	11,720	11,525	11,555	10,920	10,975	125,305
Maryland	106	114	121	169	130	170	145	160	97	148	146	109	1,615
Missouri	185	260	399	386	144	224	449	555	416	464	444	521	4,447
Montana:													
Bituminous	260	465	510	455	110	100	140	214	165	215	210	281	[2] 3,124
Lignite	25	50	55	45	10	10	15	25	14	25	19	30	323
Total	285	515	565	500	120	110	155	239	179	240	229	310	3,447
New Mexico	523	572	473	622	574	631	656	725	739	741	594	511	7,361
North Dakota	577	483	457	493	361	354	361	469	421	569	491	603	5,639
Ohio	4,100	4,125	4,411	4,414	4,682	4,843	4,764	5,271	5,049	4,737	4,437	4,518	55,351
Oklahoma	179	171	189	186	178	202	203	207	222	225	218	247	2,427
Pennsylvania	6,201	6,619	7,111	6,954	6,752	6,393	5,307	6,894	7,050	7,380	6,592	7,238	80,491
Tennessee	416	439	534	627	648	942	931	665	804	801	728	702	8,237
Utah	429	361	404	381	321	309	218	452	439	490	481	448	4,733
Virginia	2,731	2,670	2,986	3,034	3,009	3,311	1,977	3,068	3,326	3,319	2,814	2,771	35,016
Washington	5	------	6	------	5	------	------	6	5	5	------	5	37
West Virginia	11,733	11,852	13,464	12,191	12,176	12,344	6,601	12,069	13,236	13,799	12,351	12,256	144,072
Wyoming	622	619	656	689	580	546	464	576	374	751	595	750	7,222
Total	46,685	47,078	52,247	50,671	49,154	49,913	39,790	53,009	54,324	55,859	51,182	53,018	[2] 602,932

[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; 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 5.—Production of bituminous coal and lignite in the United States, with estimates by weeks

(Thousand short tons)

Week ended—	1969 Production	1969 Maximum number of working days	1969 Average production per working day	Week ended—	1970 Production	1970 Maximum number of working days	1970 Average production per working day
Jan. 4	4,551	[1] 3	[2] 1,517	Jan. 3	2,735	[1] 2	[2] 1,368
Jan. 11	10,826	6	1,804	Jan. 10	9,382	6	1,564
Jan. 18	11,400	6	1,900	Jan. 17	11,550	6	1,925
Jan. 25	10,922	6	1,820	Jan. 24	10,853	6	1,808
Feb. 1	10,891	6	1,815	Jan. 31	12,165	6	2,028
Feb. 8	11,038	6	1,840	Feb. 7	11,096	6	1,849
Feb. 15	11,229	6	1,872	Feb. 14	11,885	6	1,981
Feb. 22	10,821	6	1,804	Feb. 21	11,722	6	1,953
Mar. 1	9,218	6	1,536	Feb. 28	12,375	6	2,063
Mar. 8	7,893	6	1,316	Mar. 7	11,562	6	1,927
Mar. 15	10,196	6	1,699	Mar. 14	12,125	6	2,021
Mar. 22	12,020	6	2,003	Mar. 21	12,285	6	2,048
Mar. 29	11,733	6	1,956	Mar. 28	12,250	6	2,042
Apr. 5	9,994	5.3	1,886	Apr. 4	10,746	5.3	2,027
Apr. 12	10,791	6	1,799	Apr. 11	12,195	6	2,033
Apr. 19	11,269	6	1,878	Apr. 18	11,650	6	1,942
Apr. 26	11,451	6	1,909	Apr. 25	11,795	6	1,963
May 3	11,451	6	1,909	May 2	10,854	6	1,809
May 10	11,380	6	1,897	May 9	11,556	6	1,926
May 17	11,431	6	1,905	May 16	11,598	6	1,933
May 24	11,617	6	1,936	May 23	11,782	6	1,963
May 31	9,929	5.1	1,947	May 30	11,674	5.1	2,289
June 7	11,723	6	1,954	June 6	11,668	6	1,945
June 14	10,090	6	1,682	June 13	12,042	6	2,007
June 21	9,924	6	1,654	June 20	11,970	6	1,995
June 28	11,325	6	1,888	June 27	10,683	6	1,781
July 5	4,612	1.9	2,427	July 4	6,845	2	3,423
July 12	4,995	2.2	2,270	July 11	6,504	2.2	2,957
July 19	9,253	4.3	2,152	July 18	10,706	4.3	2,490
July 26	9,752	5.3	1,840	July 25	10,610	6	1,768
Aug. 2	11,577	6	1,930	Aug. 1	10,616	6	1,769
Aug. 9	11,693	6	1,949	Aug. 8	11,984	6	1,998
Aug. 16	11,521	6	1,920	Aug. 15	12,595	6	2,099
Aug. 23	10,675	6	1,779	Aug. 22	12,104	6	2,018
Aug. 30	11,406	6	1,901	Aug. 29	12,366	6	2,061
Sept. 6	9,848	5	1,970	Sept. 5	12,630	6	2,105
Sept. 13	11,632	6	1,939	Sept. 12	11,395	5	2,279
Sept. 20	11,839	6	1,973	Sept. 19	12,664	6	2,111
Sept. 27	11,930	6	1,988	Sept. 26	12,706	6	2,118
Oct. 4	11,658	6	1,943	Oct. 3	12,265	6	2,044
Oct. 11	12,086	6	2,014	Oct. 10	12,852	6	2,142
Oct. 18	11,567	6	1,928	Oct. 17	12,613	6	2,103
Oct. 25	11,874	6	1,979	Oct. 24	12,474	6	2,079
Nov. 1	11,869	6	1,978	Oct. 31	12,605	6	2,101
Nov. 8	11,607	6	1,935	Nov. 7	12,886	6	2,147
Nov. 15	10,670	5.3	2,013	Nov. 14	11,869	5.3	2,240
Nov. 22	11,678	6	1,946	Nov. 21	13,205	6	2,201
Nov. 29	10,579	5	2,116	Nov. 28	10,723	5	2,145
Dec. 6	12,499	6	2,083	Dec. 5	13,192	6	2,198
Dec. 13	12,333	6	2,056	Dec. 12	11,792	6	1,965
Dec. 20	12,056	6	2,009	Dec. 19	13,235	6	2,206
Dec. 27	8,261	4.5	1,836	Dec. 26	9,075	4.5	2,017
Jan. 3	5,922	[1] 3	[2] 1,974	Jan. 2	8,223	[1] 4	2,056
Total	560,505	295.9	1,894	Total	[3] 602,932	296.7	2,032

[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.
[3] Data may not add to total shown because of independent rounding.

Table 6.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by States

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]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
Alabama	129	14,740	5,029	792	----------	20,560	$8.09	5,126	244	1,253	16.41
Alaska	3	457	3	89	----------	549	7.39	66	243	16	34.13
Arizona	1	----------	----------	----------	132	132	NA	75	63	5	27.90
Arkansas	8	258	11	----------	----------	268	8.30	137	167	23	11.73
Colorado	48	4,763	1,236	14	10	6,025	5.85	1,273	251	319	18.88
Illinois	59	54,715	6,844	3,493	67	65,119	4.92	9,277	269	2,494	26.11
Indiana	38	17,309	3,304	1,599	51	22,263	4.60	2,275	271	617	36.07
Iowa	13	637	350	----------	----------	987	4.11	166	254	42	23.36
Kansas	5	1,581	45	----------	1	1,627	5.59	235	284	67	24.30
Kentucky:											
Eastern	1,623	65,874	6,572	----------	55	72,502	6.73	20,452	183	3,744	19.36
Western	98	41,720	5,603	5,437	43	52,803	4.22	5,239	303	1,586	33.28
Total	1,721	107,594	12,175	5,437	99	125,305	5.63	25,691	207	5,330	23.50
Maryland	50	736	878	----------	----------	1,615	5.01	357	201	72	22.53
Missouri	9	1,820	760	439	1,428	4,447	4.39	480	318	153	29.11
Montana:											
Bituminous	6	3,094	30	----------	----------	3,124	1.83	92	261	24	130.17
Lignite	2	322	1	----------	----------	323	2.13	17	218	4	87.16
Total	8	3,416	31	----------	----------	3,447	1.85	109	254	28	124.41
New Mexico	4	1,333	7	6,021	----------	7,361	2.89	426	252	107	68.67
North Dakota (lignite)	20	3,265	568	460	1,346	5,639	1.95	306	241	74	76.49
Ohio	306	34,149	15,255	5,939	8	55,351	4.74	9,251	235	2,173	25.47
Oklahoma	11	2,356	71	----------	----------	2,427	6.27	603	254	153	15.83
Pennsylvania	807	56,513	17,518	5,848	611	80,491	7.27	22,501	248	5,580	14.42
Tennessee	203	4,282	3,895	56	4	8,237	4.90	1,999	192	384	21.44
Utah	20	3,945	380	394	14	4,733	7.28	1,469	226	332	14.27
Virginia	803	33,304	1,656	----------	56	35,016	7.03	10,630	219	2,329	15.04
Washington	3	----------	37	----------	----------	37	12.81	30	231	7	5.33
West Virginia	1,319	139,281	3,877	643	270	144,072	7.93	47,144	219	10,318	13.96
Wyoming	13	3,990	45	3,152	36	7,222	3.38	514	234	120	60.15
Total [3]	5,601	490,448	73,977	34,373	4,134	602,932	6.26	140,140	228	31,996	18.84

NA Not available.
[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 heat, made into beehive coke at mine, 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. mines. Includes value estimated by producer for coal not sold.

Table 7.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by districts

District	Number of active mines	Production (thousand short tons): Shipped by rail or water [1]	Shipped by truck	Mine-mouth generating plants	All others [2]	Total [3]	Average value per ton [4]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
1. Pennsylvania, eastern	656	25,771	12,472	5,848	552	44,644	6.67	11,883	237	2,818	15.84
2. Pennsylvania, western	229	33,893	6,594	--------	59	40,546	7.72	11,693	256	2,997	13.53
3. West Virginia, northern	370	41,490	1,642	--------	11	43,143	6.44	11,643	225	2,619	16.47
4. Ohio	306	34,149	15,255	5,939	8	55,351	4.74	9,251	235	2,173	25.47
5. Panhandle	20	7,840	328	643	3	8,814	5.55	2,716	225	612	14.40
6. Southern Numbered 1	469	38,549	285	--------	192	39,027	10.09	15,455	206	3,177	12.28
7. Southern Numbered 2	3,013	151,306	12,518	56	175	164,056	7.15	49,214	205	10,107	16.23
8. West Kentucky	98	41,720	5,603	5,437	43	52,803	4.22	5,239	303	1,586	33.28
9. Illinois	59	54,715	6,844	3,493	67	65,119	4.92	9,277	269	2,494	26.11
10. Indiana	38	17,309	3,304	1,599	51	22,263	4.60	2,275	271	617	36.07
11. Iowa	13	637	350	--------	--------	987	4.11	166	254	42	23.36
12. Southeastern	177	15,881	5,587	792	3	22,262	7.78	5,605	241	1,350	16.49
13. Arkansas-Oklahoma	13	884	11	--------	--------	895	9.67	503	218	110	8.16
14. Southwestern	20	5,130	876	439	1,430	7,874	4.75	952	301	286	27.51
15. Northern Colorado	3	407	172	--------	2	581	4.82	153	239	37	15.88
16. Southern Colorado	46	5,296	1,063	14	9	6,382	5.90	1,285	251	323	19.77
17. New Mexico	4	395	7	6,021	132	6,556	2.50	336	213	71	91.71
18. Wyoming	13	3,990	45	3,152	36	7,222	3.38	514	234	120	60.15
19. Utah	20	3,945	380	394	14	4,733	7.28	1,469	226	332	14.27
20. North-South Dakota	20	3,265	568	460	1,346	5,639	1.95	306	241	74	76.49
21. Montana	8	3,416	31	--------	--------	3,447	1.85	109	254	28	124.41
22. Washington	6	457	40	89	--------	586	7.73	96	239	23	25.48
Total [3]	5,601	490,448	73,977	34,373	4,134	602,932	6.26	140,140	228	31,996	18.84

[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 heat, made into beehive coke at mine, 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. mines. Includes value estimated by producer for coal not sold.

Table 8.—Number and production of bituminous coal and lignite mines, in the United States, in 1970, by States, 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	5	6,544	4	1,708	2	678	------	------	5	87	19	61	35	9,078
Strip	4	3,096	8	2,185	28	4,050	17	1,255	27	702	7	51	91	11,339
Auger	------	------	------	------	1	107	------	------	2	36	------	------	3	143
Total [1]	9	9,640	12	3,893	31	4,835	17	1,255	34	825	26	111	129	20,560
Alaska: Strip	1	510	------	------	------	------	------	------	1	36	1	3	3	549
Arizona: Strip	------	------	------	------	1	132	------	------	------	------	------	------	1	132
Arkansas:														
Underground	------	------	------	------	------	------	1	45	------	------	1	6	2	51
Strip	------	------	------	------	1	104	1	55	2	48	2	11	6	217
Total [1]	------	------	------	------	1	104	2	100	2	48	3	17	8	268
Colorado:														
Underground	2	1,457	5	1,563	3	394	2	127	14	269	14	48	40	3,858
Strip	3	1,990	------	------	------	------	2	154	1	16	2	8	8	2,167
Total [1]	5	3,447	5	1,563	3	394	4	280	15	284	16	56	48	6,025
Illinois:														
Underground	20	31,032	3	723	2	237	1	62	1	36	1	3	28	32,093
Strip	22	32,205	1	438	1	185	1	84	3	95	3	18	31	33,026
Total [1]	42	63,238	4	1,161	3	422	2	147	4	131	4	21	59	65,119
Indiana:														
Underground	2	1,909	------	------	------	------	2	150	1	27	1	8	6	2,094
Strip	12	19,548	------	------	------	------	5	375	7	209	8	37	32	20,169
Total [1]	14	21,457	------	------	------	------	7	525	8	236	9	45	38	22,263
Iowa:														
Underground	------	------	1	251	1	170	------	------	------	------	1	2	3	423
Strip	------	------	------	------	1	105	4	292	5	168	------	------	10	565
Total [1]	------	------	1	251	2	275	4	292	5	168	1	2	13	987
Kansas: Strip	1	1,170	1	253	1	193	------	------	------	------	2	11	5	1,627

Kentucky:														
Underground	33	31,599	27	8,537	40	5,600	85	5,876	384	8,746	535	2,252	1,104	62,610
Strip	18	32,222	22	6,630	35	5,039	65	4,537	162	3,890	108	518	410	52,836
Auger	2	1,285	4	1,171	20	2,824	25	1,804	99	2,532	57	243	207	9,859
Total [1]	53	65,106	53	16,338	95	13,464	175	12,217	645	15,168	700	3,013	1,721	125,305
Maryland:														
Underground	------	------	------	------	------	------	2	127	3	60	11	51	16	238
Strip	------	------	1	216	4	575	1	61	14	376	8	37	28	1,266
Auger	------	------	------	------	------	------	1	73	1	20	4	18	6	111
Total [1]	------	------	1	216	4	575	4	261	18	455	23	106	50	1,615
Missouri: Strip	3	2,991	3	1,388	------	------	------	------	3	67	------	------	9	4,447
Montana:														
Underground	------	------	------	------	------	------	------	------	1	10	3	18	4	28
Strip	2	3,096	1	322	------	------	------	------	------	------	1	1	4	3,419
Total [1]	2	3,096	1	322	------	------	------	------	1	10	4	19	8	3,447
New Mexico:														
Underground	1	938	------	------	------	------	------	------	------	------	------	------	1	938
Strip	1	6,021	1	385	------	------	------	------	1	17	------	------	3	6,423
Total [1]	2	6,959	1	385	------	------	------	------	1	17	------	------	4	7,361
North Dakota: Strip	5	4,518	2	725	2	298	1	19	1	43	9	35	20	5,639
Ohio:														
Underground	18	17,440	1	319	------	------	2	118	6	159	17	75	44	18,111
Strip	16	21,579	21	6,194	21	2,984	42	3,033	68	1,808	49	221	217	35,818
Auger	------	------	------	------	2	228	11	686	17	426	15	82	45	1,422
Total [1]	34	39,019	22	6,513	23	3,211	55	3,836	91	2,393	81	378	306	55,351
Oklahoma:														
Underground	------	------	1	202	------	------	------	------	1	17	------	------	2	219
Strip	2	1,659	1	233	1	167	2	138	------	------	2	3	8	2,201
Auger	------	------	------	------	------	------	------	------	------	------	1	7	1	7
Total [1]	2	1,659	2	435	1	167	2	138	1	17	3	11	11	2,427
Pennsylvania:														
Underground	40	41,956	22	7,513	25	3,650	18	1,344	33	696	60	224	198	55,382
Strip	1	613	5	1,531	62	7,686	94	6,858	261	7,092	132	667	555	24,447
Auger	------	------	------	------	------	------	1	65	21	418	32	178	54	661
Total [1]	41	42,569	27	9,044	87	11,337	113	8,266	315	8,206	224	1,069	807	80,491

See footnote at end of table.

Table 8.—Number and production of bituminous coal and lignite mines, in the United States, in 1970, by States, 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
Tennessee:														
Underground	1	1,357	2	661	5	827	7	469	35	801	66	235	116	4,350
Strip	------	------	------	------	11	1,339	20	1,459	34	850	15	81	80	3,729
Auger	------	------	------	------	------	------	1	83	4	61	2	13	7	157
Total [1]	1	1,357	2	661	16	2,166	28	2,011	73	1,713	83	329	203	8,237
Utah: Underground	4	3,149	2	543	5	721	3	228	5	90	1	2	20	4,733
Virginia:														
Underground	13	12,583	17	5,598	13	1,723	19	1,353	233	4,891	271	1,869	566	28,018
Strip	------	------	1	305	6	898	9	683	103	2,891	35	327	154	5,103
Auger	------	------	------	------	1	108	8	557	55	1,161	19	68	83	1,895
Total [1]	13	12,583	18	5,903	20	2,729	36	2,593	391	8,944	325	2,264	803	35,016
Washington:														
Underground	------	------	------	------	------	------	------	------	2	32	------	------	2	32
Strip	------	------	------	------	------	------	------	------	------	------	1	5	1	5
Total [1]	------	------	------	------	------	------	------	------	2	32	1	5	3	37
West Virginia:														
Underground	67	67,875	91	29,479	62	8,427	71	4,912	196	4,651	261	1,070	748	116,414
Strip	3	2,473	15	4,420	36	4,700	71	4,754	199	5,007	94	531	418	21,885
Auger	------	------	2	529	10	1,362	22	1,476	92	2,286	27	119	153	5,772
Total [1]	70	70,348	108	34,429	108	14,489	164	11,142	487	11,944	382	1,720	1,319	144,072
Wyoming:														
Underground	------	------	------	------	1	110	------	------	------	------	3	8	4	118
Strip	5	6,700	1	274	1	107	------	------	1	22	1	2	9	7,105
Total [1]	5	6,700	1	274	2	217	------	------	1	22	4	10	13	7,222
United States:														
Underground	206	217,839	176	57,097	159	22,537	213	14,811	920	20,572	1,265	5,932	2,939	338,788
Strip	99	140,391	84	25,499	212	28,562	335	23,757	893	23,337	480	2,567	2,103	244,117
Auger	2	1,285	6	1,700	34	4,629	69	4,744	291	6,940	157	728	559	20,027
Total [1]	307	359,516	266	84,297	405	55,729	617	43,310	2,104	50,849	1,902	9,227	5,601	602,932

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

Table 9.—Production of bituminous coal and lignite in the United States, in 1970, by districts, and by underground, strip, and auger mining
(Thousand short tons)

District	Underground	Strip	Auger	Total
1. Pennsylvania eastern	22,859	21,124	661	44,644
2. Pennsylvania, western	34,678	5,749	119	40,546
3. West Virginia, northern	34,180	8,784	180	43,143
4. Ohio	18,111	35,818	1,422	55,351
5. Panhandle	8,466	348	-------	8,814
6. Southern Numbered 1	33,293	4,747	987	39,027
7. Southern Numbered 2	113,229	34,628	16,198	164,056
8. West Kentucky	19,367	33,131	305	52,803
9. Illinois	32,093	33,026	-------	65,119
10. Indiana	2,094	20,169	-------	22,263
11. Iowa	423	565	-------	987
12. Southeastern	10,019	12,094	149	22,262
13. Arkansas-Oklahoma	270	617	7	895
14. Southwestern	-------	7,874	-------	7,874
15. Northern Colorado	581	-------	-------	581
16. Southern Colorado	4,215	2,167	-------	6,382
17. New Mexico	-------	6,556	-------	6,556
18. Wyoming	118	7,105	-------	7,222
19. Utah	4,733	-------	-------	4,733
20. North-South Dakota	-------	5,639	-------	5,639
21. Montana	28	3,419	-------	3,447
22. Washington	32	554	-------	586
Total [1]	338,788	244,117	20,027	602,932

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

Table 10.–Underground mine data for bituminous coal and lignite mines in the United States, in 1970, by States

(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	35	9,078	71	8,333	88	95	674	------	31	67	2,981	42	5,400	49	42	2	4
Arkansas	2	51	------	51	6	9	------	------	2	6	51	------	------	------	------	1	------
Colorado	40	3,858	21	752	42	18	3,086	------	25	40	177	3	275	43	------	------	2
Illinois	28	32,093	------	13,563	54	251	18,510	20	28	10	3,524	56	13,296	138	------	3	------
Indiana	6	2,094	------	1,563	17	92	531	------	6	4	35	12	1,528	30	------	------	2
Iowa	3	423	------	423	5	85	------	------	2	2	170	1	251	------	------	------	------
Kentucky	1,104	62,610	3,083	47,978	815	59	11,196	353	885	912	21,415	297	31,423	383	79	3	2
Maryland	16	238	------	173	16	11	65	------	10	13	96	------	------	7	------	------	2
Montana	4	28	------	28	7	4	------	------	4	8	28	------	------	1	------	------	------
New Mexico	1	938	------	------	------	------	938	------	1	------	------	------	------	3	2	------	------
Ohio	44	18,111	------	7,535	87	87	10,575	------	32	15	119	52	8,522	130	------	14	1
Oklahoma	2	219	------	------	------	------	219	------	------	------	------	------	------	------	------	------	------
Pennsylvania	198	55,382	173	7,177	154	47	46,114	1,919	157	128	4,762	12	1,943	271	291	23	44
Tennessee	116	4,350	173	3,311	86	39	866	------	94	111	2,601	15	875	19	2	------	------
Utah	20	4,733	3	500	20	25	3,321	909	19	10	60	12	328	14	23	------	1
Virginia	566	28,018	1,290	15,094	441	34	10,079	1,555	550	637	9,690	65	6,945	161	120	6	20
Washington	2	32	32	------	------	------	------	------	2	16	32	------	------	------	------	------	------
West Virginia	748	116,414	723	49,591	774	64	63,723	2,376	664	709	20,824	311	30,138	707	166	9	10
Wyoming	4	118	------	118	11	11	------	------	3	7	114	1	3	4	------	------	------
Total	2,939	338,788	5,569	156,190	2,623	60	169,897	7,132	2,515	2,695	66,679	879	100,927	1,960	725	62	88

Table 11.—Haulage units in use in bituminous coal and lignite underground mines in the United States, in 1970, by States

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	108	--------	--------	49	63	2,263	--------	157	--------	--------	67	23.3
Arkansas	--------	--------	--------	--------	--------	11	--------	--------	--------	--------	2	.6
Colorado	65	16	--------	9	--------	1,717	--------	112	3	1	31	6.9
Illinois	60	10	--------	39	92	517	45	315	12	--------	246	127.8
Indiana	5	--------	--------	--------	--------	92	--------	25	--------	--------	9	9.2
Iowa	5	--------	--------	--------	--------	124	--------	5	--------	--------	--------	--------
Kentucky	375	40	13	331	252	5,503	1,281	680	121	300	338	120.4
Maryland	--------	2	--------	3	3	30	2	4	--------	20	7	1.2
Montana (bituminous)	4	3	--------	--------	--------	49	--------	5	--------	--------	--------	--------
New Mexico	--------	1	--------	4	--------	--------	--------	10	--------	--------	8	3.9
Ohio	175	10	--------	28	11	2,984	1	218	25	--------	107	43.0
Oklahoma	--------	--------	--------	--------	--------	--------	--------	12	--------	--------	8	2.5
Pennsylvania	975	50	5	126	286	14,018	187	1,013	27	13	562	199.6
Tennessee	75	7	--------	41	62	818	59	56	--------	14	24	13.7
Utah	73	5	1	15	11	1,896	9	109	2	--------	65	15.8
Virginia	150	15	5	528	170	2,395	1,868	295	40	17	308	128.9
Washington	5	--------	--------	--------	--------	32	--------	--------	--------	--------	--------	--------
West Virginia	1,230	25	6	354	280	30,199	1,201	2,130	70	195	1,226	481.8
Wyoming	--------	--------	--------	--------	--------	6	--------	7	--------	--------	4	1.1
Total	3,305	184	30	2,027	1,230	62,149	4,653	5,153	300	560	3,012	1,179.7

Table 12.—Method of haulage at bituminous coal and lignite underground mines in the United States, in 1970, by States

(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	4,602	----------	----------	4,358	118	9,078
Arkansas	45	----------	----------	6	----------	51
Colorado	1,791	----------	2	878	1,187	3,858
Illinois	4,446	----------	----------	27,257	390	32,093
Indiana	185	----------	----------	1,909	----------	2,094
Iowa	423	----------	----------	----------	----------	423
Kentucky	16,485	5,887	2,997	25,046	12,195	62,610
Maryland	8	2	46	135	47	238
Montana (bituminous)	28	----------	----------	----------	----------	28
New Mexico	----------	----------	----------	938	----------	938
Ohio	11,430	10	----------	4,348	2,323	18,111
Oklahoma	----------	----------	----------	219	----------	219
Pennsylvania	33,048	64	15	20,096	2,159	55,382
Tennessee	1,134	244	35	2,188	749	4,350
Utah	3,061	90	----------	845	737	4,733
Virginia	7,478	5,305	21	14,517	697	28,018
Washington	32	----------	----------	----------	----------	32
West Virginia	79,556	2,132	849	32,286	1,591	116,414
Wyoming	1	----------	----------	110	7	118
Total	163,753	13,734	3,965	135,136	22,200	338,788

Table 13.—Rail mine cars used and haulage at bituminous coal and lignite underground mines in the United States, in 1970, by States

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 [1]
Alabama	------	------	25	873	987	378	2,263	------	------	11	1,118	2,456	1,017	4,602
Arkansas	------	------	------	------	11	------	11	------	------	------	------	45	------	45
Colorado	123	1,008	186	300	------	100	1,717	48	389	14	485	------	855	1,791
Illinois	------	42	36	177	187	75	517	------	109	131	757	2,417	1,032	4,446
Indiana	------	55	16	21	------	------	92	------	35	68	82	------	------	185
Iowa	50	------	74	------	------	------	124	2	------	421	------	------	------	423
Kentucky	35	387	1,318	1,770	500	1,493	5,503	13	793	1,938	2,332	2,519	8,890	16,485
Maryland	30	------	------	------	------	------	30	8	------	------	------	------	------	8
Montana (bituminous)	------	41	8	------	------	------	49	------	24	4	------	------	------	28
Ohio	28	84	86	438	920	1,428	2,984	21	26	577	1,419	2,676	6,710	11,430
Pennsylvania	269	1,345	1,808	1,024	7,392	2,180	14,018	44	530	2,038	861	19,173	10,402	33,048
Tennessee	8	46	17	242	------	------	313	6	170	96	861	------	------	1,134
Utah	------	21	------	1,584	291	------	1,896	------	13	------	2,301	748	------	3,061
Virginia	11	146	171	1,282	120	665	2,395	41	826	182	3,345	427	2,657	7,478
Washington	------	------	------	32	------	------	32	------	------	------	32	------	------	32
West Virginia	85	665	5,084	10,632	5,108	8,625	30,199	41	629	5,570	18,737	14,631	39,948	79,556
Wyoming	------	6	------	------	------	------	6	------	1	------	------	------	------	1
Total	639	3,846	8,829	18,375	15,516	14,944	62,149	224	3,545	11,050	32,330	45,092	71,511	[1] 163,753

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

Table 14.—Rubber-tired mine cars used and haulage at bituminous coal and lignite underground mines in the United States, in 1970, by States

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 [1]
Illinois	------	------	------	------	45	------	45	------	------	------	------	------	------	------
Kentucky	43	622	282	293	19	22	1,281	146	1,885	1,342	2,110	395	10	5,887
Maryland	2	------	------	------	------	------	2	2	------	------	------	------	------	2
Ohio	------	1	------	------	------	------	1	------	10	------	------	------	------	10
Pennsylvania	15	105	30	------	------	37	187	2	52	10	------	------	------	64
Tennessee	------	26	29	4	------	------	59	------	64	175	5	------	------	244
Utah	------	------	------	7	2	------	9	------	------	------	67	23	------	90
Virginia	60	952	677	164	------	15	1,868	199	3,351	1,234	521	------	------	5,305
West Virginia	78	288	222	217	8	388	1,201	142	621	899	250	200	20	2,132
Total	198	1,994	1,240	685	74	462	4,653	491	5,983	3,660	2,953	618	30	[1] 13,734

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

Table 15.—Number and production of underground bituminous coal and lignite mines using gathering and haulage conveyors, and number and length of units in use, in the United States, by States [1]

State	Number of mines		Production (thousand short tons)		Number of units in use		Average length (feet)		Total length (miles)	
	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
Alabama	7	6	3,389	4,369	84	67	2,076	1,836	33.0	23.3
Arkansas	1	1	25	6	2	2	1,500	1,500	.6	.6
Colorado	6	11	1,961	1,908	27	31	2,163	1,172	11.1	6.9
Illinois	20	23	29,663	30,755	204	246	2,478	2,743	95.7	127.8
Indiana	2	1	1,838	1,909	13	9	2,600	5,400	6.4	9.2
Kentucky	84	75	39,385	33,230	436	338	1,807	1,881	149.2	120.4
Maryland	4	4	196	135	7	7	1,057	928	1.4	1.2
New Mexico	1	1	832	938	6	8	2,550	2,550	2.9	3.9
Ohio	19	19	15,914	17,697	108	107	1,954	2,121	40.0	43.0
Oklahoma	2	2	115	219	2	8	500	1,625	.2	2.5
Pennsylvania	109	96	36,925	35,100	574	562	1,896	1,875	206.1	199.6
Tennessee	9	6	2,163	2,280	40	24	2,739	3,003	20.8	13.7
Utah	12	13	4,034	5,186	45	65	1,397	1,287	11.9	15.8
Virginia	40	44	18,598	18,256	232	308	2,179	2,209	95.7	128.9
West Virginia	317	284	95,424	89,639	1,313	1,226	1,810	2,075	450.1	481.8
Wyoming	1	1	122	110	4	4	1,500	1,500	1.1	1.1
Total	634	587	250,584	241,737	3,097	3,012	1,920	2,068	1,126.2	1,179.7

[1] Includes all mines using belt conveyors, 500 feet long or more for transporting coal underground. Excludes mainslope conveyors.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by States and counties

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Alabama:													
Bibb	1	8	------	34	123	------	60	306	------	5.47	27.48	------	26.36
Blount	------	4	------	------	65	------	------	279	------	------	14.89	------	14.89
Cullman	------	1	------	------	26	------	------	208	------	------	24.87	------	24.87
Etowah	------	1	------	------	23	------	------	271	------	------	9.53	------	9.53
Jackson	------	3	------	------	105	------	------	229	------	------	40.24	------	40.24
Jefferson	20	24	1	2,626	351	5	243	275	240	10.05	35.68	91.05	13.54
Marion	6	7	------	55	99	------	136	250	------	5.48	24.55	------	20.10
St. Clair	------	1	------	------	4	------	------	180	------	------	32.35	------	32.35
Shelby	3	3	------	273	24	------	240	90	------	7.58	32.36	------	8.38
Tuscaloosa	1	12	------	8	228	------	86	279	------	10.36	33.96	------	33.74
Walker	4	22	2	679	309	18	256	209	216	12.12	32.35	9.29	17.47
Winston	------	5	------	------	71	------	------	223	------	------	29.97	------	29.97
Total	35	91	3	3,675	1,428	23	242	252	220	10.22	31.51	28.31	16.41
Alaska	------	3	------	------	66	------	------	243	------	------	34.13	------	34.13
Arizona:													
Navajo	------	1	------	------	75	------	------	63	------	------	27.90	------	27.90
Arkansas:													
Franklin	------	1	------	------	20	------	------	258	------	------	19.95	------	19.95
Johnson	2	2	------	42	32	------	162	207	------	7.47	12.40	------	9.89
Logan	------	1	------	------	20	------	------	35	------	------	11.55	------	11.55
Sebastian	------	2	------	------	23	------	------	151	------	------	6.60	------	6.60
Total	2	6	------	42	95	------	162	168	------	7.47	13.56	------	11.73
Colorado:													
Delta	4	1	------	125	3	------	175	104	------	20.33	7.31	------	20.11
Fremont	9	3	------	50	16	------	187	199	------	19.12	32.56	------	32.60
Garfield	1	------	------	4	------	------	190	------	------	3.48	------	------	3.48
Gunnison	6	------	------	139	------	------	243	------	------	20.10	------	------	20.10
Huerfano	2	------	------	21	------	------	222	------	------	4.92	------	------	4.92
La Plata	4	------	------	18	------	------	207	------	------	6.22	------	------	6.22
Las Animas	1	------	------	400	------	------	271	------	------	5.54	------	------	5.54
Mesa	1	------	------	6	------	------	159	------	------	15.41	------	------	15.41
Moffat	3	------	------	64	------	------	284	------	------	25.77	------	------	25.77
Montrose	------	1	------	------	15	------	------	244	------	------	18.72	------	18.72
Pitkin	3	------	------	162	------	------	267	------	------	19.07	------	------	19.07
Rio Blanco	2	------	------	4	------	------	86	------	------	9.72	------	------	9.72
Routt	1	3	------	6	87	------	193	332	------	10.30	69.23	------	66.93
Weld	3	------	------	153	------	------	239	------	------	15.88	------	------	15.88
Total	40	8	------	1,152	121	------	246	297	------	13.63	60.28	------	18.88

See footnote at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Illinois:													
Christian	1	-------	-------	798	-------	-------	242	-------	-------	25.36	-------	-------	25.36
Douglas	1	-------	-------	153	-------	-------	288	-------	-------	25.85	-------	-------	25.85
Franklin	4	-------	-------	1,110	-------	-------	273	-------	-------	27.46	-------	-------	27.46
Fulton	-------	4	-------	-------	590	-------	-------	327	-------	-------	29.20	-------	29.20
Gallatin	2	1	-------	617	83	-------	247	364	-------	14.10	24.74	-------	15.86
Jackson	-------	2	-------	-------	18	-------	-------	267	-------	-------	27.95	-------	27.95
Jefferson	3	-------	-------	1,226	-------	-------	254	-------	-------	20.53	-------	-------	20.53
Kankakee	-------	1	-------	-------	153	-------	-------	351	-------	-------	18.14	-------	18.14
Knox	-------	1	-------	-------	127	-------	-------	261	-------	-------	46.17	-------	46.17
Macoupin	1	-------	-------	102	-------	-------	149	-------	-------	17.29	-------	-------	17.29
Mercer	1	1	-------	11	4	-------	228	14	-------	14.20	108.16	-------	16.21
Montgomery	2	-------	-------	566	-------	-------	246	-------	-------	19.04	-------	-------	19.04
Peoria	-------	3	-------	-------	292	-------	-------	335	-------	-------	29.40	-------	29.40
Perry	-------	3	-------	-------	501	-------	-------	335	-------	-------	48.21	-------	48.21
Pope	-------	2	-------	-------	11	-------	-------	43	-------	-------	25.14	-------	25.14
Randolph	1	2	-------	168	240	-------	251	335	-------	19.65	34.40	-------	29.33
St. Clair	3	3	-------	313	380	-------	233	293	-------	19.00	53.76	-------	40.02
Saline	3	4	-------	379	476	-------	231	250	-------	17.33	16.29	-------	16.73
Stark	-------	1	-------	-------	86	-------	-------	355	-------	-------	20.31	-------	20.31
Vermilion	2	1	-------	30	85	-------	183	140	-------	11.88	15.47	-------	14.34
Williamson	4	2	-------	584	174	-------	241	281	-------	17.33	31.09	-------	20.87
Total	28	31	-------	6,057	3,220	-------	249	305	-------	21.25	33.58	-------	26.11
Indiana:													
Clay	-------	6	-------	-------	133	-------	-------	277	-------	-------	33.48	-------	33.48
Fountain	-------	1	-------	-------	8	-------	-------	155	-------	-------	14.63	-------	14.63
Gibson	1	-------	-------	163	-------	-------	260	-------	-------	18.93	-------	-------	18.93
Greene	-------	4	-------	-------	240	-------	-------	301	-------	-------	37.97	-------	37.97
Parke	-------	1	-------	-------	4	-------	-------	233	-------	-------	8.38	-------	8.38
Pike	1	8	-------	17	500	-------	275	270	-------	14.55	31.05	-------	30.49
Spencer	-------	1	-------	-------	22	-------	-------	239	-------	-------	14.32	-------	14.32
Sullivan	2	3	-------	278	282	-------	242	283	-------	16.90	42.97	-------	31.06
Vermillion	-------	1	-------	-------	48	-------	-------	264	-------	-------	75.11	-------	75.11
Vigo	1	-------	-------	19	-------	-------	233	-------	-------	18.56	-------	-------	18.56
Warrick	1	7	-------	10	551	-------	66	279	-------	12.35	48.85	-------	48.69
Total	6	32	-------	487	1,788	-------	245	278	-------	17.56	40.51	-------	36.07
Iowa:													
Appanoose	1	-------	-------	13	-------	-------	120	-------	-------	1.28	-------	-------	1.28
Lucas	1	-------	-------	26	-------	-------	265	-------	-------	24.60	-------	-------	24.60
Mahaska	-------	5	-------	-------	50	-------	-------	283	-------	-------	22.35	-------	22.35
Marion	-------	3	-------	-------	35	-------	-------	291	-------	-------	20.79	-------	20.79

Monroe	1	1	-------	23	12	-------	302	125	-------	36.15	14.00	-------	32.21
Van Buren	-------	1	-------	-------	7	-------	-------	143	-------	-------	15.15	-------	15.15
Total	3	10	-------	62	104	-------	249	258	-------	27.44	21.06	-------	23.36
Kansas:													
Cherokee	-------	2	-------	-------	131	-------	-------	286	-------	-------	31.26	-------	31.26
Crawford	-------	3	-------	-------	104	-------	-------	281	-------	-------	15.33	-------	15.33
Total	-------	5	-------	-------	235	-------	-------	284	-------	-------	24.30	-------	24.30
Kentucky:													
Eastern:													
Bell	18	28	14	367	309	79	216	182	212	8.79	29.24	27.51	18.39
Boyd	1	3	1	5	12	3	150	198	35	2.50	15.23	18.67	11.99
Breathitt	6	11	5	21	180	128	73	299	254	14.67	46.75	25.16	38.18
Carter	2	2	-------	7	12	-------	48	142	-------	8.80	13.66	-------	12.88
Clay	23	9	5	162	30	16	155	138	193	11.44	29.10	35.91	16.04
Clinton	3	2	-------	19	32	-------	90	273	-------	7.70	17.72	-------	16.09
Floyd	156	12	8	1,811	113	70	173	158	136	13.53	43.59	35.32	15.70
Harlan	93	28	20	2,276	246	94	217	166	136	14.86	36.13	42.79	17.15
Jackson	-------	2	-------	-------	9	-------	-------	49	-------	-------	25.96	-------	25.96
Johnson	35	9	7	205	103	81	152	247	96	9.43	62.95	39.18	34.13
Knott	64	20	13	917	125	71	168	131	166	15.64	48.09	44.25	20.40
Knox	25	21	2	145	182	20	120	101	45	6.63	36.18	17.81	21.72
Laurel	1	12	1	6	74	5	78	70	190	7.93	30.77	13.57	26.42
Lawrence	-------	7	3	-------	45	10	-------	154	90	-------	36.60	36.58	36.60
Lee	2	-------	-------	26	-------	-------	210	-------	-------	4.95	-------	-------	4.95
Leslie	26	19	11	884	107	63	163	189	137	9.49	54.07	50.68	14.30
Letcher	114	48	27	1,895	362	149	218	131	119	10.43	58.56	58.26	16.97
McCreary	5	3	-------	194	29	-------	183	146	-------	10.13	28.22	-------	12.04
Magoffin	1	3	2	5	32	60	55	281	184	11.27	45.21	27.70	35.27
Martin	6	5	4	279	35	66	237	244	258	16.22	32.28	15.34	17.55
Morgan	2	3	-------	4	10	-------	120	137	-------	8.33	12.05	-------	11.11
Perry	44	50	28	1,074	370	354	194	177	142	13.37	48.18	44.49	25.22
Pike	419	32	45	5,425	208	281	186	138	127	17.45	58.22	56.43	19.83
Pulaski	2	-------	-------	63	-------	-------	242	-------	-------	5.51	-------	-------	5.51
Rockcastle	-------	2	1	-------	6	2	-------	60	60	-------	28.89	30.00	29.22
Wayne	1	2	-------	6	5	-------	44	150	-------	18.94	66.67	-------	53.97
Whitley	23	15	5	327	105	30	115	121	117	5.11	32.68	27.46	13.07
Wolfe	-------	1	-------	-------	6	-------	-------	43	-------	-------	39.58	-------	39.58
Total	1,072	349	202	16,123	2,747	1,582	189	163	152	14.15	43.93	39.60	19.36
Western:													
Butler	2	4	-------	24	31	-------	198	147	-------	10.19	39.51	-------	24.67
Christian	-------	4	-------	-------	39	-------	-------	188	-------	-------	23.08	-------	23.08
Daviess	-------	1	-------	-------	91	-------	-------	236	-------	-------	37.42	-------	37.42
Henderson	3	-------	-------	68	-------	-------	176	-------	-------	7.76	-------	-------	7.76
Hopkins	14	19	2	1,504	464	46	239	244	72	19.69	46.87	43.53	26.32
McLean	-------	3	-------	-------	28	-------	-------	100	-------	-------	33.55	-------	33.55
Muhlenberg	7	18	2	697	1,401	14	248	308	130	25.27	49.81	26.92	42.74
Ohio	1	12	1	231	395	10	292	257	260	30.72	50.11	43.77	42.38

See footnote at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Total
Kentucky—Continued													
Western—Continued													
Union	4	-------	-------	61	-------	-------	246	-------	-------	19.55	-------	-------	19.55
Webster	1	-------	-------	135	-------	-------	321	-------	-------	25.04	-------	-------	25.04
Total	32	61	5	2,720	2,449	70	329	279	110	21.61	48.55	39.68	33.28
Grand total	1,104	410	207	18,843	5,196	1,652	210	218	151	15.84	46.72	39.60	23.50
Maryland:													
Allegany	6	10	4	34	75	14	176	207	100	9.27	21.74	12.92	17.93
Garrett	10	18	2	83	138	13	164	244	115	13.39	27.64	61.79	24.69
Total	16	28	6	117	213	27	167	229	110	12.03	25.56	43.87	22.53
Missouri:													
Barton	-------	1	-------	-------	35	-------	-------	297	-------	-------	42.20	-------	42.20
Boone	-------	1	-------	-------	88	-------	-------	320	-------	-------	18.33	-------	18.33
Callaway	-------	1	-------	-------	8	-------	-------	254	-------	-------	12.80	-------	12.80
Henry	-------	2	-------	-------	159	-------	-------	331	-------	-------	35.95	-------	35.95
Macon	-------	1	-------	-------	151	-------	-------	313	-------	-------	22.14	-------	22.14
Putnam	-------	1	-------	-------	8	-------	-------	275	-------	-------	14.23	-------	14.23
Randolph	-------	1	-------	-------	25	-------	-------	351	-------	-------	55.45	-------	55.45
Vernon	-------	1	-------	-------	6	-------	-------	202	-------	-------	7.71	-------	7.71
Total	-------	9	-------	-------	480	-------	-------	318	-------	-------	29.11	-------	29.11
Montana (bituminous):													
Musselshell	4	-------	-------	28	-------	-------	127	-------	-------	8.28	-------	-------	8.28
Rosebud	-------	2	-------	-------	64	-------	-------	322	-------	-------	150.98	-------	150.98
Total	4	2	-------	28	64	-------	127	322	-------	8.28	150.98	-------	130.17
Montana (lignite):													
Powder River	-------	1	-------	-------	2	-------	-------	77	-------	-------	6.06	-------	6.60
Richland	-------	1	-------	-------	15	-------	-------	236	-------	-------	90.96	-------	90.96
Total	-------	2	-------	-------	17	-------	-------	218	-------	-------	87.16	-------	87.16
Total Montana	4	4	-------	28	81	-------	127	300	-------	8.28	141.21	-------	124.41
New Mexico:													
Colfax	1	-------	-------	165	-------	-------	245	-------	-------	23.19	-------	-------	23.19
McKinley	-------	2	-------	-------	30	-------	-------	264	-------	-------	50.91	-------	50.91
San Juan	-------	1	-------	-------	231	-------	-------	255	-------	-------	102.32	-------	102.32

Total	1	3	------	165	261	------	245	256	------	23.19	96.23	------	68.67
North Dakota (lignite):													
Adams	------	1	------	------	3	------	------	113	------	------	13.42	------	13.42
Bowman	------	1	------	------	13	------	------	246	------	------	56.68	------	56.68
Burke	------	2	------	------	42	------	------	268	------	------	53.24	------	53.24
Grant	------	2	------	------	3	------	------	127	------	------	20.62	------	20.62
McLean	------	1	------	------	10	------	------	218	------	------	9.04	------	9.04
Mercer	------	3	------	------	120	------	------	253	------	------	111.72	------	111.72
Morton	------	1	------	------	5	------	------	76	------	------	15.83	------	15.83
Oliver	------	3	------	------	55	------	------	190	------	------	75.50	------	75.50
Stark	------	3	------	------	13	------	------	211	------	------	46.43	------	46.43
Ward	------	2	------	------	40	------	------	309	------	------	41.49	------	41.49
Williams	------	1	------	------	2	------	------	60	------	------	41.67	------	41.67
Total	------	20	------	------	306	------	------	241	------	------	76.49	------	76.49
Ohio:													
Athens	2	3	------	10	4	------	136	205	------	9.25	51.22	------	22.73
Belmont	8	20	8	1,667	750	44	220	240	214	16.50	46.50	16.07	26.20
Carroll	------	3	1	------	77	3	------	288	35	------	22.26	72.07	22.50
Columbiana	3	27	8	22	290	35	180	170	284	15.53	19.50	21.83	19.62
Coshocton	1	8	2	68	218	12	295	298	260	26.14	34.20	53.95	33.03
Gallia	2	5	------	8	33	------	186	178	------	12.10	33.81	------	29.44
Guernsey	------	2	------	------	14	------	------	237	------	------	14.04	------	14.04
Harrison	5	15	3	2,133	432	11	230	250	256	12.89	55.98	65.76	20.84
Hocking	------	7	------	------	31	------	------	230	------	------	23.11	------	23.11
Holmes	------	3	------	------	61	------	------	247	------	------	24.70	------	24.70
Jackson	7	10	2	58	124	4	109	203	117	15.91	33.29	65.54	30.28
Jefferson	2	27	6	230	579	22	261	253	189	13.61	28.33	36.88	24.30
Lawrence	1	4	------	2	56	------	61	285	------	8.26	20.21	------	20.12
Mahoning	------	8	1	------	79	2	------	252	190	------	21.91	36.84	22.19
Meigs	1	1	1	5	5	2	216	64	8	5.93	18.66	62.50	9.46
Monroe	1	------	------	296	------	------	230	------	------	18.25	------	------	18.25
Morgan	------	2	------	------	393	------	------	239	------	------	47.18	------	47.18
Muskingum	3	7	2	28	98	21	216	166	164	8.26	36.67	27.36	28.77
Noble	------	4	2	------	134	18	------	288	296	------	61.53	28.71	57.56
Perry	5	15	3	395	110	31	297	210	101	21.79	47.77	23.54	25.99
Stark	------	9	------	------	67	------	------	268	------	------	18.82	------	18.82
Tuscarawas	3	27	6	122	310	28	249	272	148	10.60	19.89	41.42	18.24
Vinton	------	8	------	------	83	------	------	236	------	------	30.76	------	30.76
Washington	------	1	------	------	27	------	------	60	------	------	16.21	------	16.21
Wayne	------	1	------	------	4	------	------	263	------	------	34.81	------	34.81
Total	44	217	45	5,044	3,974	233	233	242	200	15.41	37.32	30.51	25.47
Oklahoma:													
Craig	------	1	------	------	5	------	------	307	------	------	36.95	------	36.95
Haskill	1	2	1	45	77	3	180	288	24	2.09	18.08	92.54	13.98
LeFlore	1	------	------	241	------	------	234	------	------	3.58	------	------	3.58
Muskogee	------	2	------	------	3	------	------	130	------	------	8.63	------	8.63
Rogers	------	3	------	------	229	------	------	282	------	------	26.91	------	26.91
Total	2	8	1	286	314	3	226	282	24	3.39	24.82	92.54	15.83

See footnote at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Pennsylvania:													
Allegheny	10	13	-------	1,249	88	-------	253	262	-------	12.39	32.03	-------	13.71
Armstrong	21	42	10	1,390	356	37	219	177	92	19.04	28.86	52.95	21.02
Beaver	1	5	1	51	16	3	219	208	68	12.75	20.04	42.41	14.86
Bedford	2	4	-------	7	6	-------	222	153	-------	4.48	10.50	-------	7.28
Butler	6	28	2	261	204	12	216	209	63	18.56	21.17	48.95	19.90
Cambria	29	22	-------	2,911	177	-------	240	221	-------	8.25	20.34	-------	8.89
Centre	3	19	-------	158	128	-------	243	269	-------	13.95	23.41	-------	18.40
Clarion	1	61	1	2	491	1	279	294	110	12.54	30.32	25.00	30.24
Clearfield	13	81	7	412	950	16	230	267	178	13.01	17.88	37.56	16.73
Clinton	-------	6	-------	-------	71	-------	-------	272	-------	-------	23.20	-------	23.20
Elk	3	10	5	11	48	10	133	283	149	10.43	25.66	28.10	24.55
Fayette	3	31	1	700	162	2	253	207	108	4.79	29.00	31.47	8.66
Greene	18	8	-------	3,487	58	-------	259	141	-------	12.54	32.02	-------	12.71
Indiana	35	31	8	2,265	207	34	237	225	147	13.31	23.92	25.49	14.26
Jefferson	7	51	12	80	231	18	242	236	188	12.08	24.53	27.84	21.54
Lawrence	-------	20	3	-------	148	15	-------	294	52	-------	19.60	38.41	19.93
Lycoming	-------	3	-------	-------	10	-------	-------	299	-------	-------	22.53	-------	22.53
Mercer	-------	3	-------	-------	18	-------	-------	297	-------	-------	42.61	-------	42.61
Somerset	27	59	3	529	505	13	225	245	56	10.62	19.86	29.28	15.37
Tioga	-------	8	-------	-------	114	-------	-------	290	-------	-------	26.87	-------	26.87
Venango	-------	10	-------	-------	69	-------	-------	277	-------	-------	25.02	-------	25.02
Washington	12	18	1	3,897	105	4	275	232	137	12.79	31.05	8.01	13.19
Westmoreland	7	22	-------	647	117	-------	246	167	-------	15.06	10.87	-------	14.06
Total	198	555	54	18,057	4,279	165	250	246	118	12.28	23.26	34.08	14.42
Tennessee:													
Anderson	29	15	2	342	77	10	160	175	92	20.51	49.33	30.91	26.44
Bledsoe	-------	2	-------	-------	13	-------	-------	239	-------	-------	34.42	-------	34.42
Campbell	20	20	2	120	188	9	189	216	160	14.56	28.78	62.57	24.60
Clairborne	5	10	-------	354	97	-------	224	153	-------	18.70	30.33	-------	20.53
Cumberland	2	1	-------	6	1	-------	46	25	-------	13.43	40.00	-------	15.48
Fentress	5	-------	-------	32	-------	-------	191	-------	-------	7.01	-------	-------	7.01
Grundy	-------	1	-------	-------	29	-------	-------	243	-------	-------	18.77	-------	18.77
Hamilton	-------	2	1	-------	6	5	-------	76	65	-------	25.03	18.40	22.22
Marion	27	-------	-------	236	-------	-------	185	-------	-------	17.06	-------	-------	17.06
Morgan	7	11	-------	42	36	-------	216	220	-------	13.43	39.56	-------	25.65
Putnam	1	-------	-------	28	-------	-------	200	-------	-------	14.33	-------	-------	14.33
Roane	-------	1	-------	-------	7	-------	-------	141	-------	-------	30.50	-------	30.50
Scott	12	10	2	80	85	6	193	149	48	14.84	27.37	93.60	21.31
Sequatchie	8	2	-------	104	12	-------	208	254	-------	9.05	32.52	-------	12.00
Van Buren	-------	5	-------	-------	74	-------	-------	252	-------	-------	21.57	-------	21.57
Total	116	80	7	1,344	625	30	192	197	101	16.84	30.34	51.85	21.44

Utah:													
Carbon	10	-------	-------	986	-------	-------	217	-------	-------	15.65	-------	-------	15.65
Emery	8	-------	-------	467	-------	-------	244	-------	-------	11.34	-------	-------	11.34
Sevier	1	-------	-------	10	-------	-------	250	-------	-------	32.41	-------	-------	32.41
Summit	1	-------	-------	6	-------	-------	197	-------	-------	10.58	-------	-------	10.58
Total	20	-------	-------	1,469	-------	-------	226	-------	-------	14.27	-------	-------	14.27
Virginia:													
Buchanan	388	48	49	4,901	191	130	210	209	188	12.31	29.27	39.93	13.55
Dickenson	58	16	13	1,736	119	30	234	209	160	14.52	39.56	55.51	16.39
Lee	31	12	9	210	79	14	207	211	99	12.57	19.22	72.63	17.68
Montgomery	1	-------	-------	5	-------	-------	95	-------	-------	3.89	-------	-------	3.89
Russell	7	9	1	719	63	2	238	135	35	12.07	31.17	28.57	12.97
Scott	1	1	-------	8	1	-------	191	56	-------	6.09	35.71	-------	7.17
Tazewell	13	8	3	293	48	11	239	154	15	11.11	44.53	52.94	14.37
Wise	67	60	8	1,695	334	41	240	186	172	14.86	32.67	54.80	17.78
Total	566	154	83	9,567	835	228	223	191	176	13.16	31.95	47.35	15.04
Washington:													
King	2	-------	-------	28	-------	-------	231	-------	-------	4.92	-------	-------	4.92
Lewis	-------	1	-------	-------	2	-------	-------	218	-------	-------	11.48	-------	11.48
Total	2	1	-------	28	2	-------	231	218	-------	4.92	11.48	-------	5.33
West Virginia:													
Barbour	23	29	1	531	388	3	226	144	120	13.60	34.72	95.02	20.48
Boone	44	31	29	2,506	667	492	217	233	184	15.33	16.69	14.14	15.46
Brooke	3	9	-------	228	39	-------	238	178	-------	12.54	46.06	-------	16.31
Clay	3	-------	-------	205	-------	-------	239	-------	-------	4.88	-------	-------	4.88
Fayette	39	16	4	1,559	115	18	228	250	145	9.76	35.26	81.59	12.15
Gilmer	2	3	-------	23	30	-------	151	80	-------	10.95	22.97	-------	15.86
Grant	3	8	-------	452	121	-------	253	280	-------	16.30	16.44	-------	16.34
Greenbrier	16	3	-------	199	42	-------	216	70	-------	8.93	31.73	-------	10.38
Hancock	-------	1	-------	-------	13	-------	-------	30	-------	-------	81.84	-------	81.84
Harrison	13	44	2	1,308	271	9	246	172	35	16.91	36.95	84.97	19.50
Kanawha	48	13	21	2,800	202	181	219	179	163	14.46	50.61	34.76	17.27
Lewis	1	8	3	9	41	9	64	143	122	5.23	44.67	66.42	44.75
Logan	44	13	28	3,428	138	213	225	244	182	13.53	20.95	38.47	14.97
Marion	8	5	1	2,648	44	5	241	138	102	13.95	58.87	68.63	14.42
Marshall	5	-------	-------	1,642	-------	-------	226	-------	-------	13.91	-------	-------	13.91
Mason	3	-------	-------	434	-------	-------	208	-------	-------	7.15	-------	-------	7.15
McDowell	149	39	8	6,721	331	49	223	141	83	10.45	29.88	21.98	11.07
Mercer	9	8	-------	474	45	-------	231	111	-------	9.69	19.78	-------	10.13
Mineral	3	9	1	40	38	3	77	171	69	16.36	47.28	38.65	37.22
Mingo	33	13	12	720	163	60	199	150	166	10.79	18.66	22.07	12.51
Monongalia	21	17	-------	2,784	86	-------	249	156	-------	17.79	37.01	-------	18.15
Nicholas	60	26	4	2,769	148	95	229	156	52	10.90	41.07	28.12	10.99
Ohio	2	-------	-------	794	-------	-------	226	-------	-------	14.63	-------	-------	14.63
Pocahontas	3	-------	-------	26	-------	-------	146	-------	-------	10.67	-------	-------	10.67
Preston	30	39	-------	377	316	-------	160	244	-------	14.37	27.90	-------	21.08
Raleigh	52	31	17	3,314	356	247	235	205	81	9.84	29.91	28.99	11.96

See footnote at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1970, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
West Virginia—Continued													
Randolph	13	5	-------	239	49	-------	194	186	-------	10.54	17.70	-------	11.70
Summers	-------	2	-------	-------	10	-------	-------	97	-------	-------	22.08	-------	22.08
Taylor	3	6	-------	25	49	-------	48	158	-------	5.03	28.18	-------	25.07
Tucker	-------	4	-------	-------	64	-------	-------	192	-------	-------	24.39	-------	24.39
Upshur	6	14	-------	99	193	-------	211	133	-------	14.26	22.21	-------	18.64
Wayne	4	1	-------	135	8	-------	126	45	-------	5.76	21.30	-------	6.04
Webster	11	3	2	148	30	5	143	254	98	6.11	15.36	15.12	8.60
Wyoming	94	18	20	4,686	248	187	225	148	81	10.86	26.59	35.73	11.72
Total	748	418	153	41,323	4,245	1,576	225	185	139	12.50	27.89	26.40	13.96
Wyoming:													
Campbell	-------	1	-------	-------	29	-------	-------	260	-------	-------	85.07	-------	85.07
Carbon	-------	1	-------	-------	90	-------	-------	238	-------	-------	68.35	-------	68.35
Converse	-------	2	-------	-------	38	-------	-------	254	-------	-------	191.35	-------	191.35
Hot Springs	3	-------	-------	12	-------	-------	141	-------	-------	4.92	-------	-------	4.92
Lincoln	-------	2	-------	-------	147	-------	-------	249	-------	-------	43.18	-------	43.18
Sheridan	-------	2	-------	-------	114	-------	-------	259	-------	-------	49.67	-------	49.67
Sweetwater	1	1	-------	50	34	-------	197	111	-------	11.15	27.97	-------	16.11
Total	4	9	-------	62	452	-------	185	240	-------	10.27	65.44	-------	60.15
Total United States	2,939	2,103	559	107,808	28,395	3,937	229	236	148	13.76	35.96	34.26	18.84

[1] In certain counties the average tons per man per day is larger because of auger mining, strip mining, or mechanical loading underground.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1970, by States and counties

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Alabama:												
Bibb	1	11	8	1,035			227	819			1,046	$6.05
Blount			4	270			160	110			270	7.62
Cullman			W	W				W			W	W
Etowaha			W	W			W				W	W
Jackson			3	967			949	17			967	4.05
Jefferson	20	6,413	24	3,443	1	107	7,849	2,059	55		9,963	7.46
Marion	6	41	7	610			337	313			650	6.18
St. Clair			W	W				W			W	W
Shelby	3	497	3	70			488	80			568	11.40
Tuscaloosa	1	7	12	2,161			1,973	196			2,169	5.58
Walker	4	2,108	22	2,092	2	36	2,606	894	737		4,237	8.99
Winston			5	474			92	382			474	5.41
Other counties			3	219			59	160			219	
Total [4]	35	9,078	91	11,339	3	143	14,740	5,029	792		20,560	8.09
Alaska			3	549			457	3	89		549	7.39
Arizona:												
Navajo			1	132						132	132	W
Total [4]			1	132						132	132	W
Arkansas:												
Franklin			1	104			104				104	8.06
Johnson	2	51	2	82			133				133	8.51
Logan			1	8				8			8	8.13
Sebastian			2	23			21	3			23	8.13
Total [4]	2	51	6	217			258	11			268	8.30
Colorado:												
Delta	W	W	W	W			W	W		W	W	W
Fremont	9	178	3	106			2	283			285	4.11
Garfield	1	2						2			2	11.00
Gunnison	6	680					652	27		1	680	9.18
Huerfano	2	23						23			23	8.16
La Plata	4	23						20		3	23	4.37
Las Animas	1	602					602				602	9.77
Mesa	1	14							14		14	4.81

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1970, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Colorado—Continued												
Moffat	3	468	------	------	------	------	447	22	------	------	469	$4.78
Montrose	W	W	W	W	------	------	W	W	------	W	W	W
Pitkin	3	827	------	------	------	------	827	------	------	------	827	4.98
Rio Blanco	2	3	------	------	------	------	------	3	------	------	3	6.26
Routt	1	12	3	1,990	------	------	1,395	607	------	------	2,002	6.52
Weld	3	581	------	------	------	------	406	172	------	2	580	4.82
Other counties	4	443	2	70	------	------	432	77	------	4	513	9.87
Total [4]	40	3,858	8	2,167	------	------	4,763	1,236	14	10	6,025	5.85
Illinois:												
Christian	1	4,900	------	------	------	------	1,880	384	2,635	------	4,900	W
Douglass	1	1,140	------	------	------	------	449	687	------	3	1,140	W
Franklin	4	8,324	------	------	------	------	8,292	31	------	1	8,324	4.98
Fulton	------	------	4	5,635	------	------	5,257	371	------	6	5,635	4.88
Gallatin	2	2,149	1	749	------	------	2,898	------	------	------	2,898	5.15
Jackson	------	------	2	134	------	------	134	------	------	------	134	W
Jefferson	3	6,395	------	------	------	------	6,172	191	------	32	6,395	6.06
Kankakee	------	------	1	976	------	------	613	363	------	------	976	W
Knox	------	------	1	1,528	------	------	1,474	55	------	------	1,528	W
Macoupin	1	262	------	------	------	------	254	------	------	8	262	W
Mercer	1	36	1	6	------	------	------	42	------	------	42	W
Montgomery	2	2,651	------	------	------	------	1,441	365	844	1	2,651	W
Peoria	------	------	3	2,875	------	------	2,262	613	------	------	2,875	4.80
Perry	------	------	3	8,086	------	------	8,009	76	------	1	8,086	3.77
Pope	------	------	2	12	------	------	6	6	------	------	12	5.26
Randolph	1	827	2	2,767	------	------	3,462	131	------	1	3,594	4.46
St. Clair	3	1,384	3	5,992	------	------	4,447	2,928	------	------	7,375	5.36
Saline	3	1,519	4	1,938	------	------	3,404	30	13	10	3,457	5.73
Stark	------	------	1	622	------	------	622	------	------	------	622	W
Vermilion	2	65	1	185	------	------	24	226	------	3	250	5.72
Williamson	4	2,441	2	1,520	------	------	3,613	344	------	4	3,961	5.70
Total [4]	28	32,093	31	33,026	------	------	54,715	6,844	3,493	67	65,119	4.92
Indiana:												
Clay	------	------	6	1,237	------	------	482	738	------	17	1,237	5.18
Fountain	------	------	W	W	------	------	------	W	------	------	W	W
Gibson	W	W	------	------	------	------	W	W	------	------	W	W
Greene	------	------	4	2,748	------	------	2,491	256	------	------	2,748	W
Parke	------	------	1	8	------	------	------	8	------	------	8	3.50
Pike	1	68	8	4,190	------	------	3,516	642	73	28	4,258	4.45
Spencer	------	------	W	W	------	------	W	W	------	------	W	W

Sullivan	2	1,135	3	3,434			3,911	653		6	4,569	4.93
Vigo	W	W						W			W	W
Vermillion			1	953			797	156			953	W
Warrick	1	8	7	7,506			5,325	662	1,526		7,514	4.20
Other counties	2	883	2	92			788	187			975	6.68
Total [4]	6	2,094	32	20,169			17,309	3,304	1,599	51	22,263	4.60
Iowa:												
Appanoose	1	2						2			2	8.00
Lucas	1	170					146	24			170	4.03
Mahaska			5	315			257	59			315	4.06
Marion			3	213			213				213	4.29
Monroe	1	251	1	21			21	251			272	4.02
Van Buren			1	15				15			15	4.61
Total [4]	3	423	10	565			637	350			987	4.11
Kansas:												
Cherokee			2	1,179			1,165	14			1,179	5.52
Crawford			3	448			416	31		1	448	5.80
Total [4]			5	1,627			1,581	45		1	1,627	5.59
Kentucky:												
Eastern:												
Bell	18	697	28	1,646	14	461	2,569	234			2,803	5.83
Boyd	1	2	3	37	1	2		40			40	6.00
Breathitt	6	23	11	2,517	5	817	3,170	186			3,356	5.01
Carter	2	3	2	24				27			27	6.25
Clay	23	288	9	119	5	113	289	232			520	6.63
Clinton	3	13	2	155			1	166			168	6.37
Floyd	156	4,239	12	775	8	335	4,390	958			5,349	6.09
Harlan	93	7,338	28	1,537	20	547	8,332	1,046		44	9,422	7.59
Jackson			2	11				11			11	5.00
Johnson	35	294	9	1,600	7	303	1,830	366			2,196	5.18
Knott	64	2,409	20	785	13	524	3,162	557			3,718	6.10
Knox	25	115	21	664	2	16	574	214		7	795	6.13
Laurel	1	4	12	160	1	13		176			176	5.00
Lawrence			7	253	3	33		286			286	6.00
Lee	2	27					9	15		2	27	7.38
Leslie	26	1,368	19	515	11	440	2,301	22			2,322	7.60
Letcher	114	4,309	48	2,780	27	1,030	7,665	454			8,119	6.23
McCreary	5	360	3	119			410	69			479	7.15
Magoffin	1	3	3	407	2	304	714	3			714	5.00
Martin	6	1,072	5	277	4	263	1,329	285			1,612	5.05
Morgan	2	4	3	17				21			21	6.82
Perry	44	2,786	50	3,152	28	2,237	7,768	407			8,175	6.61
Pike	419	17,609	32	1,675	45	2,015	20,769	528		2	21,299	7.64
Pulaski	2	84					84				84	6.00
Rockcastle			2	10	1	4		14			14	5.00
Wayne	1	5	2	48				53			53	5.00

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1970, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Kentucky—Continued												
Eastern—Continued												
Whitley	23	192	15	415	5	98	514	191	---	---	704	$4.42
Wolfe	---	---	1	10	---	---	---	10	---	---	10	5.00
Total [4]	1,072	43,243	349	19,705	202	9,554	65,874	6,572	---	55	72,502	6.73
Western:												
Butler	W	W	4	179	---	---	---	228	---	---	228	4.14
Christian	---	---	4	170	---	---	115	55	---	---	170	3.22
Daviess	---	---	1	804	---	---	---	804	---	---	804	3.91
Henderson	3	93	---	---	---	---	---	93	---	---	93	4.60
Hopkins	14	7,077	19	5,312	W	W	11,844	689	---	---	12,533	4.92
McLean	---	---	3	94	---	---	42	52	---	---	94	3.91
Muhlenberg	7	4,365	18	21,491	2	48	16,872	3,566	5,437	28	25,903	3.84
Ohio	W	W	12	5,081	W	W	7,137	116	---	16	7,269	3.71
Union	4	4,620	---	---	---	---	4,620	---	---	---	4,620	5.00
Webster	1	1,089	---	---	---	---	1,089	---	---	---	1,089	5.50
Other counties	3	2,121	---	---	3	258	---	---	---	---	---	---
Total [4]	32	19,367	61	33,131	5	305	41,720	5,603	5,437	43	52,803	4.22
Grand total [4]	1,104	62,610	410	52,836	207	9,859	107,594	12,175	5,437	99	125,305	5.68
Maryland:												
Allegany	6	56	10	338	4	18	94	317	---	---	412	5.20
Garrett	10	182	18	929	2	93	642	561	---	---	1,203	4.94
Total [4]	16	238	28	1,266	6	111	736	878	---	---	1,615	5.01
Missouri:												
Barton	---	---	1	439	---	---	---	---	439	---	439	4.36
Boone	---	---	1	516	---	---	309	207	---	---	516	5.35
Callaway	---	---	1	26	---	---	---	26	---	---	26	4.36
Henry	---	---	2	1,890	---	---	458	4	---	1,427	1,890	4.01
Macon	---	---	1	1,048	---	---	1,045	3	---	---	1,048	4.89
Putnam	---	---	1	31	---	---	---	31	---	---	31	4.91
Randolph	---	---	1	487	---	---	---	487	---	---	487	3.72
Vernon	---	---	1	10	---	---	8	1	---	1	10	6.00
Total [4]	---	---	9	4,447	---	---	1,820	760	439	1,428	4,447	4.39
Montana (bituminous):												
Musselshell	4	28	---	---	---	---	---	28	---	---	28	9.39

Rosebud	-	-	2	3,096	-	-	3,094	2	-	-	3,096	1.76
Total [4]	4	28	2	3,096	-	-	3,094	30	-	-	3,124	1.83
Montana (lignite):												
Powder River	-	-	1	1	-	-	-	1	-	-	1	5.50
Richland	-	-	1	322	-	-	322	-	-	-	322	W
Total [4]	-	-	2	323	-	-	322	1	-	-	323	2.13
Total Montana [4]	4	28	4	3,419	-	-	3,416	31	-	-	3,447	1.85
New Mexico:												
Colfax	W	W	-	-	-	-	W	-	-	-	W	W
McKinley	-	-	W	W	-	-	W	W	-	-	W	W
San Juan	W	W	W	W	-	-	-	W	-	-	W	W
Other counties	1	938	3	6,423	-	-	1,333	7	6,021	-	7,361	2.89
Total [4]	1	938	3	6,423	-	-	1,333	7	6,021	-	7,361	2.89
North Dakota (lignite):												
Adams	-	-	1	5	-	-	-	5	-	-	5	4.00
Bowman	-	-	W	W	-	-	W	W	W	-	W	W
Burke	-	-	W	W	-	-	W	W	W	-	W	W
Grant	-	-	2	8	-	-	-	8	-	-	8	3.61
McLean	-	-	1	19	-	-	-	19	-	-	19	3.97
Mercer	-	-	3	3,378	-	-	2,314	19	238	808	3,378	1.85
Morton	-	-	1	6	-	-	-	6	-	-	6	3.03
Oliver	-	-	3	796	-	-	-	258	-	538	796	1.70
Stark	-	-	3	125	-	-	-	125	-	-	125	4.00
Ward	-	-	W	W	-	-	W	W	W	-	W	W
Williams	-	-	1	5	-	-	-	5	-	-	5	3.00
Other counties	-	-	5	1,297	-	-	951	124	222	-	1,297	2.11
Total [4]	-	-	20	5,639	-	-	3,265	568	460	1,346	5,639	1.95
Ohio:												
Athens	2	13	3	44	-	-	-	56	-	-	56	$3.93
Belmont	8	6,047	20	8,371	8	153	13,729	842	-	1	14,572	4.78
Carroll	-	-	W	W	W	W	W	W	-	-	503	5.75
Columbiana	3	61	27	960	8	218	174	1,065	-	-	1,239	4.41
Coshocton	1	526	8	2,172	2	167	573	894	1,397	-	2,865	4.96
Gallia	2	18	5	200	-	-	135	83	-	-	218	4.29
Guernsey	-	-	2	48	-	-	48	-	-	-	48	4.60
Harrison	5	6,351	15	6,041	3	183	11,710	841	20	5	12,575	4.96
Hocking	-	-	7	165	-	-	-	165	-	-	165	4.35
Holmes	-	-	3	372	-	-	118	253	-	-	372	4.03
Jackson	7	101	10	837	2	31	458	510	-	-	968	4.14
Jefferson	2	818	27	4,148	6	156	2,194	2,458	468	2	5,122	4.63
Lawrence	W	W	W	W	-	-	125	200	-	-	325	4.48
Mahoning	-	-	8	434	1	14	65	383	-	-	448	4.72
Meigs	1	6	1	6	W	W	6	7	-	-	13	5.50
Monroe	W	W	W	-	-	-	W	-	-	-	W	W

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1970, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Ohio—Continued												
Morgan			2	4,437			352	32	4,053		4,437	$4.74
Muskingham	3	50	7	599	2	94		743			743	2.96
Noble			4	2,380	2	153	592	1,941			2,533	4.50
Perry	5	2,556	15	1,102	3	74	2,192	1,539			3,731	4.64
Stark			9	339				339			339	4.07
Tuscarawas	3	323	27	1,675	6	170	128	2,039		1	2,167	4.52
Vinton			8	605			152	453			605	4.03
Washington			W	W				W			W	W
Wayne			1	40				40			40	4.30
Other counties	2	1,242	8	845	2	9	1,400	370			1,267	5.77
Total [4]	44	18,111	217	35,818	45	1,422	34,149	15,255	5,939	8	55,351	4.74
Oklahoma:												
Craig			W	W				W			W	W
Haskell	W	W	W	W	W	W	W				W	W
Le Flore	W	W					W				W	W
Muskogee			W	W				W			W	W
Rogers			W	W			W	W			W	W
Other counties	2	219	8	1,738	1	7	2,356	71			2,427	6.27
Total [4]	2	219	8	2,201	1	7	2,356	71			2,427	6.27
Pennsylvania:												
Allegheny	10	3,912	13	731			3,517	1,125		1	4,642	7.53
Armstrong	21	5,796	42	1,818	10	182	2,381	2,125	2,998	291	7,795	6.20
Beaver	W	W	5	68	W	W		219			219	5.68
Bedford	W	W	W	W				19			19	5.70
Butler	6	1,047	28	901	2	36	1,328	627		28	1,984	5.16
Cambria	29	5,764	22	795			5,707	838		13	6,559	10.20
Centre	3	539	19	803			759	437		146	1,342	5.56
Clarion	W	W	61	4,373	W	W	2,972	1,411			4,383	5.01
Clearfield	13	1,234	81	4,537	7	107	2,491	3,300		88	5,879	5.23
Clinton			6	451			376	68		6	451	5.86
Elk	3	15	10	345	5	42	193	209			402	5.95
Fayette	3	848	31	971	1	6	1,015	801		10	1,825	7.53
Greene	18	11,324	8	263			11,312	274		1	11,586	8.82
Indiana	35	7,145	31	1,116	8	128	4,395	1,144	2,849		8,389	7.22
Jefferson	7	235	51	1,336	12	92	1,427	234		3	1,663	6.60
Lawrence			20	853	3	30		883			883	5.26
Lycoming			W	W			5	61			66	4.37
Mercer			3	226				226			226	5.00

Somerset	27	1,264	59	2,457	3	22	2,620	1,103	1	19	3,743	6.62
Tioga	--------	--------	8	885	--------	--------	11	873	--------	--------	885	5.12
Venango	--------	--------	10	477	--------	--------	169	308	--------	--------	477	4.42
Washington	12	13,707	18	753	1	4	13,699	763	--------	2	14,464	7.98
Westmoreland	7	2,397	22	213	--------	--------	2,135	471	--------	4	2,610	6.77
Other counties	4	156	7	77	2	12	--------	--------	--------	--------	--------	--------
Total [4]	198	55,382	555	24,447	54	661	56,513	17,518	5,848	611	80,491	7.27
Tennessee:												
Anderson	29	1,121	15	665	2	27	560	1,253	--------	--------	1,813	5.31
Bledsoe	--------	--------	W	W	--------	--------	W	W	--------	W	W	W
Campbell	20	329	20	1,167	2	95	647	944	--------	--------	1,591	4.95
Claiborne	5	1,483	10	450	--------	--------	1,595	339	--------	--------	1,933	4.88
Cumberland	2	4	1	1	--------	--------	--------	5	--------	--------	5	5.25
Fentress	5	43	--------	--------	--------	--------	--------	43	--------	--------	43	5.04
Grundy	--------	--------	1	134	--------	--------	134	--------	--------	--------	134	3.00
Hamilton	--------	--------	2	11	1	6	--------	17	--------	--------	17	4.42
Marion	27	745	--------	--------	--------	--------	420	325	--------	--------	745	3.99
Morgan	7	121	11	313	--------	--------	--------	434	--------	--------	434	5.33
Putnam	1	80	--------	--------	--------	--------	--------	24	56	--------	80	5.00
Roane	--------	--------	W	W	--------	--------	W	W	--------	--------	W	W
Scott	12	228	10	348	2	29	339	266	--------	--------	605	5.74
Sequatchie	8	196	2	103	--------	--------	263	35	--------	--------	298	3.78
Van Buren	--------	--------	5	400	--------	--------	254	146	--------	--------	400	4.64
Other counties	--------	--------	3	137	--------	--------	70	64	--------	--------	137	4.12
Total [4]	116	4,350	80	3,729	7	157	4,282	3,895	56	4	8,237	4.90
Utah:												
Carbon	10	3,349	--------	--------	--------	--------	2,794	135	394	14	3,349	7.59
Emery	8	1,292	--------	--------	--------	--------	1,120	173	--------	--------	1,292	5.37
Sevier	W	W	--------	--------	--------	--------	W	W	--------	--------	W	W
Summit	W	W	--------	--------	--------	--------	W	W	--------	--------	W	W
Other counties	2	92	--------	--------	--------	--------	20	72	--------	--------	92	5.75
Total [4]	20	4,733	--------	--------	--------	--------	3,945	380	394	14	4,733	7.28
Virginia:												
Buchanan	388	12,670	48	1,171	49	974	14,233	578	--------	3	14,815	7.02
Dickenson	58	5,900	16	983	13	264	6,856	291	--------	--------	7,147	7.69
Lee	31	546	12	322	9	258	976	149	--------	--------	1,127	6.12
Montgomery	W	W	W	W	--------	--------	--------	W	--------	--------	W	W
Russell	7	2,066	9	266	1	2	2,276	58	--------	--------	2,333	8.41
Scott	W	W	W	W	--------	--------	--------	W	--------	--------	W	W
Tazewell	13	778	8	328	3	9	1,048	46	--------	21	1,115	7.54
Wise	67	6,046	60	2,031	8	388	7,913	521	--------	32	8,466	6.16
Other counties	2	11	1	2	--------	--------	--------	13	--------	--------	13	6.59
Total [4]	566	28,018	154	5,103	83	1,895	33,304	1,656	--------	56	35,016	7.03

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1970, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Washington:												
King	W	W	W	W	--------	--------	--------	W	--------	--------	W	W
Lewis	W	W	W	W	--------	--------	--------	W	--------	--------	W	W
Other counties	2	32	1	5	--------	--------	--------	37	--------	--------	37	$12.81
Total [4]	2	32	1	5	--------	--------	--------	37	--------	--------	37	12.81
West Virginia:												
Barbour	23	1,633	29	1,942	1	38	3,603	9	--------	--------	3,612	7.71
Boone	44	8,337	31	2,595	29	1,280	12,078	119	--------	15	12,212	7.51
Brooke	3	679	9	316	--------	--------	214	138	643	--------	995	4.90
Clay	W	W	--------	W	--------	--------	W	W	--------	W	W	W
Fayette	39	3,470	16	1,013	4	217	4,653	40	--------	7	4,700	8.14
Gilmer	2	38	3	55	--------	--------	91	2	--------	--------	93	5.35
Grant	3	1,865	8	556	--------	--------	2,006	416	--------	--------	2,422	6.15
Greenbrier	16	384	3	94	--------	--------	474	4	--------	--------	478	5.89
Hancock	W	W	W	W	--------	--------	W	W	--------	W	W	W
Harrison	13	5,443	44	1,720	2	27	6,866	324	--------	--------	7,190	6.17
Kanawha	48	8,867	13	1,833	21	1,024	11,246	474	--------	4	11,724	7.08
Lewis	1	3	8	259	3	71	330	3	--------	--------	333	6.82
Logan	44	10,435	13	704	28	1,494	12,596	34	--------	2	12,632	9.37
Marion	8	8,901	5	359	1	35	9,075	216	--------	3	9,294	6.59
Marshall	5	5,162	--------	--------	--------	--------	5,077	85	--------	--------	5,162	5.20
Mason	3	646	--------	--------	--------	--------	685	11	--------	--------	646	8.17
McDowell	149	15,662	39	1,394	8	89	16,872	137	--------	137	17,146	11.15
Mercer	9	1,060	8	99	--------	--------	1,155	1	--------	3	1,159	10.52
Mineral	3	51	9	304	1	8	130	233	--------	--------	363	3.32
Mingo	33	1,547	13	457	12	220	2,061	118	--------	46	2,225	7.56
Monongalia	21	12,331	17	497	--------	--------	12,544	283	--------	--------	12,827	5.60
Nicholas	60	6,192	26	946	4	139	7,162	115	--------	--------	7,277	8.55
Ohio	W	W	W	W	--------	--------	W	W	--------	W	W	W
Pocahontas	3	40	--------	--------	--------	--------	40	--------	--------	--------	40	10.00
Preston	30	867	39	2,152	--------	--------	2,347	672	--------	--------	3,019	5.20
Raleigh	52	7,663	31	2,184	17	581	10,353	46	--------	27	10,426	10.10
Randolph	13	489	5	161	--------	--------	597	46	--------	6	649	7.46
Summers	--------	--------	2	21	--------	--------	21	--------	--------	--------	21	9.75
Taylor	3	6	6	219	--------	--------	225	--------	--------	--------	225	5.91
Tucker	--------	--------	4	300	--------	--------	278	22	--------	--------	300	4.33
Upshur	6	299	14	571	--------	--------	870	--------	--------	--------	870	5.61
Wayne	4	98	1	8	--------	--------	77	28	--------	--------	105	7.50
Webster	11	129	3	118	2	8	214	39	--------	1	254	9.64
Wyoming	94	11,451	18	977	20	540	12,799	152	--------	18	12,969	8.52
Other counties	5	2,668	1	32	--------	--------	2,590	108	--------	3	2,700	6.53

Total [4]	748	116,414	418	21,885	153	5,772	139,281	3,877	643	270	144,072	7.93
Wyoming:												
Campbell	-------	--------	W	W	--------	--------	W	W	--------	W	W	W
Carbon	-------	--------	W	W	--------	--------	W	W	--------	W	W	W
Converse	-------	--------	2	1,844	--------	--------	--------	2	1,842	--------	1,844	3.45
Hot Springs	3	8	--------	--------	--------	--------	--------	8	--------	--------	8	9.56
Lincoln	-------	--------	2	1,583	--------	--------	273	--------	1,310	--------	1,583	3.80
Sheridan	-------	--------	2	1,465	--------	--------	1,443	22	--------	--------	1,465	3.32
Sweetwater	1	110	1	107	--------	--------	182	1	--------	34	217	4.78
Other counties	-------	--------	2	2,105	--------	--------	2,092	12	--------	2	2,106	2.88
Total [4]	4	118	9	7,105	--------	--------	3,990	45	3,152	36	7,222	3.38
Total United States [4]	2,939	338,788	2,103	244,117	559	20,027	490,448	73,977	34,373	4,134	602,932	6.26

W Withheld to avoid disclosing individual company data; included with "Other counties."

[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] Value received or charged for coal f.o.b. mine. Includes 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.

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

Table 18.—Number and production of bituminous coal and lignite strip mines and units of stripping and loading equipment in the United States, in 1970, by States

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 carryall scrapers	Number of bulldozers	Front-end loaders	Wheel excavators	Power brooms	Motor graders	Coal drills
Alabama	91	11,339	11	8	140	3	56	53	47	6	100	62	162	6	207	64	-----	3	11	3
Alaska	3	549	----	-----	4	----	1	3	----	----	4	-----	4	8	9	9	-----	-----	3	-----
Arizona	1	132	2	-----	1	----	----	2	1	----	3	-----	3	-----	3	2	-----	-----	1	-----
Arkansas	6	217	----	-----	7	----	1	6	----	----	3	4	7	1	8	4	-----	1	2	-----
Colorado	8	2,167	7	1	5	----	5	8	----	----	7	6	13	2	19	6	-----	-----	3	5
Illinois	31	33,026	71	16	29	----	28	49	22	17	68	48	116	2	140	44	7	-----	26	17
Indiana	32	20,169	44	7	43	10	56	26	11	11	56	48	104	1	118	37	-----	1	18	1
Iowa	10	565	----	1	21	1	21	2	----	----	9	14	23	3	20	12	-----	-----	4	11
Kansas	5	1,627	7	2	3	----	5	5	1	1	6	6	12	-----	17	4	-----	-----	3	-----
Kentucky:																				
Eastern	349	19,705	----	4	427	----	342	82	7	----	398	33	431	20	409	79	3	-----	22	3
Western	61	33,131	53	3	75	----	64	46	15	6	100	31	131	2	171	47	14	-----	29	13
Total	410	52,836	53	7	502	----	406	128	22	6	498	64	562	22	580	126	17	-----	51	16
Maryland	28	1,266	----	7	43	----	45	5	----	----	36	14	50	1	43	23	-----	-----	3	1
Missouri	9	4,447	16	1	5	2	12	7	4	1	16	8	24	4	35	13	-----	-----	9	-----
Montana:																				
Bituminous	2	3,096	5	-----	----	----	----	3	2	----	3	2	5	1	4	2	-----	-----	2	1
Lignite	2	323	1	-----	1	----	1	1	----	----	1	1	2	1	2	2	-----	1	1	1
Total	4	3,419	6	-----	1	----	1	4	2	----	4	3	7	2	6	4	-----	1	3	2
New Mexico	3	6,423	7	-----	2	----	1	4	4	----	6	3	9	4	9	10	-----	1	4	1
North Dakota (lignite)	20	5,639	21	4	17	6	33	9	6	----	33	15	48	15	26	11	-----	2	12	7
Ohio	217	35,818	48	33	415	15	387	102	17	5	360	151	511	40	477	123	-----	12	50	6
Oklahoma	8	2,201	7	3	4	----	6	3	5	----	8	6	14	1	16	13	-----	1	4	-----
Pennsylvania	555	24,447	8	37	865	24	738	189	7	----	570	364	934	10	705	177	11	6	41	1
Tennessee	80	3,729	----	4	110	----	51	63	----	----	95	19	114	1	154	31	-----	3	15	-----
Virginia	154	5,103	----	-----	65	----	44	21	----	----	65	-----	65	4	84	46	-----	-----	7	1
Washington	1	5	----	1	----	----	1	----	----	----	1	-----	1	-----	1	1	-----	-----	-----	-----
West Virginia	418	21,885	4	20	329	----	293	57	3	----	316	37	353	20	452	165	3	9	56	40
Wyoming	9	7,105	7	-----	8	1	11	4	1	----	13	3	16	16	23	11	-----	4	7	13
Total	2,103	244,117	319	152	2,619	62	2,202	750	153	47	2,277	875	3,152	163	3,152	936	38	44	333	125

Table 19.—Bituminous coal and lignite strip mines using power drills in bank or overburden in the United States, by States

State	Number of mines		Production: Quantity (thousand short tons)		Number of power drills: Horizontal		Vertical		Total	
	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
Alabama	47	51	7,169	7,173	5	7	48	50	53	57
Alaska	3	3	667	549	1	1	3	3	4	4
Arizona	---	1	-------	132	---	---	---	2	---	2
Arkansas	4	4	160	194	1	1	3	4	4	5
Colorado	7	7	1,905	2,165	2	2	7	9	9	11
Illinois	27	26	32,199	32,750	19	21	22	27	41	48
Indiana	24	25	17,823	18,241	9	9	33	36	42	45
Iowa	9	9	432	544	8	8	11	9	19	17
Kansas	4	5	1,313	1,627	7	9	1	1	8	10
Kentucky:										
Eastern	57	65	6,122	6,182	27	30	42	45	69	75
Western	31	30	22,713	24,099	11	12	47	48	58	60
Total	88	95	28,835	30,281	38	42	89	93	127	135
Maryland	10	8	552	500	2	2	5	4	7	6
Missouri	8	9	3,299	4,447	10	9	5	6	15	15
Montana:										
Bituminous	2	2	166	3,096	---	---	2	4	2	4
Lignite	1	---	1	-------	1	---	---	---	1	---
Total	3	2	167	3,096	1	---	2	4	3	4
New Mexico	2	2	3,628	6,406	1	2	3	1	4	3
North Dakota (lignite)	1	2	1	7	1	1	---	1	1	2
Ohio	106	101	25,490	30,589	33	43	106	99	139	142
Oklahoma	5	6	1,048	2,197	4	7	8	6	12	13
Pennsylvania	214	225	13,348	14,467	46	40	134	138	180	178
Tennessee	30	44	2,050	2,160	18	22	25	31	43	53
Virginia	17	19	1,610	2,247	7	7	21	24	28	31
West Virginia	140	118	11,434	11,710	44	39	94	95	138	134
Wyoming	5	5	2,400	4,492	5	4	6	6	11	10
Total	754	767	155,530	175,974	262	276	626	649	888	925

Table 20.—Equipment used at bituminous coal and lignite auger mines in the United States, in 1970, number of units

State	Augers	Power shovels	Power drills	Bull-dozers	Front-end loaders	Power brooms	Motor graders
Alabama	2	--	--	2	--	--	--
Kentucky	213	17	8	59	8	--	1
Maryland	7	--	--	1	1	--	--
Ohio	45	1	--	11	7	--	2
Oklahoma	1	--	--	--	--	--	--
Pennsylvania	48	3	5	3	3	--	--
Tennessee	7	1	--	4	1	--	1
Virginia	85	--	3	73	14	--	2
West Virginia	154	2	23	151	43	--	5
Total	562	24	39	304	77	--	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	1969	1970
Mobile loading machines:		
Direct into mine cars or onto conveyors	22,178	23,303
Into shuttle cars	133,222	128,073
Continuous-mining machines:		
Onto conveyors	17,574	13,871
Into shuttle cars or rubber-tired mine cars	125,943	128,214
Onto bottom	29,125	27,810
Longwall machines	6,344	7,132
Duckbills, scraper loaders, hand-loaded conveyors	1,046	784
Total mechanically loaded [1]	335,431	329,189

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

Table 22.—Comparative changes in underground mechanical loading of bituminous coal and lignite by principal types of loading devices in the United States, by States

(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	
	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
Alabama	8,215	8,257	652	674	--------	--------	231	38	9,098	8,969	9,098	8,969
Arkansas	--------	--------	--------	--------	--------	--------	61	51	61	51	61	51
Colorado	800	724	2,776	3,086	--------	--------	27	37	3,603	3,847	3,603	3,847
Illinois	12,208	13,563	17,832	18,510	38	20	--------	--------	30,079	32,093	30,079	32,093
Indiana	1,952	1,563	158	531	--------	--------	--------	--------	2,110	2,094	2,110	2,094
Iowa	366	421	--------	--------	--------	--------	--------	--------	366	421	366	421
Kentucky	46,631	45,913	11,624	11,196	--------	353	33	72	58,288	57,534	58,555	57,534
Maryland	150	127	87	65	--------	--------	3	2	240	193	240	193
Montana	19	14	--------	--------	--------	--------	14	14	33	28	33	28
New Mexico	--------	--------	832	938	--------	--------	--------	--------	832	938	832	938
Ohio	8,215	7,474	10,262	10,575	--------	--------	4	--------	18,481	18,050	18,481	18,050
Oklahoma	--------	--------	115	219	--------	--------	--------	--------	115	219	115	219
Pennsylvania	8,441	7,120	45,228	46,114	1,967	1,919	146	80	55,782	55,233	55,792	55,233
Tennessee	3,484	3,237	502	866	--------	--------	64	86	4,050	4,189	4,050	4,189
Utah	507	480	3,693	3,321	441	909	10	10	4,652	4,720	4,652	4,731
Virginia	14,806	14,326	11,543	10,079	1,532	1,555	72	60	27,953	26,020	27,971	26,020
Washington	22	17	--------	--------	--------	--------	31	14	53	32	53	32
West Virginia	49,467	48,027	67,337	63,723	2,365	2,376	343	314	119,512	114,440	119,531	114,611
Wyoming	115	112	--------	--------	--------	--------	7	5	122	118	122	118
Total [1]	155,400	151,375	172,642	169,897	6,344	7,132	1,046	784	335,430	329,189	335,744	329,371

[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 in the United States, by States

State	Number of mines										Number of loading devices							
	Using mobile loading machines		Using continuous-mining machines only		Using duckbills, scraper loaders, hand-loaded conveyors only		Using more than one type of loading device		Total		Mobile loading machines		Continuous-mining machines		Longwall machines		Duckbills, scraper loaders, hand-loaded conveyors	
	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
Alabama	10	8	-----	-----	19	4	5	4	34	16	75	70	8	9	-----	-----	37	6
Arkansas	-----	-----	-----	-----	2	2	-----	-----	2	2	-----	-----	-----	-----	-----	-----	4	4
Colorado	20	14	14	13	3	5	2	4	39	36	52	47	35	37	-----	-----	9	11
Illinois	10	9	8	8	-----	-----	9	10	27	27	69	77	85	97	1	1	-----	-----
Indiana	5	5	-----	-----	-----	-----	1	1	6	6	22	22	1	5	-----	-----	-----	-----
Iowa	2	2	-----	-----	-----	-----	-----	-----	2	2	4	3	-----	-----	-----	-----	-----	-----
Kentucky	421	474	38	39[1]	5	1	14	7	478	523[2]	643	690	114	111	-----	5	9	7
Maryland	2	3	2	2	1	-----	-----	1	5	6	5	7	3	2	-----	-----	1	2
Montana	4	2	-----	-----	2	2	-----	-----	6	4	5	4	-----	-----	-----	-----	7	6
New Mexico	-----	-----	1	1	-----	-----	-----	-----	1	1	5	5	5	5	-----	-----	-----	-----
Ohio	13	14	13	12	1	-----	5	3	32	29	57	66	79	83	-----	-----	2	-----
Oklahoma	-----	-----	2	2	-----	-----	-----	-----	2	2	2	-----	5	6	-----	-----	-----	-----
Pennsylvania	35	31	98	90	19	9	19	19	171	149	187	152	458	464	9	10	40	19
Tennessee	35	17	6	-----	11	3	1	1	53	21	59	32	11	5	-----	-----	12	5
Utah	8	4	8	11	-----	-----	5	5	21	20	27	25	29	31	2	2	3	3
Virginia	310	299	51	55	4	2	11	11	376	367	365	366	118	116	5	4	6	4
Washington	2	-----	-----	-----	1	-----	-----	1	3	1	3	1	-----	-----	-----	-----	3	1
West Virginia	331	279	144	142	9	7	96	81	580	509	884	849	620	595	11	12	40	33
Wyoming	2	2	-----	-----	2	2	-----	-----	4	4	2	4	-----	-----	-----	-----	5	5
Total	1,210	1,163	385	375	79	37	168	148	1,842	1,723[2]	2,466	2,420	1,571	1,566	28	34	178	106

[1] Includes 2 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 in the United States, by States and methods of loading

(Thousand short tons)

State	Hand-loaded		Mechanically loaded		Total underground production	
	1969	1970	1969	1970	1969	1970
Alabama	188	109	9,098	8,969	9,287	9,078
Arkansas	-------	-------	61	51	61	51
Colorado	12	11	3,603	3,847	3,615	3,858
Illinois	3	-------	30,079	32,093	30,082	32,093
Indiana	-------	-------	2,110	2,094	2,110	2,094
Iowa	2	2	366	421	368	423
Kentucky	6,048	5,076	58,288	57,534	64,336	62,610
Maryland	82	45	240	193	322	238
Missouri	1	-------	-------	-------	1	-------
Montana	1	-------	33	28	35	28
New Mexico	4	-------	832	938	836	938
Ohio	144	61	18,481	18,050	18,625	18,111
Oklahoma	-------	-------	115	219	115	219
Pennsylvania	257	149	55,782	55,233	56,039	55,382
Tennessee	423	161	4,050	4,189	4,473	4,350
Utah	5	13	4,652	4,720	4,657	4,733
Virginia	2,420	1,998	27,953	26,020	30,373	28,018
Washington	-------	-------	53	32	53	32
West Virginia	2,111	1,974	119,512	114,440	121,623	116,414
Wyoming	-------	-------	122	118	122	118
Total [1]	11,700	9,599	335,430	329,189	347,132	338,788

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

Table 25.—Mechanical cleaning at bituminous coal and lignite mines in the United States, in 1970, by States

(Thousand short tons)

State	Total production	Mechanical cleaning			
		Number of cleaning plants	Raw coal	Cleaned coal	Refuse
Alabama	20,560	22	21,382	13,223	8,158
Alaska	549	2	91	58	34
Arkansas	268	1	29	27	2
Colorado	6,025	3	2,336	2,029	307
Illinois	65,119	39	64,134	51,151	12,983
Indiana	22,263	12	22,924	17,711	5,214
Kansas	1,627	3	2,374	1,621	753
Kentucky	125,305	49	51,290	40,094	11,195
Missouri	4,447	4	2,815	2,036	780
New Mexico	7,361	1	1,168	930	239
Ohio	55,351	18	19,540	14,528	5,012
Oklahoma	2,427	4	798	447	351
Pennsylvania	80,491	74	68,201	51,284	16,917
Tennessee	8,237	4	1,961	1,533	429
Utah	4,733	7	4,002	3,434	568
Virginia	35,016	33	27,247	20,978	6,270
Washington	37	2	69	32	37
West Virginia	144,072	136	136,166	102,259	33,908
Wyoming	7,222	1	79	77	2
Other States [1]	11,820	---	-------	-------	-------
Total [2]	602,932	415	426,606	323,452	103,159

[1] Includes Arizona, Iowa, Maryland, 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 types of equipment

(Thousand short tons)

Type of equipment	1969	1970
Wet methods:		
Jigs	155,027	140,457
Concentrating tables	45,328	44,058
Classifiers	3,401	3,593
Launders	4,644	5,199
Dense medium processes:		
Magnetite	71,701	76,590
Sand	24,023	23,290
Calcium chloride	1,911	1,714
Total [1]	97,636	101,593
Flotation	9,560	10,694
Total, wet methods [1]	315,596	305,594
Pneumatic methods	19,163	17,855
Grand total [1]	334,761	323,452

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

Table 27.—Mechanical cleaning at bituminous coal and lignite mines in the United States, in 1970, by States and by 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	9,078	8,732	11,339	4,490	143	-------	20,560	13,223
Alaska	-------	-------	549	58	-------	-------	549	58
Arkansas	51		217	27	-------	-------	268	27
Colorado	3,858	1,999	2,167	30	-------	-------	6,025	2,029
Illinois	32,093	22,841	33,026	28,310	-------	-------	65,119	51,151
Indiana	2,094	1,384	20,169	16,327	-------	-------	22,263	17,711
Kansas	-------	-------	1,627	1,621	-------	-------	1,627	1,621
Kentucky	62,610	26,161	52,836	13,932	9,859	-------	125,305	40,094
Missouri	-------	-------	4,447	2,036	-------	-------	4,447	2,036
New Mexico	938	930	6,423	-------	-------	-------	7,361	930
Ohio	18,111	11,592	35,818	2,707	1,422	229	55,351	14,528
Oklahoma	219	219	2,201	220	7	7	2,427	447
Pennsylvania	55,382	41,981	24,447	9,261	661	42	80,491	51,284
Tennessee	4,350	1,494	3,729	39	157	-------	8,237	1,533
Utah	4,733	3,434	-------	-------	-------	-------	4,733	3,434
Virginia	28,018	20,793	5,103	93	1,895	93	35,016	20,978
Washington	32	32	5	-------	-------	-------	37	32
West Virginia	116,414	93,353	21,885	7,548	5,772	1,358	144,072	102,259
Wyoming	118	77	7,105	-------	-------	-------	7,222	77
Other States [1]	689	-------	11,021	-------	111	-------	11,820	--------
Total [2]	338,788	235,022	244,117	86,699	20,027	1,729	602,932	323,452

[1] Includes Arizona, Iowa, Maryland, Montana, and North Dakota.
[2] Data may not add to totals shown because of independent rounding.

Table 28.—Mechanical crushing of bituminous coal and lignite at mines in the United States, by States

State	Number of plants crushing coal		Coal crushed (thousand short tons)	
	1969	1970	1969	1970
Alabama	22	26	7,865	7,838
Alaska	3	3	667	670
Arkansas	6	4	206	178
Colorado	34	28	3,496	3,450
Illinois	56	50	41,291	41,035
Indiana	26	21	13,632	13,600
Iowa	12	11	757	838
Kansas	1	1	250	250
Kentucky	137	145	43,122	43,070
Maryland	9	12	594	754
Missouri	7	8	2,874	2,896
Montana:				
Bituminous	10	6	710	845
Lignite	2	2	306	200
Total	12	8	1,016	1,045
New Mexico	4	4	4,464	4,456
North Dakota (lignite)	15	14	4,542	4,567
Ohio	95	98	26,128	26,106
Oklahoma	5	6	1,520	1,500
Pennsylvania	163	154	37,348	36,950
Tennessee	43	43	4,072	3,935
Utah	14	14	1,605	1,595
Virginia	54	65	16,189	16,056
Washington	3	2	11	4
West Virginia	217	225	51,227	50,967
Wyoming	8	11	2,477	2,422
Total	946	953	265,353	264,182

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)	
	1969	1970	1969	1970
Fluidized-bed	80	75	40,639	42,595
Multilouver	29	24	10,067	8,554
Rotary	5	4	1,204	876
Screen	25	16	5,100	4,806
Suspension or flash	35	29	7,381	5,410
Vertical tray and cascade	18	15	2,691	1,924
Total	192	163	67,082	64,165

Table 30.—Comparison of thermal drying of bituminous coal and lignite with mechanical cleaning at mines in the United States, by States

(Thousand short tons)

State	Number of cleaning plants: Total		Number of cleaning plants: With thermal drying		Production mechanically cleaned		Thermally dried	
	1969	1970	1969	1970	1969	1970	1969	1970
Colorado	4	3	1	1	1,701	2,029	552	648
Illinois	43	39	21	16	54,911	51,151	10,717	10,129
Indiana	11	12	4	3	16,570	17,711	1,813	1,942
Kentucky	52	49	10	9	47,149	40,094	3,529	3,296
North Dakota (lignite)	---	---	2	2	-------	-------	112	199
Ohio	19	18	6	6	15,567	14,528	4,212	3,555
Pennsylvania	77	74	10	9	50,755	51,284	4,547	6,143
Utah	6	7	2	2	3,157	3,434	715	1,120
Virginia	33	33	8	10	21,176	20,978	10,121	8,589
West Virginia	143	136	55	53	106,297	102,259	30,764	28,544
Other states	47	44	---	---	17,478	19,984	-------	-------
Total	435	415	119	111	334,761	323,452	67,082	64,165

Table 31.—Thermal drying of bituminous coal and lignite at mines in the United States, by States

(Thousand short tons)

State	Number of thermal drying 1969	Number of thermal drying 1970	Grand total production 1969	Grand total production 1970	Thermally dried 1969	Thermally dried 1970
Colorado	1	1	5,530	6,025	552	648
Illinois	39	24	64,722	65,119	10,717	10,129
Indiana	5	4	20,086	22,263	1,813	1,942
Kentucky	18	12	109,049	125,305	3,529	3,296
North Dakota (lignite)	2	2	4,704	5,639	112	199
Ohio	13	13	51,242	55,351	4,212	3,555
Pennsylvania	11	11	78,631	80,491	4,547	6,143
Utah	2	2	4,657	4,733	715	1,120
Virginia	19	23	35,555	35,016	10,121	8,589
West Virginia	82	71	141,011	144,072	30,764	28,544
Other States	---	---	45,317	58,918	-------	-------
Total	192	163	[1] 560,505	602,932	67,082	64,165

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

Table 32.—Bituminous coal and lignite loaded for shipment by railroads and by waterways in the United States, in 1970, as reported by mine operators

(Thousand short tons)

Route	State	By State	Total for route
RAILROAD			
Alaska	Alaska	457	457
Atchison, Topeka & Santa Fe	Illinois	307	1,640
	New Mexico	1,333	
Baltimore & Ohio	Illinois	449	32,752
	Ohio	10,116	
	Pennsylvania	2,679	
	West Virginia	19,508	
Bessemer & Lake Erie	Pennsylvania	2,002	2,002
Burlington Northern	Illinois	10,788	19,268
	Iowa	238	
	Montana (bituminous and lignite)	3,416	
	North Dakota (lignite)	2,754	
	Wyoming	2,072	
Cambria & Indiana	Pennsylvania	2,817	2,817
Carbon County	Utah	651	651
Chesapeake & Ohio	Kentucky	18,838	59,713
	Ohio	42	
	Virginia	13	
	West Virginia	40,820	
Cheswick & Harmar	Pennsylvania	174	174
Chicago & Eastern Illinois	Illinois	2,766	5,455
	Indiana	2,689	
Chicago & Illinois Midland	Illinois	1,880	1,880
Chicago, Milwaukee, St. Paul & Pacific	Indiana	3,861	3,861
Chicago & North Western	Illinois	1,758	1,763
	Iowa	5	
Chicago, Rock Island & Pacific	Illinois	1,474	1,794
	Iowa	320	
Clinchfield	Kentucky	639	4,812
	Virginia	4,173	
Colorado & Wyoming	Colorado	602	602
Denver & Rio Grande Western	do	3,756	5,808
	Utah	2,052	
Erie-Lackawanna	Ohio	174	174
Gulf, Mobile & Ohio	Illinois	5,936	5,936
Illinois Central	do	14,872	27,621
	Kentucky	12,749	
Interstate	Virginia	4,626	4,626
Kansas City Southern	Missouri	1,045	1,421
	Oklahoma	376	
Kentucky & Tennessee	Kentucky	407	407
Lake Erie, Franklin & Clarion	Pennsylvania	368	368

See footnotes at end of table.

Table 32.—Bituminous coal and lignite loaded for shipment, by railroads and by waterways in the United States, in 1970, as reported by mine operators—Continued

(Thousand short tons)

Route	State	By State	Total for route
RAILROAD—Continued			
	Alabama	2,298	
Louisville & Nashville	Kentucky	43,231	46,345
	Tennessee	579	
	Virginia	237	
Mary Lee	Alabama	928	928
	Kansas	1,165	
Missouri-Kansas-Texas	Missouri	458	1,856
	Oklahoma	233	
	Arkansas	237	
Missouri Pacific	Illinois	5,439	
	Missouri	8	5,701
	Oklahoma	17	
Monongahela	West Virginia	7,302	7,302
	Iowa	75	
	Kentucky	11,724	
Norfolk & Western	Missouri	309	
	Ohio	7,296	78,200
	Virginia	20,694	
	West Virginia	38,102	
Penn Central (includes coal shipped over Kanawha & Michigan, Kelley's Creek, Toledo & Ohio Central, and Zanesville & Western)	Illinois	2,940	
	Indiana	9,262	
	Ohio	11,756	50,967
	Pennsylvania	21,835	
	West Virginia	5,174	
Pittsburgh & Shawmut	Pennsylvania	2,220	2,220
	Alabama	337	
St. Louis—San Francisco	Arkansas	21	
	Kansas	416	2,503
	Oklahoma	1,729	
Soo Line	North Dakota (lignite)	511	511
	Alabama	3,413	
	Indiana	1,498	
Southern	Kentucky	523	11,418
	Tennessee	2,424	
	Virginia	3,560	
Tennessee	Tennessee	676	676
Tennessee Coal, Iron & Railroad Co	Alabama	2,013	2,013
Toledo, Peonia & Western	Illinois	634	634
Union Pacific	Colorado	407	2,325
	Wyoming	1,918	
Unity	Pennsylvania	1,024	1,024
Utah	Utah	1,243	1,243
	Maryland	736	
Western Maryland	Pennsylvania	395	6,226
	West Virginia	5,095	
Woodward Iron Co	Alabama	1,017	1,017
Total railroad shipments		409,111	409,111
WATERWAY			
Allegheny River	Pennsylvania	954	954
Black Warrior River	Alabama	3,785	3,785
Cumberland River	Kentucky	75	75
Green River	do	15,467	15,467
Illinois River	Illinois	2,569	2,569
Kanawha River	West Virginia	6,105	6,105
Monongahela River	Pennsylvania	22,045	32,158
	West Virginia	10,113	
	Illinois	2,905	
Ohio River	Kentucky	3,941	
	Ohio	4,764	18,672
	West Virginia	7,062	
Tennessee River	Alabama	949	
	Tennessee	603	1,552
Total waterway shipments		81,337	81,337
Total loaded at mines for shipment by railroads and waterways		490,448	490,448
Shipped by truck from mine to final destination		73,977	73,977
Coal transported to electric utility plants adjacent to or near the mine		34,373	34,373
Used at mine [1]		4,134	4,134
Total production		602,932	602,932

[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 in the United States

(Thousand short tons)

State	1969	1970
Alabama	2,257	3,088
Arkansas	40	-------
Colorado	1,336	2,427
Illinois	17,621	17,217
Indiana	1,913	2,997
Kansas	96	-------
Kentucky:		
Eastern	7,420	9,361
Western	6,845	8,762
Total	14,265	18,123
Maryland	150	232
Missouri	365	-------
Montana (bituminous)	2	3,022
New Mexico	742	1,130
North Dakota (lignite)	787	916
Ohio	13,014	13,308
Oklahoma	934	974
Pennsylvania	20,370	21,325
Tennessee	-------	398
Utah	2,031	2,055
Virginia	5,067	5,861
West Virginia	40,733	30,110
Wyoming	-------	107
Total [1]	121,722	123,289

[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]
1966	264,202	609	2,369	93,523	7,117	98,481	19,965	486,266
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:								
January	29,041	1	73	7,379	633	8,642	3,007	48,776
February	24,771	-------	70	6,937	563	7,774	2,323	42,438
March	26,304	3	86	7,579	608	8,132	1,747	44,459
April	22,383	28	97	7,581	477	7,343	614	38,523
May	23,142	36	88	7,866	411	6,925	434	38,902
June	24,391	31	87	7,656	374	6,442	387	39,368
July	27,173	41	78	7,755	348	6,094	512	42,001
August	26,794	40	111	7,729	332	6,140	622	41,768
September	24,544	39	120	7,594	361	6,096	866	39,620
October	25,226	44	111	7,981	414	6,734	1,244	41,754
November	25,735	36	105	7,664	476	7,118	1,300	42,434
December	28,957	14	132	8,022	563	7,934	1,610	47,232
Total	308,461	313	1,158	91,743	5,560	85,374	14,666	507,275
1970:								
January	30,167	-------	133	7,659	702	7,707	2,078	48,446
February	26,121	-------	126	7,238	577	6,959	1,481	42,502
March	26,668	3	123	8,116	582	7,166	1,072	43,730
April	24,170	28	123	7,853	510	7,079	540	40,303
May	24,118	40	114	8,099	410	6,657	203	39,641
June	25,625	39	114	7,786	353	6,240	504	40,661
July	27,521	40	117	7,841	332	5,913	516	42,280
August	28,458	37	114	7,822	327	5,984	672	43,414
September	26,424	37	117	7,809	328	5,997	1,038	41,750
October	25,254	37	122	8,216	369	7,197	1,339	42,534
November	26,453	27	113	7,957	385	7,607	1,300	43,842
December	29,481	10	112	8,185	535	8,403	1,329	48,055
Total	320,460	298	1,428	94,581	5,410	82,909	12,072	517,158

[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, in 1970

Date	Total stocks (thousand short tons)	Days' 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	70,776	54	31	17	39	5	45
Feb. 28	67,805	54	30	18	38	6	45
Mar. 31	67,888	58	32	19	41	6	48
Apr. 30	70,743	65	33	21	40	6	53
May 31	75,761	71	35	25	49	9	59
June 30	77,925	67	36	29	51	18	58
July 31	71,849	62	26	33	51	16	53
Aug. 31	73,120	61	27	33	53	15	52
Sept. 30	78,297	68	27	29	55	12	56
Oct. 31	86,853	81	31	29	52	10	63
Nov. 30	91,555	79	33	27	50	11	63
Dec. 31	92,275	75	34	20	43	9	60

Table 36.—Distribution of bituminous coal and lignite, in 1970, 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, and overseas exports	339,351	103,043	14,782	[1] 86,501	752	1,486
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	175,678	55,790	7,867	[1] 52,057	--------	--------
River and ex-river	74,187	26,278	625	6,071	--------	--------
Great Lakes [2]	20,945	13,850	2,661	9,713	--------	--------
Tidewater [3]	5,054	5,131	1	260	--------	--------
Truck	39,909	1,960	3,628	18,400	--------	--------
Tramway, conveyor, private railroad	23,578	34	--------	--------	--------	--------
Method of movement and/or consumer uses unknown	--------	--------	--------	--------	752	1,486
Total	339,351	103,043	14,782	[1] 86,501	752	1,486

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	261	−16	--------	51,766	66	597,992
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] 291,392
River and ex-river	--------	--------	--------	--------	--------	107,161
Great Lakes [2]	--------	--------	--------	--------	--------	47,169
Tidewater [3]	--------	--------	--------	--------	--------	10,446
Truck	--------	--------	--------	--------	--------	63,897
Tramway, conveyor, private railroad	--------	--------	--------	--------	--------	23,612
Method of movement and/or consumer uses unknown	261	−16	--------	51,766	66	54,315
Total	261	−16	--------	51,766	66	597,992

[1] Includes overseas exports from producing districts 13 and 17.
[2] Excludes shipments to Canadian Great Lakes commercial docks and U.S. dock storage for which consumer uses are not available; however, includes vessel fuel, the destinations of which are not available.
[3] Excludes overseas exports for which consumer uses are not available.
[4] Consumer use unknown.
[5] Excludes Canada; consumer use unknown.
[6] Excludes overseas exports from producing districts 13 and 17.

Table 37.—Distribution of bituminous coal and lignite, in 1970, 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	31,089	4,959	669	6,728	106	323
2	8,804	24,563	406	5,772	1	22
3 and 6	36,809	5,371	262	5,334	19	24
4	41,893	----------	1,501	12,094	129	17
7	1,192	16,055	631	1,030	79	658
8	62,009	34,718	7,094	27,821	238	213
9	47,844	77	832	4,708	57	----------
10	50,745	4,617	1,282	10,919	79	57
11	15,956	202	392	5,895	12	4
12	812	----------	1	69	----------	----------
13	11,296	6,586	391	[2] 2,198	----------	2
14	----------	640	----------	170	----------	----------
15 [3]	6,981	154	55	287	----------	----------
16	522	----------	26	42	----------	2
17	2,357	3,322	353	[2] 592	----------	----------
18	6,525	----------	8	22	----------	----------
19	6,405	34	92	661	14	6
20	1,005	1,745	600	896	1	44
21	4,870	----------	151	771	9	114
22 and 23	2,237	----------	36	492	8	----------
Total	339,351	103,043	14,782	86,501	752	1,486

District of origin [1]	Canadian Great Lakes commercial docks [4]	U.S. Great Lakes dock storage [4]	U.S. tidewater dock storage [4]	Overseas exports [5]	Net change in mine inventory	Total
1	----------	24	----------	2,709	40	46,647
2	22	−8	----------	----------	−1	39,581
3 and 6	5	72	----------	2,275	−118	50,053
4	64	−103	----------	----------	104	55,699
7	----------	34	----------	17,430	19	37,128
8	170	24	----------	28,902	−167	161,022
9	----------	−5	----------	----------	−153	53,360
10	----------	−54	----------	----------	15	67,660
11	----------	----------	----------	----------	180	22,641
12	----------	----------	----------	----------	----------	882
13	----------	----------	----------	(6)	38	20,511
14	----------	----------	----------	190	----------	1,000
15 [3]	----------	----------	----------	----------	148	7,625
16	----------	----------	----------	----------	1	593
17	----------	----------	----------	(6)	−22	6,602
18	----------	----------	----------	----------	−57	6,498
19	----------	----------	----------	----------	3	7,215
20	----------	----------	----------	260	35	4,586
21	----------	----------	----------	----------	1	5,916
22 and 23	----------	----------	----------	----------	----------	2,773
Total	261	−16	----------	51,766	66	597,992

[1] Producing districts are defined in Bureau of Mines Bituminous Coal and Lignite Distribution Calendar Year 1970; Mineral Industry Survey, March 23, 1971, 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, in 1970, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others [1]
New England:					
Massachusetts	608	444	-------	29	135
Connecticut	1,832	1,700	-------	-------	132
Maine, New Hampshire, Vermont, Rhode Island	1,128	1,067	-------	10	51
Middle Atlantic:					
New York	23,032	11,579	6,051	87	5,315
New Jersey	4,951	4,272	334	3	342
Pennsylvania	63,009	28,381	26,527	822	7,279
East North Central:					
Ohio	67,375	37,145	12,699	1,888	15,643
Indiana	42,385	22,780	12,672	826	6,107
Illinois	42,310	29,453	3,688	2,590	6,579
Michigan	36,633	23,244	4,942	1,008	7,439
Wisconsin	17,308	10,986	352	1,523	4,447
West North Central:					
Minnesota	8,769	6,181	604	675	1,309
Iowa	6,159	4,190	-------	210	1,759
Missouri	13,397	11,497	293	109	1,498
North Dakota and South Dakota	4,799	4,103	-------	205	491
Nebraska and Kansas	1,974	1,600	-------	55	319
South Atlantic:					
Delaware and Maryland	13,928	7,790	5,037	69	1,032
District of Columbia	1,113	681	-------	47	385
Virginia	11,065	6,653	27	550	3,835
West Virginia	24,395	14,329	5,080	226	4,760
North Carolina	21,696	19,075	-------	515	2,106
South Carolina	6,143	4,153	-------	290	1,700
Georgia and Florida	13,219	12,600	-------	149	470
East South Central:					
Kentucky	23,672	19,108	1,591	602	2,371
Tennessee	18,315	15,500	177	638	2,000
Alabama and Mississippi	27,198	16,248	8,533	150	2,267
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,144	-------	1,125	9	10
Mountain:					
Colorado	5,136	3,264	1,024	271	577
Utah	3,010	463	1,937	129	481
Montana and Idaho	1,065	652	-------	228	185
Wyoming	3,809	3,589	-------	25	195
New Mexico	6,032	6,021	-------	1	10
Arizona and Nevada	1,180	1,039	-------	74	67
Pacific:					
Washington and Oregon	374	-------	-------	78	296
California	2,317	-------	2,177	128	12
Alaska	612	151	-------	27	434
Canada [2]	18,381	8,310	7,220	391	2,460
Mexico	163	-------	-------	-------	163
Destinations not revealable	[3] 2,969	1,103	953	145	[3] 768
Destinations and/or consumer uses not available:					
Great Lakes movement:					
Canadian commercial docks	261	-------	-------	-------	-------
Vessel fuel	1,072	-------	-------	-------	-------
U.S. dock storage	−16	-------	-------	-------	-------
Tidewater movement:					
Overseas exports (except Canada)	[4] 51,766	-------	-------	-------	-------
Bunker fuel	-------	-------	-------	-------	-------
U.S. dock storage	-------	-------	-------	-------	-------
Railroad fuel:					
U.S. companies	721	-------	-------	-------	-------
Canadian companies	31	-------	-------	-------	-------
Coal used at mines and sales to employees	1,486	-------	-------	-------	-------
Net change in mine inventory	66	-------	-------	-------	-------
Total	597,992	-------	-------	-------	-------

[1] Excludes vessel fuel and bunker fuel, the destinations of which are not available.
[2] Excludes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.
[3] Includes overseas exports from producing districts 13 and 17.
[4] Excludes overseas exports from producing districts 13 and 17.

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				
	1966	1967	1968	1969	1970	1966	1967	1968	1969	1970
Total	532,366	552,647	545,319	559,880	597,992	100.0	100.0	100.0	100.0	100.0
New England	10,877	9,741	6,956	5,659	3,568	2.0	1.8	1.3	1.0	.6
Massachusetts	4,415	4,022	2,872	2,225	608	.8	.7	.5	.4	.1
Connecticut	5,434	4,793	3,013	2,295	1,832	1.0	.9	.6	.4	.3
Maine, New Hampshire, Vermont, Rhode Island	1,028	926	1,071	1,139	1,128	.2	.2	.2	.2	.2
Middle Atlantic	93,913	96,362	91,289	89,485	90,992	17.6	17.4	16.7	16.0	15.2
New York	25,314	27,300	24,562	24,324	23,032	4.8	4.9	4.5	4.3	3.9
New Jersey	8,692	7,865	6,837	5,500	4,951	1.6	1.4	1.2	1.0	.8
Pennsylvania	59,907	61,197	59,890	59,661	63,009	11.2	11.1	11.0	10.7	10.5
East North Central	192,251	196,417	195,484	199,349	206,011	36.1	35.5	35.8	35.6	34.5
Ohio	57,622	58,726	59,912	62,160	67,375	10.8	10.6	11.0	11.1	11.7
Indiana	38,424	40,441	40,245	41,299	42,385	7.2	7.3	7.4	7.4	7.1
Illinois	46,382	46,710	43,465	45,244	42,310	8.7	8.5	8.0	8.1	7.1
Michigan	34,770	34,959	36,787	35,674	36,633	6.6	6.3	6.7	6.3	6.1
Wisconsin	15,053	15,581	15,075	14,972	17,308	2.8	2.8	2.7	2.7	2.9
West North Central	25,977	26,761	27,350	30,337	35,098	4.9	4.8	5.0	5.4	5.9
Minnesota	7,680	7,142	7,332	8,100	8,769	1.4	1.3	1.3	1.4	1.5
Iowa	5,440	5,549	5,477	5,673	6,159	1.0	1.0	1.0	1.0	1.0
Missouri	8,494	9,389	9,400	11,098	13,397	1.6	1.7	1.7	2.0	2.3
North Dakota and South Dakota	2,996	3,427	3,781	3,996	4,799	.6	.6	.7	.7	.8
Nebraska and Kansas	1,367	1,254	1,360	1,470	1,974	.3	.2	.3	.3	.3
South Atlantic	80,491	88,499	88,413	89,574	91,559	15.1	16.0	16.2	16.0	15.3
Delaware and Maryland	14,082	14,954	14,777	15,008	13,928	2.6	2.7	2.7	2.7	2.3
District of Columbia	[1] 897	[1] 886	[1] 887	1,235	1,113	[1] .2	[1] .1	[1] .2	.2	.2
Virginia	14,279	14,854	14,526	12,994	11,065	2.7	2.7	2.7	2.3	1.9
West Virginia	20,159	23,244	24,564	24,356	24,395	3.8	4.2	4.5	4.4	4.1
North Carolina	15,352	17,515	16,912	18,711	21,696	2.9	3.2	3.1	3.3	3.6
South Carolina	5,118	5,554	4,695	5,319	6,143	.9	1.0	.8	1.0	1.0
Georgia and Florida	10,604	11,492	12,052	11,951	13,219	2.0	2.1	2.2	2.1	2.2
East South Central	54,929	61,312	60,487	62,730	69,185	10.3	11.1	11.1	11.2	11.6
Kentucky	17,644	19,046	18,811	20,355	23,672	3.3	3.4	3.4	3.6	4.0
Tennessee	14,811	18,185	16,833	16,793	18,315	2.8	3.3	3.1	3.0	3.1
Alabama and Mississippi	22,474	24,081	24,843	25,582	27,198	4.2	4.4	4.6	4.6	4.5
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,084	955	976	929	1,144	.2	.2	.2	.2	.2
Mountain	14,098	14,261	14,868	16,418	20,232	2.7	2.6	2.7	2.9	3.4
Colorado	4,705	4,720	4,967	4,687	5,136	.9	.9	.9	.8	.9
Utah	2,974	2,853	2,836	2,978	3,010	.6	.5	.5	.5	.5
Montana and Idaho	995	968	1,042	1,063	1,065	.2	.2	.2	.2	.2
Wyoming	2,601	2,494	2,702	3,324	3,809	.5	.4	.5	.6	.6
New Mexico	2,084	2,526	2,392	3,263	6,032	.4	.5	.4	.6	1.0
Arizona and Nevada	739	700	929	1,103	1,180	.1	.1	.2	.2	.2
Pacific	2,575	2,592	2,546	2,683	2,691	.5	.5	.5	.5	.5
Washington and Oregon	687	541	449	452	374	.1	.1	.1	.1	.1
California	1,888	2,051	2,097	2,231	2,317	.4	.4	.4	.4	.4
Alaska	858	952	804	672	612	.2	.2	.1	.1	.1

Canada [2]	15,807	15,257	16,746	16,752	18,673	3.0	2.8	3.1	3.0	3.1
Mexico	54	62	74	84	163	(3)	(3)	(3)	(3)	(3)
Destinations not revealable	1,211	994	2,138	2,175	[4] 2,969	.2	.2	.4	.4	[4] .5
U.S. railroad fuel	1,260	1,146	976	827	721	.2	.2	.2	.1	.1
U.S. Great Lakes dock storage	−6	−62	−239	−446	−16	(3)	(3)	(3)	−.1	(3)
U.S. tidewater dock storage	4	------	−5	------	------	(3)	----	(3)	----	----
Vessel fuel	1,054	878	879	951	1,072	.2	.1	.2	.2	.2
Bunker fuel	13	5	------	------	------	(3)	(3)	----	----	----
Overseas exports	33,527	34,174	33,998	39,361	[5] 51,766	6.3	6.2	6.2	7.0	[5] 8.6
Coal used at mines and sales to employees	2,098	1,678	1,496	1,450	1,486	.4	.3	.3	.3	.2
Net change in mine inventory	291	663	83	890	66	.1	.1	(3)	.2	(3)

[1] A considerable block of tonnage is included under "Destinations not revealable."
[2] Includes shipments to Canadian Great Lakes commercial docks and railroad companies.
[3] Less than 0.1 percent.
[4] Includes overseas exports from producing districts 13 and 17.
[5] Excludes overseas exports from producing districts 13 and 17.

Table 40.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted) 1966	1967	1968	1969	1970
Total	493,895	107.8	111.9	110.4	113.4	121.1
Electric utilities	160,754	169.0	184.2	185.0	194.1	211.1
Coke and gas plants	112,901	89.1	88.4	85.5	87.4	91.3
Retail dealers	39,230	52.7	47.9	45.1	39.8	37.7
All others (includes vessel and bunker fuel)	108,711	93.7	91.9	89.2	83.7	[1] 79.6
Railroad fuel (U.S. and Canada)	9,581	13.7	12.3	10.5	8.9	7.8
Canadian Great Lakes commercial docks (consumer use not available)	2,785	15.4	13.2	16.2	18.0	9.4
U.S. Great Lakes dock storage (consumer use not available) [2]	NA	−102.0	−120.4	−178.6	−246.7	−105.3
U.S. tidewater dock storage (consumer use not available) [3]	NA	15.4	.0	−119.2	.0	.0
Coal used at mine and sales to employees	3,125	67.1	53.7	47.9	46.4	47.6
Net change in mine inventory	1,142	25.5	58.1	7.3	77.9	5.8
Overseas exports (excludes Canada—consumer use not available)	55,666	60.2	61.4	61.1	70.7	[4] 93.0
New England	11,909	91.3	81.8	58.4	47.5	30.0
Electric utilities	6,012	157.3	135.8	97.1	81.1	53.4
Coke and gas plants	1,345	33.8	35.9	11.7	.0	.0
Retail dealers	1,279	14.5	12.8	10.7	5.9	3.0
All others	3,273	23.8	28.3	25.2	21.7	9.7
Massachusetts	5,354	82.5	75.1	53.6	41.6	11.4
Electric utilities	2,575	156.1	132.7	94.0	72.3	17.2
Coke and gas plants	751	.0	.0	.0	.0	.0
Retail dealers	755	14.4	14.6	15.1	7.7	3.8
All others	1,273	22.5	38.8	26.5	24.0	10.6
Connecticut	4,105	132.4	116.8	73.4	55.9	44.6
Electric utilities	2,567	182.1	157.0	97.7	79.2	66.2
Coke and gas plants	594	76.4	81.3	26.6	.0	.0
Retail dealers	139	8.6	8.6	.7	.7	.0
All others	805	36.4	33.3	43.0	32.5	16.4
Maine, New Hampshire, Vermont, Rhode Island	2,450	42.0	37.8	43.7	46.5	46.0
Electric utilities	870	87.8	82.6	104.4	112.9	122.6
Retail dealers	385	16.9	10.9	5.7	4.2	2.6
All others	1,195	16.7	13.8	11.8	11.8	4.3
Middle Atlantic	92,596	101.4	104.1	98.6	96.6	98.3
Electric utilities	31,662	132.8	140.0	131.4	137.9	139.7
Coke and gas plants	38,448	87.1	88.0	83.2	79.9	85.6
Retail dealers	2,498	43.8	38.5	34.4	28.7	36.5
All others	19,988	86.5	86.2	84.3	72.0	64.7
New York	26,753	94.6	102.0	91.8	90.9	86.1
Electric utilities	12,335	101.2	116.2	101.9	104.5	93.9
Coke and gas plants	5,693	103.3	105.0	89.7	95.7	106.3
Retail dealers	769	33.8	21.5	19.9	11.7	11.3
All others	7,956	84.0	85.8	84.6	74.1	66.8
New Jersey	7,814	111.2	100.7	87.5	70.4	63.4
Electric utilities	4,284	166.9	149.5	127.8	107.0	99.7
Coke and gas plants	1,249	40.9	39.2	38.0	34.7	26.7
Retail dealers	130	12.3	11.5	5.4	10.8	2.3
All others	2,151	47.1	44.5	40.8	21.8	15.9
Pennsylvania	58,029	103.2	105.5	103.2	102.8	108.6
Electric utilities	15,043	148.9	156.9	156.6	174.1	188.7
Coke and gas plants	31,506	86.0	86.9	83.8	78.8	84.2
Retail dealers	1,599	51.1	48.8	43.7	38.3	51.4
All others	9,881	97.0	95.7	93.6	81.3	73.7
East North Central	[5] 170,697	112.6	115.1	114.5	116.8	120.7
Electric utilities	66,436	151.7	162.8	166.1	173.7	186.1
Coke and gas plants	38,757	86.6	83.8	80.8	85.6	88.6
Retail dealers	21,321	54.9	50.3	46.0	38.9	36.7
All others	[5] 44,183	104.5	102.0	99.6	96.1	91.0
Ohio	55,612	103.6	105.6	107.7	111.8	121.2
Electric utilities	20,193	140.3	149.0	155.8	161.8	183.9
Coke and gas plants	15,661	78.1	74.1	73.2	80.6	81.1
Retail dealers	5,077	45.9	43.2	40.0	32.7	37.2
All others	14,681	100.4	101.1	101.8	103.6	106.6
Indiana	34,938	110.0	115.8	115.2	118.2	121.3
Electric utilities	12,853	144.7	160.5	167.3	174.2	177.2
Coke and gas plants	13,736	89.2	89.7	84.0	84.2	92.3
Retail dealers	2,796	41.6	38.3	35.7	23.5	29.5
All others	5,553	115.5	115.7	111.7	120.4	110.0

See footnotes at end of table.

Table 40.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1966	1967	1968	1969	1970
East North Central—Continued						
Illinois	[5] 42,718	108.6	109.3	101.7	105.9	99.0
Electric utilities	18,584	149.6	158.7	151.9	163.5	158.5
Coke and gas plants	3,925	92.4	87.9	78.2	94.6	94.0
Retail dealers	8,623	49.4	47.2	38.4	35.7	30.0
All others	[5] 11,586	92.2	83.6	76.5	69.6	56.8
Michigan	26,255	132.4	133.2	140.1	135.9	139.5
Electric utilities	9,839	187.7	199.3	211.7	217.8	236.2
Coke and gas plants	4,877	102.8	94.1	100.8	98.9	101.3
Retail dealers	3,368	54.4	44.1	43.8	34.6	29.9
All others	8,171	115.8	113.5	117.1	101.0	91.0
Wisconsin	11,174	134.7	139.4	134.9	134.0	154.9
Electric utilities	4,967	152.7	168.3	167.6	171.8	221.2
Coke and gas plants	558	83.0	89.1	60.8	77.6	63.1
Retail dealers	1,457	145.2	131.4	136.9	119.4	104.5
All others	4,192	116.6	114.8	105.4	101.8	106.1
West North Central	[5] 20,824	124.7	128.5	131.3	145.7	168.5
Electric utilities	8,278	198.8	214.9	238.8	261.0	333.1
Coke and gas plants	1,518	76.5	75.6	40.5	89.3	59.1
Retail dealers	4,079	46.3	40.3	38.5	37.9	30.7
All others	[5] 6,949	93.2	88.9	77.7	83.9	77.4
Minnesota	5,332	144.0	133.9	137.5	151.9	164.5
Electric utilities	1,810	255.5	228.6	277.6	253.6	341.5
Coke and gas plants	1,206	78.9	77.0	32.3	82.2	50.1
Retail dealers	553	128.8	123.9	143.8	157.0	122.1
All others	1,763	79.0	78.9	63.7	93.6	74.2
Iowa	[5] 4,878	111.5	113.8	112.3	116.3	126.3
Electric utilities	1,846	157.9	174.8	185.6	199.1	227.0
Retail dealers	1,254	35.2	28.3	21.0	18.5	16.7
All others	[5] 1,778	117.2	110.6	100.6	99.3	98.9
Missouri	6,862	123.8	136.8	137.0	161.7	195.2
Electric utilities	2,605	228.3	266.6	272.3	342.7	441.3
Coke and gas plants	312	67.0	70.2	72.1	117.0	93.9
Retail dealers	1,495	18.5	12.6	10.0	8.2	7.3
All others	2,450	84.2	83.1	78.9	68.7	61.1
North Dakota and South Dakota	2,416	124.0	141.8	156.5	165.4	198.6
Electric utilities	1,378	157.7	190.3	227.0	237.5	297.8
Retail dealers	517	77.0	71.0	60.3	44.5	39.7
All others	521	81.6	84.1	65.5	94.6	94.2
Nebraska and Kansas	1,336	102.3	93.9	101.8	110.0	147.8
Electric utilities	639	124.6	134.7	171.4	178.2	250.4
Retail dealers	260	23.1	17.7	19.6	36.2	21.2
All others	437	116.9	79.4	49.0	54.2	73.0
South Atlantic	52,560	153.1	168.4	168.2	170.4	174.2
Electric utilities	22,251	231.5	267.7	272.1	279.4	293.4
Coke and gas plants	11,321	92.0	91.4	88.1	92.6	89.6
Retail dealers	4,765	52.6	50.6	50.7	42.5	38.7
All others	14,223	112.9	113.7	108.9	104.8	100.5
Delaware and Maryland	10,358	136.0	144.4	142.7	144.9	134.5
Electric utilities	3,000	270.3	290.4	286.5	278.1	259.7
Coke and gas plants	5,414	91.7	99.6	93.2	99.2	93.0
Retail dealers	420	26.4	22.1	21.4	18.8	16.4
All others	1,524	58.8	49.5	68.6	79.9	67.7
District of Columbia	1,097	[6] 81.8	[6] 80.8	[6] 80.9	112.6	101.5
Electric utilities	609	81.6	89.7	110.5	125.5	111.8
Retail dealers	188	53.7	47.3	44.1	42.6	25.0
All others	300	[6] 99.7	[6] 83.7	[6] 43.7	130.0	128.3
Virginia	10,553	135.3	140.8	137.6	123.1	104.9
Electric utilities	4,435	185.9	200.6	204.3	185.8	150.0
Coke and gas plants	165	157.6	43.6	2.4	7.3	16.4
Retail dealers	1,756	47.3	42.9	41.0	32.8	31.3
All others	4,197	117.8	122.3	112.9	99.3	91.4
West Virginia	15,771	127.4	147.4	155.8	154.4	154.7
Electric utilities	6,290	152.5	201.4	218.0	220.1	227.8
Coke and gas plants	5,742	90.4	85.1	85.8	88.9	88.5
Retail dealers	302	101.7	129.8	140.7	87.7	74.8
All others	3,437	147.4	154.1	160.2	149.6	138.5
North Carolina	8,716	176.1	210.0	194.0	214.7	248.9
Electric utilities	4,953	246.8	289.7	281.8	324.5	385.1
Retail dealers	1,248	51.2	51.0	49.6	44.6	41.3
All others	2,515	98.9	100.6	92.8	82.9	83.7
South Carolina	3,050	167.8	182.1	153.9	174.4	201.4
Electric utilities	856	378.5	452.9	381.0	427.6	485.2
Retail dealers	321	92.2	83.8	85.7	94.7	90.3
All others	1,873	84.5	75.2	61.9	72.3	90.8

See footnotes at end of table.

Table 40.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted) 1966	1967	1968	1969	1970
South Atlantic—Continued						
Georgia and Florida	3,015	351.7	381.2	399.7	396.4	438.4
Electric utilities	2,108	455.3	499.0	534.8	533.2	597.7
Retail dealers	530	42.1	33.4	38.7	30.8	28.1
All others	377	208.0	211.1	152.0	145.6	124.7
East South Central	43,283	126.9	141.7	139.7	144.9	159.8
Electric utilities	23,572	159.8	184.2	180.7	189.7	215.7
Coke and gas plants	10,380	90.0	97.0	92.1	98.6	99.2
Retail dealers	2,494	50.7	46.1	50.1	53.2	55.7
All others	6,837	97.3	97.8	103.5	94.4	97.1
Kentucky	11,167	158.0	170.6	168.5	182.3	212.0
Electric utilities	6,758	187.6	208.4	208.6	232.3	282.7
Coke and gas plants	1,683	104.0	116.3	108.8	108.6	94.5
Retail dealers	834	66.2	59.7	67.1	64.7	72.2
All others	1,892	140.0	132.3	122.9	121.1	125.3
Tennessee	15,104	98.1	120.4	111.4	111.2	121.1
Electric utilities	9,876	115.7	149.6	133.8	138.1	156.9
Coke and gas plants	258	69.8	67.4	71.3	68.6	68.6
Retail dealers	1,206	50.4	46.0	48.4	54.4	52.9
All others	3,764	69.0	71.2	75.8	61.7	53.1
Alabama and Mississippi	17,012	132.1	141.6	146.0	150.4	159.9
Electric utilities	6,938	195.3	209.7	220.4	221.6	234.2
Coke and gas plants	8,439	87.8	94.0	89.4	97.6	101.1
Retail dealers	454	22.9	21.4	23.1	28.9	33.0
All others	1,181	119.5	127.2	160.5	115.9	192.0
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,868	58.0	51.1	52.2	49.7	61.2
Electric utilities [7]	65	.0	.0	.0	.0	.0
Coke and gas plants	1,050	90.3	78.3	80.8	87.7	107.1
Retail dealers	161	17.4	14.3	8.1	4.3	5.6
All others	592	18.2	18.6	19.4	0.2	1.7
Mountain	8,779	160.6	162.4	169.4	187.0	230.5
Electric utilities	1,437	605.0	639.0	674.2	792.8	1,045.8
Coke and gas plants	3,772	83.9	77.5	79.7	75.5	78.5
Retail dealers	1,350	77.3	71.6	63.2	60.9	53.9
All others	2,220	53.9	53.6	59.5	61.1	68.2
Colorado	3,264	144.1	144.6	152.2	143.6	157.4
Electric utilities	687	401.5	424.9	439.8	434.6	475.1
Coke and gas plants	1,324	93.1	79.8	85.3	69.4	77.3
Retail dealers	326	105.2	88.7	96.9	98.8	83.1
All others	927	40.1	49.1	54.0	49.6	62.2
Utah	3,748	79.3	76.1	75.7	79.5	80.3
Electric utilities	367	132.4	130.5	132.7	111.4	126.2
Coke and gas plants	2,448	78.9	76.2	76.7	78.8	79.1
Retail dealers	334	55.7	57.8	40.1	49.7	38.6
All others	599	61.9	52.8	56.4	79.1	80.3
Montana and Idaho	923	107.8	104.9	112.9	115.2	115.4
Electric utilities [8]	1	181.6	183.3	265.4	334.6	364.2
Retail dealers	593	63.6	72.0	59.2	49.9	38.4
All others	329	89.1	64.7	65.7	51.1	56.2
Wyoming	607	428.5	410.9	445.1	547.6	627.5
Electric utilities	340	716.8	673.8	717.1	905.0	1,055.6
Retail dealers	61	63.9	45.9	49.2	42.6	41.0
All others	206	60.7	85.0	113.6	107.3	94.7
New Mexico [9]	92	184.1	223.1	211.3	288.3	532.9
Electric utilities [9]	37	190.5	230.8	218.6	299.4	554.9
Retail dealers	12	58.3	41.7	33.3	16.7	8.3
All others	43	30.2	39.5	37.2	27.9	23.3
Arizona and Nevada	145	509.7	482.8	640.7	760.7	813.8
Electric utilities [10]	5	186.3	197.3	267.2	320.0	310.1
Retail dealers	24	383.3	104.2	75.0	41.7	308.3
All others	116	19.8	12.1	13.8	18.1	57.8
Pacific	3,142	82.0	82.5	81.0	85.4	85.6
Electric utilities	4	.0	.0	.0	.0	.0
Coke and gas plants	1,708	107.7	118.1	121.3	123.7	127.5
Retail dealers	377	71.1	54.4	40.8	62.1	54.6
All others	1,053	44.4	35.1	30.4	31.9	29.2
Washington and Oregon	1,324	51.9	40.9	33.9	34.1	28.2
Electric utilities	3	.0	.0	.0	.0	.0
Retail dealers	367	69.2	52.0	39.0	35.7	21.3
All others	954	45.4	36.7	32.1	33.6	31.0
California	1,818	103.9	112.8	115.3	122.7	127.4
Electric utilities	1	.0	.0	.0	.0	.0
Coke and gas plants	1,708	107.7	118.1	121.3	123.7	127.5
Retail dealers	10	140.0	140.0	110.0	1,030.0	1,280.0
All others	99	35.4	20.2	14.1	15.2	12.1

See footnotes at end of table.

Table 40.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1966	1967	1968	1969	1970
Alaska	829	103.5	114.8	97.0	81.1	73.8
Electric utilities	470	43.4	28.7	28.1	29.6	32.1
Retail dealers	49	89.8	87.8	75.5	67.3	55.1
All others	310	196.8	249.7	204.8	161.3	140.0
Canada [11]	17,878	88.4	85.3	93.7	93.7	104.4
Electric utilities	567	794.7	869.8	998.4	1,160.0	1,465.6
Coke and gas plants	4,602	127.2	119.8	145.5	140.1	156.9
Retail dealers	857	65.1	51.6	60.2	47.8	45.6
All others	7,183	61.4	55.3	47.2	38.8	34.2
Canadian Great Lakes commercial docks (consumer use not available)	2,785	15.4	13.2	16.2	18.0	9.4
Canadian railroad companies	1,884	2.5	1.8	1.6	1.5	1.6
Mexico [12]	NA	94.7	108.8	129.8	147.7	286.0
All others [12]	NA	94.7	108.8	129.8	147.4	286.0
Destinations not revealable: [13]	-------	87.8	72.0	154.9	157.6	[1] 215.1
Electric utilities [13]	-------	62.0	98.0	237.4	292.4	221.9
Coke and gas plants [13]	-------	83.4	42.8	78.3	102.1	254.8
Retail dealers [13]	-------	80.8	49.5	59.6	136.4	146.5
All others [13]	-------	124.6	72.7	147.8	50.0	[1] 187.3
Destinations not available:						
Great Lakes vessel fuel [14]	1,859	56.7	47.2	47.3	51.2	57.7
Tidewater bunker fuel [14]	41	31.7	12.2	.0	.0	.0
Railroad fuel, United States companies [15]	7,697	16.4	14.9	12.7	10.7	9.4

NA Not available.
[1] Includes overseas exports from producing districts 13 and 17.
[2] For Great Lakes dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 304,000 tons.
[3] For tidewater dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 26,000 tons.
[4] Excludes overseas exports from producing districts 13 and 17.
[5] District 15 shipments to Illinois included with Iowa.
[6] A considerable block of tonnage is included under "Destinations not revealable."
[7] For electric utilities in Arkansas, Louisiana, Oklahoma, and Texas the annual base period is 1963 = 100. The 1963 tonnage shipped to electric utilities was 24,000 tons.
[8] For electric utilities in Montana and Idaho the annual base period is 1959 = 100. The 1959 tonnage shipped to electric utilities was 179,000 tons.
[9] For total shipments and electric utilities to New Mexico the annual base period is 1963 = 100. Total shipments to New Mexico were 1,132,000 tons and for electric utilities 1,085,000 tons.
[10] For electric utilities in Arizona and Nevada the annual base period is 1962 = 100. The 1962 annual tonnage shipped to electric utilities was 335,000 tons.
[11] Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.
[12] Since tonnages for Mexico were first published in 1960, yearly indexes are based on 1960 = 100. The 1960 tonnages were total 57,000, all others 57,000.
[13] Since "Destinations not revealable" were first published during 1960, the calendar year indexes are based on 1960 = 100. These figures are as follows: Calendar year total not revealable 1,380,000, electric utilities 497,000, coke and gas plants 374,000, retail dealers 99,000, and all others 410,000.
[14] Included in summary at beginning of table in "All others."
[15] Included in summary at beginning of table in "Railroad fuel."

Table 41.—Shipments of bituminous coal and lignite and average sulfur content by consumer use in 1970 [1]

State of origin	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	Electric utilities	Coke and gas plants	Other industrial uses and retail dealers	All other uses	Exports (overseas and Canada)	Total
Alabama	7,777	5,027	874	203	370	14,251	1.5	1.0	1.1	1.3	1.2	1.4
Alaska	209	------	36	301	------	546	.2	---	.2	.2	---	.2
Arkansas	------	------	137	------	------	137	---	---	2.5	---	---	2.5
Colorado	2,603	1,766	491	64	15	4,939	.5	.7	.6	.7	.6	.6
Illinois	35,109	2,432	9,743	349	------	47,633	3.5	.8	2.8	2.8	---	3.2
Indiana	14,383	15	3,424	80	------	[2] 17,901	3.3	NA	2.3	2.7	---	3.3
Iowa	647	------	------	53	------	700	3.5	---	---	4.8	---	3.7
Kansas	4	------	------	------	------	4	5.5	---	---	5.5	---	5.5
Kentucky:												
Eastern	5,469	6,833	2,314	1,027	1,747	17,390	1.2	.7	.9	1.0	.7	.9
Western	40,117	94	3,110	87	------	43,408	4.1	---	3.7	3.1	---	4.0
Maryland	509	------	191	215	5	920	2.2	---	2.4	1.6	1.1	2.1
Missouri	3,746	------	233	3	------	3,982	5.7	---	4.5	4.5	---	5.6
Montana	3,357	------	5	66	------	3,428	1.1	---	1.1	1.0	---	1.1
New Mexico	6,415	912	11	------	6	7,344	.7	.5	.5	.5	.5	.7
North Dakota	4,329	------	711	44	------	5,084	.9	---	.6	.7	---	.8
Ohio	30,348	124	7,257	1,252	32	[2] 39,012	3.2	---	3.3	3.3	2.8	3.2
Oklahoma	1,618	449	148	6	202	2,423	3.9	.8	3.6	.5	.5	3.1
Pennsylvania	16,835	18,113	5,931	2,338	2,897	46,114	2.3	1.3	2.0	2.1	1.9	1.7
Tennessee	1,623	------	187	372	------	2,182	1.8	---	1.6	.8	---	1.6
Utah	841	1,817	906	169	295	4,028	.5	.8	.5	.5	.8	.7
Virginia	3,575	4,667	2,409	302	3,620	14,573	1.0	.6	1.0	.8	.6	.8
Washington	------	------	32	------	------	32	---	---	.6	---	---	.6
West Virginia	30,844	23,881	7,253	1,764	23,270	87,012	2.7	.8	1.5	1.3	.9	1.6
Wyoming	5,153	------	441	47	------	5,641	.8	---	.7	.8	---	.8
Total United States	215,511	66,130	45,844	8,742	32,459	[2] 368,686	2.9	1.0	2.2	1.8	.9	2.3

NA Not available.
[1] Total shipments by producers reporting sulfur content (61 percent of total U.S. production).
[2] Data may not add to totals shown because of independent rounding.

Table 42.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced in the United States, by States

State	1969				1970			
	Underground	Strip	Auger	Total	Underground	Strip	Auger	Total
Alabama	$9.44	$5.23	$5.55	$7.47	$11.33	$5.52	$5.75	$8.09
Alaska	----	6.54	----	6.54	----	7.39	----	7.39
Arkansas	8.43	7.71	----	7.90	9.01	8.13	----	8.30
Colorado	6.15	3.59	----	5.27	7.05	3.71	----	5.85
Illinois	4.43	4.23	----	4.32	5.33	4.53	----	4.92
Indiana	4.77	4.05	----	4.13	5.79	4.47	----	4.60
Iowa	3.77	3.75	----	3.76	4.03	4.17	----	4.11
Kansas	----	5.42	----	5.42	----	5.59	----	5.59
Kentucky	4.57	3.53	3.39	4.14	6.75	4.46	5.37	5.68
Maryland	3.77	4.01	2.30	3.85	5.25	4.87	5.99	5.01
Missouri	4.33	4.33	----	4.33	----	4.39	----	4.39
Montana:								
Bituminous	9.17	1.83	----	2.18	9.39	1.76	----	1.83
Lignite	----	2.03	----	2.03	----	2.13	----	2.13
Total	9.17	1.89	----	2.13	9.39	1.79	----	1.85
New Mexico	8.37	2.58	----	3.66	5.54	2.50	----	2.89
North Dakota (lignite)	----	1.85	----	1.85	----	1.95	----	1.95
Ohio	4.65	3.79	3.63	4.10	5.43	4.41	4.18	4.74
Oklahoma	7.83	5.65	8.43	5.80	13.86	5.50	8.43	6.27
Pennsylvania	6.53	4.24	4.04	5.87	8.12	5.38	5.51	7.27
Tennessee	3.94	3.65	3.27	3.80	5.07	4.71	4.69	4.90
Utah	6.31	----	----	6.31	7.28	----	----	7.28
Virginia	5.73	3.64	3.43	5.42	7.62	4.66	4.64	7.03
Washington	8.40	6.26	----	8.21	13.47	8.50	----	12.81
West Virginia	5.90	4.77	4.61	5.73	8.07	7.06	8.34	7.93
Wyoming	6.40	3.27	----	3.36	6.72	3.33	----	3.38
Total	5.62	3.98	3.81	4.99	7.40	4.69	6.08	6.26

Table 43.—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, in 1970, by States

(Thousand short tons)

State	Production			Average value per ton, f.o.b. mines		
	Sold in open market	Not sold in open market	Total	Sold in open market	Not sold in open market	Total
Alabama	12,664	7,896	20,560	$6.41	$10.78	$8.09
Alaska	57	492	549	9.41	7.15	7.39
Arizona	132	-------	132	W	----	W
Arkansas	268	-------	268	8.30	----	8.30
Colorado	4,355	1,670	6,025	4.35	9.77	5.85
Illinois	62,983	2,136	65,119	4.86	6.96	4.92
Indiana	22,212	51	22,263	4.60	4.47	4.60
Iowa	929	59	[1] 987	4.13	3.77	4.11
Kansas	1,627	-------	1,627	5.59	----	5.59
Kentucky	116,941	8,364	125,305	5.50	8.19	5.68
Maryland	1,615	-------	1,615	5.01	----	5.01
Missouri	4,447	-------	4,447	4.39	----	4.39
Montana:						
Bituminous	3,124	-------	3,124	1.83	----	1.83
Lignite	323	-------	323	2.13	----	2.13
Total	3,447	-------	3,447	1.85	----	1.85
New Mexico	6,068	1,293	7,361	2.45	4.95	2.89
North Dakota (lignite)	5,520	119	5,639	1.91	4.00	1.95
Ohio	48,773	6,579	[1] 55,351	4.76	4.61	4.74
Oklahoma	2,427	-------	2,427	6.27	----	6.27
Pennsylvania	50,962	29,529	80,491	6.32	8.90	7.27
Tennessee	8,218	19	8,237	4.90	6.87	4.90
Utah	2,835	1,898	4,733	5.01	10.67	7.28
Virginia	34,757	259	35,016	7.03	8.00	7.03
Washington	37	-------	37	12.81	----	12.81
West Virginia	125,229	18,843	144,072	7.65	8.76	7.93
Wyoming	4,751	2,472	[1] 7,222	3.61	2.95	3.38
Total	[1] 521,253	81,679	[1] 602,932	5.89	8.59	6.26

W Withheld to avoid disclosing individual company data.
[1] Data may not add to totals shown because of independent rounding.

Table 44.—Summary of operations at lignite mines [1] in the United States, in 1970, by States [2]

Item	Montana	North Dakota	Total [3]
Number of mines	2	20	22
Production (thousand short tons):			
Shipped by rail [4]	322	3,265	3,587
Shipped by truck	2	568	570
Mine-mouth generating plants	-----	460	460
Used at mines [5]	-----	1,346	1,346
Total [3]	323	5,639	5,963
Average value per ton	$2.13	$1.95	$1.88
Number of shovels and draglines	2	48	50
Average number of men working daily	17	306	323
Average number of days worked	218	241	240
Number of man-days worked (thousands)	4	74	78
Average tons per man per day	87.16	76.49	77.02

[1] All strip.
[2] Exclusive of Texas (lignite).
[3] Data may not add to totals shown because of independent rounding.
[4] Includes coal loaded at mines directly into railroad cars and hauled by trucks to railroad sidings.
[5] Includes coal used at mine for power and heat, used by mine employees, and for all other purposes at mine.

Table 45.—Exports of bituminous coal, by country groups

(Thousand short tons and thousand dollars)

Country group	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada (including Newfoundland) and Mexico	16,822	$143,021	16,905	$147,312	18,846	$197,934
Overseas (all other countries):						
West Indies and Central America	1	11	1	8	1	9
Bermuda, Greenland, Miquelon and St. Pierre Islands	3	30	3	41	2	44
South America	2,569	26,401	2,869	30,904	2,920	40,929
Europe	15,403	154,991	15,088	163,415	21,503	303,352
Asia	15,839	171,525	21,368	243,765	27,649	408,172
Africa	(1)	1	-------	-------	(1)	1
Oceania	-------	-------	(1)	7	23	349
Total	33,815	352,959	39,329	438,140	52,098	752,856
Grand total	50,637	495,980	56,234	585,452	70,944	950,790

[1] Less than ½ unit.

Table 46.—Bituminous coal exported from the United States, by countries [1]

(Thousand short tons and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	-------	-------	-------	-------	23	$346
Austria	-------	-------	-------	-------	65	919
Argentina	441	$4,450	477	$5,017	596	8,222
Belgium-Luxembourg	1,052	10,843	943	10,394	1,881	29,977
Brazil	1,787	18,227	1,843	19,818	2,020	27,691
Canada	16,748	142,156	16,789	145,710	18,673	195,133
Chile	306	3,343	519	5,697	275	4,705
Ecuador	-------	-------	20	253	-------	-------
France	1,459	13,787	2,253	24,192	3,346	46,177
Germany:						
East	101	1,171	87	1,111	396	5,942
West	3,785	36,273	3,451	34,942	5,022	65,876
Hong Kong	-------	-------	-------	-------	10	180
Ireland	168	1,707	83	918	69	1,014
Italy	4,254	43,576	3,679	40,824	4,205	59,711
Japan	15,822	171,418	21,367	243,753	27,637	407,963
Mexico	74	865	116	1,602	173	2,801
Miquelon and St. Pierre Islands	3	30	3	41	2	44
Netherlands	1,491	14,904	1,622	17,544	2,112	27,941
Norway	305	3,043	248	2,726	192	3,051
Portugal	-------	-------	15	230	-------	-------
Romania	83	953	72	891	70	1,380
Spain	1,480	15,923	1,825	20,910	3,153	46,971
Sweden	761	8,003	668	7,365	764	11,586
Switzerland	28	303	-------	-------	-------	-------
Uruguay	34	373	10	114	26	274
Yugoslavia	436	4,504	141	1,366	225	2,681
Other	19	128	3	34	9	105
Total	50,637	495,980	56,234	585,452	70,944	950,790

[1] Amounts stated do not include fuel or bunker coal on vessels engaged in foreign trade, which aggregated 107,749 tons ($1,097,120) in 1968; 59,152 tons ($738,409) in 1969; and 67,424 tons ($916,181) in 1970.

Table 47.—Bituminous coal exported from the United States, by customs districts

(Thousand short tons and thousand dollars)

Customs district	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore, Md	2,436	$22,501	2,654	$24,746	4,723	$62,880
Boston, Mass	-------	-------	1	10	-------	-------
Buffalo, N.Y	425	3,371	444	3,653	189	1,698
Chicago, Ill	29	203	43	298	9	102
Cleveland, Ohio	15,540	131,031	15,656	134,975	18,048	187,003
Detroit, Mich	92	914	70	728	69	1,050
Duluth, Minn	3	32	5	54	3	69
El Paso, Tex	44	559	45	616	64	831
Laredo, Tex	29	304	70	981	108	1,953
Los Angeles, Calif	8	80	93	1,073	262	3,579
Miami, Fla	-------	-------	-------	-------	(1)	3
Milwaukee, Wis	10	73	-------	-------	-------	-------
Mobile, Ala	1	7	1	6	378	4,465
New Orleans, La	31	354	79	852	460	5,597
New York City	85	873	-------	-------	10	108
Norfolk, Va	31,820	334,781	37,023	416,918	46,223	676,344
Ogdensburg, N.Y	64	682	40	442	30	414
Pembina, N.D	9	86	-------	-------	3	61
Philadelphia, Pa	-------	-------	6	53	297	3,625
Port Arthur, Tex	-------	-------	-------	-------	16	263
Portland, Maine	1	17	1	9	-------	-------
Portland, Oreg	-------	-------	-------	-------	51	708
Providence, R.I	5	44	-------	-------	-------	-------
St. Albans	5	64	1	14	-------	-------
San Diego, Calif	(1)	2	(1)	5	1	17
San Francisco, Calif	-------	-------	-------	-------	(1)	(1)
Savannah, Ga	(1)	2	-------	-------	-------	-------
Seattle, Wash	-------	-------	2	19	(1)	19
Tampa, Fla	-------	-------	(1)	(1)	(1)	1
Total	50,637	495,980	56,234	585,452	70,944	950,790

[1] Less than ½ unit.

Table 48.—Bituminous coal [1] imported for consumption in the United States, by countries and customs districts

Country and customs district	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Country:						
Australia	90	$2	-------	-----	-------	-----
Canada	224,298	1,897	r 108,857	$1,074	36,312	$450
India	-------	-----	30	3	85	4
Japan	-------	-----	-------	-----	15	2
Netherlands	-------	-----	11	2	-------	-----
Norway	-------	-----	-------	-----	16	(2)
South Africa, Republic of	-------	-----	6	2	-------	-----
United Kingdom	6	1	-------	-----	13	1
Total	224,394	1,900	r 108,904	1,081	36,441	457
Customs district:						
Buffalo, N.Y	1,344	26	2,297	34	1,416	29
Chicago, Ill	36,525	237	98	2	-------	-----
Detroit, Mich	129	3	18	2	104	3
Duluth, Minn	10,212	153	4,371	65	7,185	103
Great Falls, Mont	10,103	100	35,845	304	17,145	160
Honolulu, Hawaii	-------	-----	-------	-----	15	1
Minneapolis, Minn	6	1	-------	-----	-------	-----
Mobile, Ala	-------	-----	-------	-----	16	(2)
New York City	-------	-----	41	r 6	85	4
Pembina, N.D	12,430	177	12,796	185	10,460	155
Philadelphia, Pa	90	2	6	2	13	1
Portland, Maine	153,555	1,201	43,779	401	2	1
St. Louis, Mo	-------	-----	-------	-----	(2)	(2)
Seattle, Wash	-------	-----	9,653	80	-------	-----
Total	224,394	1,900	r 108,904	1,081	36,441	457

r Revised; Ogdensburg, N.Y. district revised to none.
[1] Includes slack, culm, and lignite.
[2] Less than ½ unit.

Table 49.—Bituminous coal, anthracite, and lignite: World production, by countries

(Thousand short tons)

Country [1]	1968	1969	1970 p
North America:			
Canada:			
Bituminous	8,758	8,652	12,785
Lignite	2,250	2,021	3,820
Greenland: Bituminous	30	23	e 22
Mexico: Bituminous	r 2,872	2,709	2,980
United States:			
Anthracite (Pennsylvania)	11,461	10,473	9,729
Bituminous	540,428	555,493	596,969
Lignite [2]	4,817	5,012	5,963
South America:			
Argentina: Bituminous	520	575	e 585
Brazil: Bituminous (marketable)	2,606	2,685	2,609
Chile: Bituminous	1,776	1,878	1,669
Colombia: Anthracite and bituminous	3,417	3,656	e 3,660
Peru:			
Anthracite	8	8	e 8
Bituminous	169	171	e 172
Venezuela: Bituminous	34	35	44
Europe:			
Albania: Lignite [3]	638	e 705	736
Austria: Lignite [4]	r 4,604	4,234	4,045
Belgium:			
Anthracite	5,409	4,863	4,063
Bituminous	10,912	9,687	8,461
Bulgaria:			
Anthracite	194	198	e 198
Bituminous	290	210	e 240
Lignite [3]	31,176	31,561	31,786
Czechoslovakia:			
Bituminous	28,580	29,837	31,076
Lignite [3]	82,546	87,454	89,466
Denmark: Lignite	838	475	e 440
France:			
Anthracite	11,688	11,116	10,850
Bituminous	34,511	33,619	30,326
Lignite	3,551	3,252	3,070
Germany, East:			
Bituminous	1,741	1,468	e 1,400
Lignite [3]	272,395	280,596	287,262
Germany, West:			
Anthracite	12,507	11,692	10,700
Bituminous	110,965	111,061	113,541
Lignite	111,902	118,415	118,792
Pech	919	841	739
Greece: Lignite	6,314	7,423	8,576
Hungary:			
Bituminous	4,676	4,556	4,576
Lignite [3]	25,321	24,653	26,102
Ireland:			
Anthracite	114	e 110	87
Bituminous	69	e 59	83
Italy:			
Bituminous	402	334	330
Lignite	1,905	2,131	1,536
Netherlands:			
Anthracite	6,191	6,098	5,010
Bituminous	1,376	272	---------
Poland:			
Bituminous	141,801	148,823	154,435
Lignite [3]	29,630	34,022	36,118
Portugal:			
Anthracite	438	398	299
Lignite	34	9	e 9
Romania:			
Anthracite [5]	17	17	17
Bituminous [5]	7,902	8,288	e 9,000
Lignite [3]	10,082	12,035	e 23,580
Spain:			
Anthracite	3,155	3,050	3,166
Bituminous	10,428	9,767	8,614
Lignite	3,097	3,020	3,115
Svalbard (Spitzbergen): Bituminous:			
Controlled by Norway	381	424	513
Controlled by U.S.S.R. (shipments) e	440	440	440
Sweden: Bituminous	22	24	e 11

See footnotes at end of table.

Table 49.—Bituminous coal, anthracite, and lignite: World production, by countries—Continued

(Thousand short tons)

Country [1]	1968	1969	1970 p
Europe—Continued			
U.S.S.R.: [6]			
Anthracite	84,763	84,684	e 87,000
Bituminous	417,759	430,443	e 436,000
Lignite [3]	r 152,448	154,859	e 165,000
United Kingdom:			
Anthracite	4,345	4,002	4,061
Bituminous	179,414	164,619	155,292
Yugoslavia:			
Bituminous	920	752	709
Lignite [3]	28,546	28,456	30,621
Africa:			
Algeria: Bituminous [7]	(8)	30	e 18
Congo (Kinshasa): Bituminous	78	73	112
Morocco: Anthracite	497	438	477
Mozambique: Bituminous	346	305	387
Nigeria: Bituminous	(9)	17	39
Rhodesia, Southern: Bituminous	[10] 3,608	[10] 3,673	e 3,700
South Africa, Republic of (marketable):			
Anthracite	1,505	1,699	1,850
Bituminous	55,435	56,450	58,349
Swaziland: Bituminous	107	115	136
Tanzania: Bituminous	4	3	3
United Arab Republic: Bituminous	---------	4	---------
Zambia: Bituminous	633	438	676
Asia:			
Afghanistan: Bituminous [11]	r 138	150	e 150
Burma: Bituminous	r 17	17	e 17
China, mainland:			
Anthracite e	r 22,000	22,000	22,000
Bituminous and lignite e	308,000	338,000	378,000
India:			
Bituminous	78,058	83,126	79,816
Lignite	4,548	4,616	3,908
Indonesia: Bituminous	194	211	195
Iran: Bituminous [11]	331	276	356
Japan:			
Anthracite	1,641	1,350	1,145
Bituminous	49,698	47,913	42,611
Lignite	369	274	438
Korea, North:			
Anthracite	r 20,400	22,200	24,000
Bituminous and lignite	5,000	5,400	6,300
Korea, Republic of (South): Anthracite	11,290	11,324	13,662
Mongolia: Bituminous and lignite	1,380	1,600	1,930
Pakistan: Bituminous and lignite	1,404	1,400	e 1,500
Philippines: Bituminous	35	58	47
Taiwan: Bituminous	5,527	5,120	4,931
Thailand: Lignite e	335	384	440
Turkey:			
Bituminous [10]	4,753	5,234	4,820
Lignite [10]	5,818	6,075	6,272
Vietnam, North: Anthracite e	3,300	3,300	3,300
Oceania:			
Australia:			
Bituminous	45,006	50,851	54,548
Lignite	r 25,728	25,602	26,679
New Zealand:			
Bituminous	2,491	2,606	2,669
Lignite	190	188	219
World total:			
Anthracite	200,923	199,020	201,622
Bituminous [12]	1,757,160	1,784,415	1,827,201
Lignite	809,082	837,472	867,984
Mixed Grades [13]	319,201	350,056	391,390
All grades	3,086,366	3,170,963	3,288,197

e Estimated. 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 Includes material reported in national sources as brown coal.

4 Available sources give only lignite production; a small quantity of bituminous coal also may be produced.

5 Official sources report the aggregate of anthracite and bituminous, distribution to these separate grades is estimated from reported total.

6 Run of mine.

7 May include a small amount of anthracite.

8 Less than ½ unit.

9 Revised to none.

10 Sales.

11 Year beginning March 21 of that stated.

12 Includes pech coal from West Germany.

13 Anthracite plus bituminous coal for Colombia and bituminous plus lignite for mainland 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.

Production of Pennsylvania anthracite in 1970 was from 209 underground mines, 179 strip pits, 97 culm and silt banks, and five dredges, and totalled 9.7 million short tons, a decrease of 7 percent from that of 1969. Of this total, 47 percent was produced at strip mines, 31 percent at culm and silt banks, 18 percent at underground mines, and 4 percent from river dredging. Compared with tonnages produced in 1969, dredging declined 24 percent; underground production, 17 percent; culm and silt banks, 7 percent; and strip mine production, less than 1 percent.

Total value of the 1970 output was $105.3 million, an increase of 5 percent over that in 1969. Production of pea and larger sizes declined 8 percent from that of 1969, and the buckwheat No. 1 and smaller category, 7 percent. Although the pea and larger sizes amounted to 34.4 percent of 1970's output (35.1 percent in 1969), they accounted for 45.8 percent of the industry's total revenue because of higher prices received for these sizes. The average value for the pea and larger sizes was $15.06 f.o.b. preparation plant, a gain of $1.50; while the average value for the buckwheat and smaller was $8.92, a gain of $0.99. As a result, the average value for all sizes (excludes dredge coal), increased to $11.03, 11 percent more than in 1969.

Apparent consumption of anthracite in the United States during 1970 was estimated at 8.2 million tons, a decline of 6.4 percent. Although use data are incomplete for anthracite, the major part of the loss was attributed to the continuing decline in the demand for anthracite for space-heating.

Exports of anthracite totaled 789,499 tons, an increase of 26 percent over the 627,492 tons shipped in 1969. The increase was attributed to the greater demand from Asia and Europe. A more accurate measurement of the importance of exports to the industry 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. This computation indicates that approximately 1,481 million tons were actually exported, or about 15 percent of the total 1970 production.

Although there was a decline in production, the average number of men working daily at anthracite operations remained approximately the same, as the productivity rate decreased approximately .90 tons per man-day; 6.55 tons in 1970, as compared with 7.45 tons in 1969. The total number of man-days worked was 1,447,000, or approximately 5 percent more than in 1969.

Legislation and Government Programs.—State and Federal Government programs in the environmental area continued through 1970 and included underground mine fire control, refuse or culm bank-fire control, surface subsidence, mine-water drainage control, and reclamation of old strip pits.

A survey of anthracite solid waste accumulations (refuse banks) undertaken in 1967, disclosed a total of 861 banks containing over 910 million cubic yards of material that occupy a total of about 19 square miles. In relating the distribution of these banks to urban areas in the four anthracite fields, it was discovered that 73 percent, or 582, of the banks are located within 2 miles of the traffic centers of the principal areas of population. Twenty-

[1] Statistical assistant, Division of Fossil Fuels.

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1966	1967	1968	1969	1970
Production:					
Preparation plants short tons	12,139,106	11,481,582	10,799,260	9,920,130	9,304,221
Dredges do	661,017	631,660	605,920	535,369	409,354
Used at collieries for power and heat do	141,141	142,821	55,653	17,417	15,823
Total production do	12,941,264	12,256,063	11,460,833	10,472,916	9,729,398
Value thousands	$100,663	$96,160	$97,245	$100,770	$105,341
Average sales realization per short tons on preparation plant shipments (excludes dredge coal):					
Pea and larger	$11.11	$11.53	$12.40	$13.56	$15.06
Buckwheat No. 1 and smaller	$6.40	$6.35	$6.87	$7.93	$8.92
All sizes	$8.08	$8.15	$8.78	$9.91	$11.03
Percentage of total preparation plant shipment (excludes dredge coal):					
Pea and larger	35.6	34.8	34.6	35.1	34.4
Buckwheat No. 1 and smaller	64.4	65.2	65.4	64.9	65.6
Exports [1] short tons	766,025	594,797	518,159	627,492	789,499
Consumption, apparent [2] do	11,400,000	10,800,000	10,160,000	8,809,000	8,248,000
Average number of days worked	203	219	217	232	241
Average number of men working daily	9,292	7,750	6,932	5,927	6,000
Output per man per day short tons	6.87	7.21	7.62	7.45	6.55
Output per man per year do	1,395	1,579	1,654	1,728	1,516
Quantity cut by machines do	246,658	146,908	61,245	68,300	125,779
Quantity mined by stripping do	5,253,408	4,740,187	4,696,163	4,578,732	4,541,452
Quantity loaded by machines underground do	2,590,547	1,997,806	1,475,000	1,326,598	1,150,596
Distribution:					
Receipts in New England [3] do	[4] 149,010	---------	---------	---------	---------
Exports to Canada [1] do	624,280	448,744	401,314	472,763	438,008
Loaded into vessels at Lake Erie [5]	208,432	206,975	204,682	209,000	154,002

[1] U.S. Department of Commerce, 1966–70 export data does not include shipments to U.S. military forces. See NOTE, tables 3 and 28.
[2] Beginning with 1961 exports to the U.S. military forces in West Germany were taken into consideration. See NOTE, tables 3 and 28.
[3] Commonwealth of Massachusetts, Division on the Necessaries of Life.
[4] Data discontinued after September 1966.
[5] Ore and Coal Exchange, Cleveland, Ohio.

seven banks were burning at the time the survey was taken.

Current environmental problems in the highly populated northeastern part of Pennsylvania are attributed to past unregulated mining methods. Smoke and noxious gases emanate from burning refuse banks, acid mine water pollutes streams, and hazardous deep and surface mine openings pose a serious threat to public safety and economic growth.

Long-range plans are being projected toward completely eliminating the refuse banks and pits, which are unsightly and unsafe. The quantity of material in refuse banks is currently being diminished to some extent by reclaiming marketable coal, and by using the waste for backfilling of abandoned strip pits and underground mines.

A program was initiated to develop methods and to demonstrate the feasibility of quenching and removing burning coal refuse. An important phase of the project involved setting up instruments to monitor the atmosphere. Data were obtained concerning the types and concentration of gases and dust emitted from burning refuse banks. A preliminary report of investigation evaluating the cost data, quenching and excavating cycles, safety procedures, equipment performance, and environmental factors (control of fumes and dust) was prepared.

Projects were also undertaken in surface subsidence control caused by underground mine voids. Research on underground void filling and sealing with dry ash was extended to include the use of fly ash-cement-water grouts containing up to 10 percent portland cement and 100 gallons of water per ton of solid. Flow characteristics of the mixture were good, and the airtight seals obtained served as effective roof support. The method has now been applied in anthracite coal fields where underground fires or subsidences have created serious problems.

The Bureau of Mines and the Geological Survey continued to gather hydrologic data for evaluating mine water problems. The studies involve determination of the varying heights of underground mine pools, hydrostatic pressure effects upon barrier pillars and mine dams protecting active

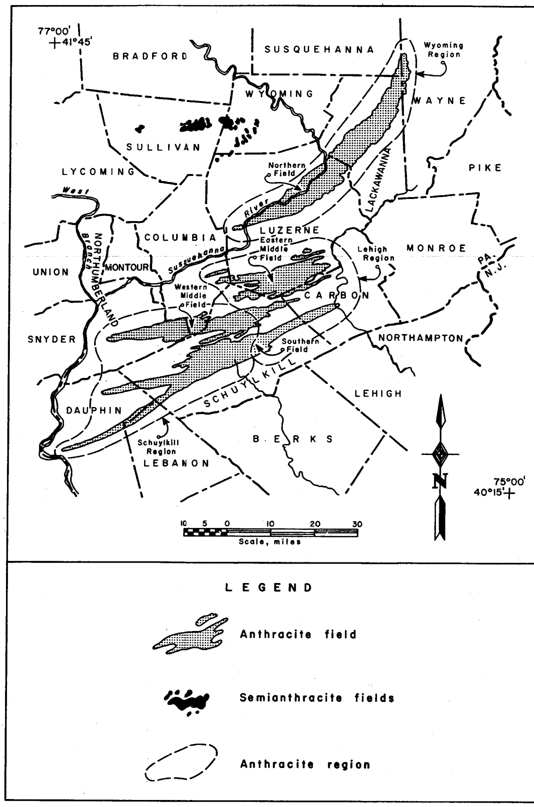

Figure 1.—Coalfields, regions, and counties of the Pennsylvania anthracite area.

mining operations and discharges from flooded mines into surface streams.

The Commonwealth of Pennsylvania contracted for an acid mine discharge plant to be located near Wilkes-Barre, Pa. The plant would treat 5 million gallons of acid water per day now flowing into the Susquehanna River. It will employ flash evaporation to produce ultrapure water for sale. Plans call for obtaining steam from proposed independent electric stations which would use culm as a fuel; otherwise, the plant will include its own boilers.

Project location	Project description	Sponsor	Status of report
	ACID COAL MINE DRAINAGE		
Anthracite fields	Monthly measurements of mine water levels and overflows	U.S. Bureau of Mines and U.S. Geological Survey.	Continuous.
Luzerne County–Sandy Run	Lime neutralization stream treatment plant	Commonwealth of Pennsylvania.	Work in progress 1970.
Luzerne County–Wyoming Valley	Demineralization plant (distillation)	do	Do.
Luzerne County–Plymouth Borough	Abatement of mine water and reclamation	do	Work started in 1969.
Luzerne County–Catawissa Creek, Hazle Township.	Channel relocations to control acid water	do	Work in progress 1970.
Carbon County–Buck Mountain	Lime neutralization stream treatment plant	do	Do.
Schuylkill County–Rausch Creek	Lime neutralization mine discharge treatment plant	do	Do.
Schuylkill County–Catawissa Creek	Plugging of abandoned Audenried Tunnel	do	Do.
Schuylkill County–Swatara Creek Watershed	Survey of Swatara Creek Watershed to evaluate abatement measures needed on Panther and Black Creeks.	do	Do.
Schuylkill County–Swatara Creek Watershed	Survey to evaluate abatement measures needed on Middle and Goodspring Creeks, and Gebhard and Coal Runs.	do	Do.
Schuylkill County–Frailey Township	Installation of flumes, drainage ditches, and sealing strip pits and reconditioning of stream beds of Bailey and Gebhard Runs.	do	Do.
Schuylkill County–Swatara Creek Watershed	Survey to determine pollution abatement measures needed on Lower Rausch Creek and Lorberry Creek.	do	Do.
Schuylkill County–Hegins Township	Rehabilitation of surface area of Rausch Creek and Lorberry Creek Watershed.	do	Do.
Lackawanna, Wayne and Susquehanna Counties, Upper Lackawanna River.	Abatement and gravity discharge, design and specifications project	do	Do.
Northumberland County–Shamokin Creek	Engineering study to determine pollution abatement measure needed.	do	Do.
Northumberland County–Shamokin Creek	Design, supervision of construction and operation of treatment plants.	do	Do.
	SURFACE SUBSIDENCE		
Lackawanna County–Scranton, Central City, West.	Appalachia project for hydraulic backfill of mine voids in top three coalbeds of abandoned Pine Brook Co. mine.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Project completed 1970.
Lackawanna County–Scranton, Central City, East.	Appalachia project for hydraulic backfill of mine voids in Pine Brook Co. mine adjacent to previous backfill project.	do	Work in progress 1970.
	UNDERGROUND MINE FIRES		
Luzerne County–Laurel Run Borough	Appalachia mine fire control, which included Phase I exploratory, Phase II (1) sealing 3 tunnels, Phase II (2) reinforcing west barrier with sand seals, Phase II (3) reinforcing east barrier with sand seals in underground mine voids.	do	All Phases completed, except Phase II (3) in progress 1970.
Luzerne County–Hazleton City	Appalachia mine fire control at site of former Hill mine property, which includes Phase I exploratory drilling and Phase II sealing with sand and total fire excavation.	do	Phase I completed 1969; Phase II work in progress 1970.
Luzerne County–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 total fire excavation.	do	Do.
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	Do.

Lackawanna County–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, all work completed 1970.
Columbia County–Centralia Borough	Appalachia mine fire control, which includes Phase I exploratory drilling and Phase II (1) western underground barrier pillars formed by injecting fly ash into mine voids. Phase II (2) east underground barrier pillars formed by injecting fly ash into mine voids.	do	Phase I completed 1968, Phase II work in progress 1970.
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 1969.

DOMESTIC PRODUCTION

Production of Pennsylvania anthracite totaled 9.7 million tons in 1970, a decrease of 7 percent, or 743,518 tons less than in 1969. All sources registered declines.

The Schuylkill region contributed 54 percent of the total production, the same level as in 1969; the Lehigh region, 25 percent (23 percent in 1969); and the Wyoming region, 21 percent (23 percent in 1969).

Production from the four fields was as follows: 16 percent from the Eastern Middle, 26 percent from the Western Middle, 37 percent from the Southern, and 21 percent from the Northern field.

Of the total fresh-mined coal (strip plus underground) produced in 1970, the Lehigh region accounted for 23 percent; Schuylkill region 52 percent; and Wyoming region, 25 percent.

Underground production continued to decline in 1970. Of the total underground output, the Lehigh region accounted for 2 percent, the same level as in 1969; Schuylkill region increased its total to 66 percent (60 percent in 1969); and Wyoming region, 32 percent (38 percent in 1969), a decrease of 16 percent. Each of the three regions showed losses in 1970. Output in the Lehigh region decreased 24 percent; Schuylkill region 9 percent; and the Wyoming region 30 percent.

Mechanical loading of underground anthracite in 1970 declined by 13 percent from the previous year with a corresponding decrease in mechanical equipment; however, of the total underground output, 66.1 percent was loaded mechanically compared with 63.0 percent for 1969. Two mining machines (1 more than in 1969) undercut 125,779 tons of anthracite.

Production from strip mines totaled 4.5 million tons, and accounted for 47 percent of total anthracite production in 1970, compared with 44 percent in 1969. Output in the Lehigh region declined approximately 13 percent; however, production in the Schuylkill and Wyoming regions increased by 3 percent and 11 percent, respectively. Of the total strip mine output, 46 percent was mined in the Schuylkill region, 32 percent in the Lehigh region, and 22 percent in the Wyoming region.

There were 94 power shovels (10 less than in 1969), and 146 draglines (19 less than in 1969), being used in stripping Pennsylvania anthracite and in the recovery of anthracite from culm banks.

Production from culm banks totaled 3.0 million tons, approximately 217,000 tons less than in 1969, or a decline of 7 percent. Output by region was as follows: Schuylkill region, 52 percent; Lehigh region, 30 percent; and the Wyoming region, 18 percent.

Dredging operations produced approximately 409,000 tons in 1970, a decrease of 24 percent compared with the previous year. As the preponderant part of the river coal is "captive" tonnage (coal used by the producer), it is not nearly as responsive to fluctuations in the general market as the small sizes produced from other sources. Approximately 4 percent of the total anthracite production was dredged.

DISTRIBUTION

For the 1969–70 coal year, shipments of Pennsylvania anthracite were about 9,567,000 tons, approximately 271,000 tons, or 2.8 percent below 1968–69 coal year shipments. Shipments to destinations within the United States declined 3.0 percent, while exports to Canada increased by 5.7 percent. In contrast, the exports to countries other than Canada decreased 3.6 percent.

Shipments of pea and larger sizes, to the markets in the United States, during the 1969–70 coal year, decreased by 10.5 percent from the level achieved in 1969. Buckwheat No. 1 declined 6.3 percent, buckwheat No. 2 (rice) dropped by 7.7 percent, while buckwheat No. 3 (barley) increased by 1.2 percent; other sizes, not otherwise identified, increased by 7.7 percent. Increased shipments to western Europe were due, in a large part, to expanded requirements of the U.S. Armed Forces in Germany.

Shipments into the New England area, the Middle Atlantic States, and the Lake States, declined by 23.1 percent, 0.9 percent, and 7.8 percent, respectively. However, the shipments to "Other States" increased by 4.9 percent.

CONSUMPTION AND USES

Apparent consumption of Pennsylvania anthracite in the United States in 1970, calculated as production minus exports, including that exported to West Germany for use of U.S. Armed Forces, totaled 8.2 million net tons, a decline of 6.4 percent. Although use data on anthracite are incomplete, the major part of the loss was attributed to the continued decline in the use of anthracite for space heating. A significant portion of the coal was consumed by electric utilities.

The approximate domestic consumption of anthracite in 1970 was as follows: 49 percent for residential and commercial heating purposes, 23 percent for electric power generation, 11 percent for the iron and steel industry, and 17 percent for other uses.

The Federal Government continued to supplement the fuel needs of the U.S. Armed Forces in West Germany with purchases of anthracite. Shipments in 1970 were 692,000 tons compared with 992,000 in 1969, a decrease of approximately 31 percent.

STOCKS

Monthly data on stocks held in retail yards indicated that dealers operated with lower inventories during the first 6 months of 1970. However, dealers increased their stocks thereafter, and by the end of December had 202,000 tons in inventory, an increase of 42.2 percent over yearend stocks of 1969.

The utilities reported a decrease of 15.3 percent in their inventory—1,099,000 tons at the end of 1970, compared with 1,297,000 tons at the end of 1969.

Stocks at coke plants totaled 121,000 tons at the end of the year, a decrease of 6.9 percent from that of 1969.

Stocks at the Upper Lake docks (Lake Superior and Lake Michigan) dropped from 21,000 in 1969 to 6,000 in 1970, a decrease of 71.4 percent.

PRICES AND SPECIFICATIONS

Based on total production, including colliery fuel and dredge coal, the value of Pennsylvania anthracite averaged $10.83 per short ton in 1970, an increase of 13 percent from the $9.62 per ton recorded in 1969. Total value reached $105,340,747, an increase of 5 percent. Average values for all sizes of anthracite increased in 1970.

Although the larger sizes of anthracite amounted to only 34.4 percent of the year's output (35.1 percent in 1969), they accounted for 45.8 percent of the industry's total revenue because of an 11 percent per ton price increase. The average value for the pea and larger group of sizes was $15.06 per ton f.o.b. preparation plant, a gain of $1.50.

The average value of the buckwheat and smaller sizes was $8.92 per ton, a gain of $0.99 over that of 1969. Increases per ton for the larger sizes—egg, stove, chestnut, pea—were $0.98, $1.35, $1.55, and $1.73, respectively. The per ton increases for the smaller sizes were as follows: Buckwheat No. 1, $1.73; buckwheat No. 2 (rice), $1.67; buckwheat No. 3 (barley), $1.57; buckwheat No. 4, $0.84; buckwheat No. 5, $0.18; and other, $0.84. All the above prices include dredge coal.

Average wholesale prices as quoted in the Black Diamond magazine were as follows: Egg and stove, $16.75 to $17.95; chestnut, $16.50 to $17.90; pea, $14.50 to $15.40; buckwheat No. 1, $14.00 to $15.00; buckwheat No. 2 (rice), $14.00 to $15.00; and buckwheat No. 3 (barley), $13.00 to $13.25.

FOREIGN TRADE

Exports of anthracite totaled 789,000 tons, an increase of approximately 26 percent over the 627,000 tons shipped to foreign countries in 1969. Shipments to Canada declined from approximately 473,000 tons in 1969 to 438,000 tons in 1970, a decrease of 7 percent. However, shipments to the European countries increased from approximately 106,000 tons in 1969 to 302,000 tons in 1970. The remainder was exported to markets in Australia, South America, and Asia.

Although anthracite from the Pennsylvania region is shipped to the Netherlands and West Germany for ultimate delivery to, and use by the U.S. Armed Forces in West Germany, it is not considered an export and therefore, is not included in the export total.

WORLD REVIEW

Precise data from all anthracite producing countries are not available. Some figures are only estimates and some countries include in their data coals which by U.S. standards are of no higher quality than semianthracite. Despite these inadequacies, information is sufficiently accurate to indicate general trends.

Europe, including the U.S.S.R., maintained the lead in world production with approximately 125.4 million tons, or 62.2 percent of the total world output. Production in the Soviet Union, the world's largest producer, was estimated at 87.0 million tons, an increase of 2.7 percent over that of 1969 and accounted for approximately 43 percent of the total world output.

Other leading anthracite producing countries, included North Korea, with 11.9 percent of world output, and mainland China, with 10.9 percent. Production of anthracite in Eastern Europe and Asia increased 4.3 percent from 1969. Total world production was approximately 201.6 million tons in 1970 compared with 199.0 million tons in 1969.

Italy's anthracite imports from January to June of 1970 totaled 378,094 short tons of which 79 percent was supplied by the Republic of South Africa, the United Kingdom, and the U.S.S.R.

Japan's imports of anthracite for the January-November period totaled 1,384,238 tons, compared with 1,296,023 tons for the same period in 1969, an increase of approximately 7 percent. Canada, mainland China, the Republic of Korea, and the Republic of South Africa supplied 76 percent of the total.

The approximate consumption of anthracite in Japan for the same period was as follows: Gas plants, 7 percent (9 percent in 1969); coke plants, 13 percent (7 percent in 1969); chemical plants, 14 percent (22 percent in 1969); briquet plants, 29 percent (26 percent in 1969); and "other", 37 percent, (36 percent in 1969).

Spain's anthracite shipments during 1970 were dispatched largely to West European countries, particularly to the European Economic Community (EEC). West Germany was the principal consignee during this 9-month period (January-September) with a total 89,957 tons, or approximately 79 percent of the total shipment of 114,086 tons.

Shipping arrangements for the exports of anthracite from the Republic of South Africa were numerous, and reportedly there were contracts for shipments to Belgium, the Netherlands, Italy, and Japan during the period from February to March.

TECHNOLOGY

Little progress has been made during the past several years in improving anthracite underground mining techniques. The Pennsylvania Department of Mines and Mineral Industries continued research and development on automated anthracite mining methods with semilongwall and pitch capabilities.

Research continued on the preparation characteristics of the Kidney Seam in the northern anthracite field.

Data collected from laboratory experiments and actual field operations over a period of 10 years demonstrated that low ash anthracite, high in anthraxylon, which has low friability and correct size and shape, had definite advantages over any other media for use as a filter medium in sewage sludge beds, alkali and acid filters, etc. Modern trends are toward coarser filter media, and more attention is being given to pretreatment and the removal of impurities before the water reaches the filter.

Many filters are using sands which are too fine and these sizes cannot be increased to the optimum size needed without increasing particle weight to a point where proper expansion is impossible with the available wash water velocity. By using an anthracite filter, a coarse grain size can be obtained and the particle is still light enough to permit the correct degree of expansion. High filter rates can be maintained without sacrificing the quality of effluent. Coatings do not build up on the anthracite to the extent that they do on sand, and the anthracite is not soluble in acids or alkalis. Losses due to attrition amount to approximately 0.2 percent annually, a rate no greater than that of sand. Data on 10 years operation show very little change in particle size or loss of filter medium.

In brief the research demonstrated that: Cost is volumetrically for anthracite filter-media lower than for sand; a high degree of expansion is obtainable, guaranteeing cleaner filters; coarser sizes can be used for higher rates; longer filter runs up to 150 percent are possible; wash water costs are reduced 30 to 50 percent; and cleaning is easier because of reduced cementing with lime, manganese or iron.

Maps of abandoned underground mines in the anthracite region continued to be microfilmed as part of a Bureau of Mines' program to preserve old mine maps for future studies of subsidence, for mine fire control, and for evaluating building sites.[2] The data accumulated by the map folio program proved an invaluable aid in developing a report requested by the U.S. Army Corps of Engineers relating to a proposed dike project in the northern anthracite field.

At the end of fiscal year 1971, a total of 8,118 maps have been recorded on 20,788 frames. Adding to this, 1,310 frames were used for recording the subsidence report of the U.S. Army Corps of Engineers, and 1,078 frames were used for recording mine-map folios, making a grand total of 23,176 frames of microfilm record.

As a solution to the problem of acid drainage from coal mine waste, experiments are being conducted on a huge gob pile on the theory that oxygen produces the sulfuric acid that seeps from the gob piles. Laboratory experiments have substantiated the theory that as little as 1 foot of earth may choke off the oxygen needed to unite with the waste to produce the acid.[3]

[2] Gait, G. B. Microfilming Maps of Abandoned Anthracite Mines: Mines in the Western Middle Anthracite Field. BuMines Inf. Cir. 8519, 1971.

[3] Coal Mining and Processing, December, 1971.

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 impurities [1]		
			Maximum	Minimum	Slate	Bone	Ash [2]
Broken	Through 4 3/8	-----	-----	-----	1½	2	11
	Over 3¼ to 3	-----	15	7½	-----	-----	-----
Egg	Through 3¼ 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.

Table 3.—Summary of monthly developments in the Pennsylvania anthracite industry in 1970

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1970	Change from 1969 (percent)	Year 1969
Production (including mine fuel, local sales, and dredge coal)	808	770	814	759	763	809	707	898	880	895	815	811	9,729	− 7.1	10,473
Shipments (breakers and washeries only, all sizes):															
By rail [1]	173	216	268	337	385	399	280	425	409	402	323	298	3,915	− 13.3	4,518
By truck [2]	499	444	432	257	353	326	289	352	363	413	362	437	4,527	− 6.1	4,821
Carloadings [3]	3	4	4	6	7	7	5	7	7	7	6	5	68	− 18.1	83
Distribution:															
Lake Erie loadings [4]	-----	-----	-----	13	36	24	11	10	25	22	11	2	154	− 27.3	209
Upper Lake dock trade:[5]															
Receipts:															
Lake Superior	-----	-----	-----	6	6	-----	-----	-----	3	3	6	4	28	− 37.8	45
Lake Michigan	(6)	(6)	(6)	1	2	(6)	(6)	-----	-----	(6)	(6)	(6)	3	− 25.0	4
Deliveries (reloadings):															
Lake Superior	4	4	5	5	4	4	2	-----	4	4	3	4	43	-----	43
Lake Michigan	1	1	1	(6)	(6)	(6)	(6)	(6)	(6)	1	(6)	(6)	4	− 20.0	5
Exports [7]	16	17	22	57	51	43	110	79	135	101	78	80	789	+ 26.0	627
Industrial consumption and stocks by:															
Electric utilities:[8]															
Consumption	157	154	126	150	164	165	168	173	168	151	161	160	1,897	+ 2.6	1,849
Stocks	1,266	1,243	1,236	1,247	1,254	1,248	1,234	1,225	1,209	1,195	1,154	1,099	1,099	− 15.3	1,297
Coke plants:															
Used for carbonizing	47	45	43	39	44	38	38	33	36	35	39	35	472	− 13.1	543
Stocks	101	81	71	65	77	82	78	88	96	113	112	121	121	− 6.9	130
Stocks on Upper Lake docks:[5]															
Lake Superior	16	12	7	8	10	5	3	3	2	1	5	5	5	− 75.0	20
Lake Michigan	1	1	1	1	3	3	2	2	2	1	1	1	1	-----	1
Stocks in retail dealer yards:[9]															
Chestnut and larger	58	58	58	46	90	115	126	138	144	134	123	108	108	+ 33.3	81
Pea	7	7	7	8	10	10	12	14	16	16	15	13	13	+ 44.4	9
Buckwheat No. 1 and rice	35	35	35	35	49	67	77	86	92	98	93	81	81	+ 55.8	52
Total	100	100	100	89	149	192	215	238	252	248	231	202	202	+ 42.2	142
Retail dealer deliveries:[9]															
Chestnut and larger	90	90	90	49	21	40	45	48	70	122	99	113	877	− 16.6	1,052
Pea	54	54	55	24	16	48	21	30	32	49	50	57	490	+268.4	133
Buckwheat No. 1 and rice	51	50	51	33	25	27	39	74	74	44	40	57	565	+ 51.5	373
Total	195	194	196	106	62	115	105	152	176	215	189	227	1,932	+ 24.0	1,558

Wholesale price indexes (1957–59 = 100):[10]														
F.o.b. car at mines:														
Chestnut	111.1	111.1	111.1	111.1	107.1	107.1	108.4	108.4	113.1	115.5	123.5	139.6	116.3	+ 13.9	102.1
Buckwheat No. 1	120.5	120.5	120.5	120.5	120.5	120.5	122.3	122.3	128.6	131.9	139.1	155.3	126.9	+ 15.8	109.6

[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, 976,501 short tons of anthracite was exported to Europe during 1970 compared with 1,111,967 tons for 1969. Of this total 685,599 tons was consigned to West Germany and the Netherlands including exports to the U.S. military forces. This compares with 1,037,470 tons for 1969.

Table 4.—Commercial production of Pennsylvania anthracite in 1970, by regions and sizes

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:																		
Egg	89	5	93	47	2	50	49	2	51	185	9	194	------	------	------	185	9	194
Stove	168	57	225	271	248	519	114	101	214	553	405	958	------	------	------	553	405	958
Chestnut	102	163	264	197	399	596	88	235	323	387	796	1,183	------	------	------	387	796	1,183
Pea	76	143	220	107	295	402	34	206	240	217	645	861	------	------	------	217	645	861
Total pea and larger [2]	435	368	803	623	944	1,567	284	543	827	1,342	1,855	3,197	------	------	------	1,342	1,855	3,197
Buckwheat No. 1	112	132	244	170	361	531	55	265	320	337	758	1,095	------	------	------	337	758	1,095
Buckwheat No. 2 (rice)	31	192	224	83	389	472	24	158	181	138	739	877	------	------	------	138	739	877
Buckwheat No. 3 (barley)	87	197	284	181	451	632	61	161	222	329	808	1,137	------	------	------	329	808	1,137
Buckwheat No. 4	138	33	172	193	138	332	79	32	110	411	203	614	------	------	------	411	203	614
Buckwheat No. 5	311	38	349	511	140	651	28	66	94	850	244	1,094	------	------	------	850	244	1,094
Other [3]	2	306	308	185	470	655	4	322	327	191	1,098	1,290	328	81	409	519	1,179	1,699
Total buckwheat No. 1 and smaller [2]	683	898	1,581	1,323	1,949	3,273	250	1,004	1,254	2,256	3,851	6,107	328	81	409	2,584	3,932	6,516
Grand total [2]	1,118	1,266	2,384	1,946	2,893	4,839	534	1,547	2,081	3,598	5,706	9,304	328	81	409	3,926	5,787	9,714
Value, thousands:																		
Egg	$1,326	$73	$1,400	$672	$38	$710	$764	$26	$790	$2,762	$138	$2,900	------	------	------	$2,762	$138	$2,900
Stove	2,499	869	3,368	4,151	3,815	7,965	1,823	1,608	3,430	8,472	6,291	14,764	------	------	------	8,472	6,291	14,764
Chestnut	1,521	2,495	4,016	3,008	6,104	9,111	1,499	3,907	5,406	6,026	12,507	18,535	------	------	------	6,026	12,507	18,535
Pea	1,008	1,971	2,979	1,432	3,976	5,409	505	3,051	3,557	2,946	8,999	11,945	------	------	------	2,946	8,999	11,945
Total pea and larger [2]	6,355	5,408	11,763	9,263	13,934	23,196	4,590	8,593	13,183	20,206	27,935	48,144	------	------	------	20,206	27,935	48,144
Buckwheat No. 1	1,447	1,678	3,125	2,260	4,780	7,040	771	3,587	4,358	4,477	10,046	14,524	------	------	------	4,477	10,046	14,524
Buckwheat No. 2 (rice)	389	2,506	2,895	1,073	5,059	6,132	338	2,158	2,497	1,800	9,723	11,524	------	------	------	1,800	9,723	11,524
Buckwheat No. 3 (barley)	992	2,155	3,147	1,904	5,078	6,982	693	1,760	2,452	3,588	8,993	12,581	------	------	------	3,588	8,993	12,581
Buckwheat No. 4	1,025	203	1,228	1,499	1,021	2,520	537	254	790	3,061	1,478	4,539	------	------	------	3,061	1,478	4,539
Buckwheat No. 5	1,934	233	2,167	2,896	710	3,606	168	247	415	4,998	1,189	6,188	------	------	------	4,998	1,189	6,188
Other [3]	8	1,269	1,277	776	1,632	2,409	24	1,445	1,469	808	4,346	5,154	2,181	312	2,493	2,989	4,658	7,647
Total buckwheat No. 1 and smaller [2]	5,795	8,044	13,839	10,408	18,280	28,689	2,531	9,450	11,981	18,734	35,775	54,509	2,181	312	2,493	20,915	36,087	57,002

Grand total[2]	12,149	13,452	25,602	19,672	32,214	51,886	7,121	18,044	25,164	38,943	63,710	102,653	2,181	312	2,493	41,123	64,023	105,146
Average value per ton:[4]																		
Egg	$14.86	$15.76	$14.90	$14.20	$15.52	$14.27	$15.62	$15.61	$15.62	$14.89	$15.66	$14.93	------	------	------	$14.89	$15.66	$14.93
Stove	14.90	15.22	14.98	15.29	15.41	15.35	16.04	15.96	16.00	15.33	15.52	15.41	------	------	------	15.33	15.52	15.41
Chestnut	14.98	15.32	15.19	15.24	15.31	15.29	17.00	16.66	16.75	15.58	15.71	15.67	------	------	------	15.58	15.71	15.67
Pea	13.21	13.75	13.56	13.40	13.47	13.46	14.97	14.81	14.83	13.58	13.96	13.87	------	------	------	13.58	13.96	13.87
Total pea and larger	14.61	14.70	14.65	14.87	14.7	14.81	16.14	15.82	15.93	15.06	15.06	15.06	------	------	------	15.06	15.06	15.06
Buckwheat No. 1	12.86	12.72	12.78	13.31	13.23	13.26	14.10	13.52	13.62	13.29	13.24	13.26	------	------	------	13.29	13.24	13.26
Buckwheat No. 2 (rice)	12.40	13.03	12.94	12.92	13.01	12.99	14.34	13.69	13.77	13.05	13.16	13.14	------	------	------	13.05	13.16	13.14
Buckwheat No. 3 (barley)	11.35	10.95	11.07	10.51	11.27	11.05	11.39	10.94	11.07	10.90	11.12	11.06	------	------	------	10.90	11.12	11.06
Buckwheat No. 4	7.40	6.13	7.16	7.75	7.38	7.60	6.81	8.02	7.15	7.46	7.27	7.40	------	------	------	7.46	7.27	7.40
Buckwheat No. 5	6.21	6.14	6.20	5.66	5.07	5.54	6.05	3.73	4.41	5.88	4.87	5.65	------	------	------	5.88	4.87	5.65
Other[3]	3.75	4.15	4.14	4.20	3.47	3.68	5.46	4.48	4.50	4.23	3.61	3.70	6.64	3.85	6.09	5.75	3.95	4.50
Total buckwheat No. 1 and smaller	8.48	8.96	8.75	7.87	9.38	8.77	10.12	9.41	9.56	8.30	9.29	8.92	6.64	3.85	6.09	7.37	9.17	8.76
Grand total	10.87	10.63	10.74	10.11	11.13	10.72	13.32	11.66	12.09	10.82	11.17	11.03	6.64	3.85	6.09	10.47	11.06	10.83

[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 5.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by regions

(Percent)

Size	Lehigh region					Schuylkill region				
	1966	1967	1968	1969	1970	1966	1967	1968	1969	1970
Lump [1] and broken	----	----	----	----	----	----	----	----	----	----
Egg	2.7	4.6	4.5	4.6	4.0	0.9	1.2	1.2	1.2	1.0
Stove	11.1	11.0	10.3	10.0	9.4	9.3	9.4	9.4	9.8	10.7
Chestnut	12.4	12.1	12.0	13.1	11.1	12.0	10.7	11.1	11.3	12.3
Pea	7.4	9.0	10.9	10.7	9.2	8.3	8.0	7.7	7.4	8.3
Total pea and larger	33.6	36.7	37.7	38.4	33.7	30.5	29.3	29.4	29.7	32.3
Buckwheat No. 1	11.3	10.5	11.0	11.7	10.2	12.1	11.0	11.0	11.2	11.0
Buckwheat No. 2 (rice)	9.9	8.9	9.6	11.2	9.4	10.2	9.2	9.5	9.2	9.8
Buckwheat No. 3 (barley)	9.1	9.1	10.3	10.8	11.9	13.3	11.1	11.8	14.5	13.1
Buckwheat No. 4	6.2	6.0	6.6	8.0	7.2	7.0	6.7	6.5	7.0	6.8
Buckwheat No. 5	14.8	15.9	16.9	16.9	14.7	14.1	12.8	13.0	13.2	13.5
Other [2]	15.1	12.9	7.9	3.0	12.9	12.8	19.9	18.8	15.2	13.5
Total buckwheat No. 1 and smaller	66.4	63.3	62.3	61.6	66.3	69.5	70.7	70.6	70.3	67.7

Size	Wyoming region [3]					Total				
	1966	1967	1968	1969	1970	1966	1967	1968	1969	1970
Lump [1] and broken	(4)	(4)	(4)	----	----	(4)	(4)	(4)	----	----
Egg	3.4	3.0	1.9	3.1	2.4	2.0	2.6	2.2	2.5	2.1
Stove	13.1	12.0	11.7	12.0	10.3	10.8	10.5	10.2	10.4	10.3
Chestnut	17.2	15.8	15.6	15.9	15.5	13.5	12.4	12.5	12.8	12.7
Pea	12.6	12.1	12.2	12.2	11.5	9.3	9.3	9.7	9.4	9.3
Total pea and larger	46.3	42.9	41.4	43.2	39.7	35.6	34.8	34.6	35.1	34.4
Buckwheat No. 1	15.0	13.3	14.4	14.7	15.4	12.7	11.5	11.9	12.2	11.8
Buckwheat No. 2 (rice)	9.7	9.4	9.2	9.4	8.7	9.9	9.2	9.4	9.7	9.4
Buckwheat No. 3 (barley)	10.8	10.6	10.3	9.7	10.7	11.6	10.4	11.1	12.4	12.2
Buckwheat No. 4	4.7	2.6	2.6	3.6	5.3	6.2	5.4	5.5	6.4	6.6
Buckwheat No. 5	4.3	6.0	5.1	2.6	4.5	11.6	11.9	11.8	11.6	11.8
Other [2]	9.2	15.2	17.0	16.8	15.7	12.4	16.8	15.7	12.6	13.8
Total buckwheat No. 1 and smaller	53.7	57.1	58.6	56.8	60.3	64.4	65.2	65.4	64.9	65.6

[1] Quantity of lump included is insignificant.
[2] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[3] Includes Sullivan County.
[4] Less than 0.05 percent.

Table 6.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by regions

(Percent)

Size	Lehigh Region: Shipped by rail	Lehigh Region: Shipped by truck	Lehigh Region: Total	Schuylkill Region: Shipped by rail	Schuylkill Region: Shipped by truck	Schuylkill Region: Total
Egg	8.0	0.4	4.0	2.4	0.1	1.0
Stove	15.0	4.5	9.4	14.0	8.5	10.7
Chestnut	9.1	12.9	11.1	10.1	13.8	12.3
Pea	6.8	11.3	9.2	5.5	10.2	8.3
Total pea and larger	38.9	29.1	33.7	32.0	32.6	32.3
Buckwheat No. 1	10.1	10.4	10.2	8.7	12.5	11.0
Buckwheat No. 2 (rice)	2.8	15.2	9.4	4.3	13.4	9.8
Buckwheat No. 3 (barley)	7.8	15.5	11.9	9.3	15.6	13.1
Buckwheat No. 4	12.4	2.6	7.2	9.9	4.8	6.8
Buckwheat No. 5	27.8	3.0	14.7	26.3	4.8	13.5
Other [1]	.2	24.2	12.9	9.5	16.3	13.5
Total buckwheat No. 1 and smaller	61.1	70.9	66.3	68.0	67.4	67.7
	Wyoming Region [2]			**Total**		
Egg	9.1	.1	2.4	5.1	.2	2.1
Stove	21.3	6.5	10.3	15.4	7.1	10.3
Chestnut	16.5	15.2	15.5	10.8	13.9	12.7
Pea	6.3	13.3	11.5	6.0	11.3	9.3
Total pea and larger	53.2	35.1	39.7	37.3	32.5	34.4
Buckwheat No. 1	10.2	17.2	15.4	9.4	13.3	11.8
Buckwheat No. 2 (rice)	4.4	10.2	8.7	3.8	12.9	9.4
Buckwheat No. 3 (barley)	11.4	10.4	10.7	9.2	14.2	12.2
Buckwheat No. 4	14.8	2.0	5.3	11.4	3.6	6.6
Buckwheat No. 5	5.2	4.3	4.5	23.6	4.3	11.8
Other [1]	.8	20.8	15.7	5.3	19.2	13.8
Total buckwheat No. 1 and smaller	46.8	64.9	60.3	62.7	67.5	65.6

[1] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[2] Includes Sullivan County.

Table 7.—Production of Pennsylvania anthracite in 1970, by regions and counties

(Thousand short tons and thousand dollars)

Source	Rail shipments: Quantity	Rail shipments: Value [2]	Truck shipments: Quantity	Truck shipments: Value [2]	Colliery fuel: Quantity	Colliery fuel: Value	Total production [1]: Quantity	Total production [1]: Value [2]
REGIONS								
Lehigh:								
Preparation plants	1,118	$12,150	1,266	$13,452	6	$79	2,390	$25,682
Schuylkill:								
Preparation plants	1,946	19,672	2,893	32,214	5	61	4,844	51,947
Dredges	328	2,180	81	312	-------	-------	409	2,493
Total Schuylkill [1]	2,274	21,852	2,974	32,526	5	61	5,253	54,440
Wyoming:								
Preparation plants [3]	534	7,121	1,547	18,044	5	55	2,086	25,219
Total: [1]								
Preparation plants	3,598	38,943	5,706	63,710	16	195	9,320	102,848
Dredges	328	2,180	81	312	-------	-------	409	2,493
Grand total [1]	3,926	41,123	5,787	64,022	16	195	9,729	105,341
COUNTIES								
Berks, Lancaster, and Snyder	328	2,180	81	312	-------	-------	409	2,493
Carbon	324	3,517	139	1,013	-------	-------	463	4,530
Columbia	175	2,355	214	1,764	-------	-------	389	4,119
Dauphin	14	174	74	250	-------	-------	88	425
Lackawanna	175	2,218	226	2,911	1	$3	402	5,132
Lebanon	-------	-------	-------	-------	-------	-------	-------	-------
Luzerne	922	11,222	1,916	21,654	10	127	2,848	33,003
Northumberland	242	2,001	764	8,738	1	3	1,007	10,741
Schuylkill	1,746	17,454	2,256	26,417	5	62	4,007	43,933
Sullivan	-------	-------	116	964	-------	-------	116	964
Susquehanna	-------	-------	-------	-------	-------	-------	-------	-------
Total [1]	3,926	41,123	5,787	64,022	16	195	9,729	105,341

[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 fields

(Thousand short tons)

Field	1966	1967	1968	1969	1970
Eastern Middle: Breakers and washeries	2,009	2,039	1,559	1,583	1,511
Western Middle:					
Breakers and washeries	3,025	2,893	2,840	2,806	2,540
Dredges	26	27	17	5	W
Total	3,051	2,920	2,857	2,811	W
Southern:					
Breakers and washeries	3,781	3,604	3,557	3,183	3,183
Dredges	635	605	589	530	W
Total	4,416	4,209	4,146	3,713	W
Northern: Breakers and washeries [1]	3,465	3,088	2,899	2,366	2,086
Total: [1]					
Breaker and washeries	12,280	11,624	10,855	9,938	9,320
Dredges	[2] 662	632	606	535	409
Grand total	[2] 12,941	12,256	11,461	10,473	9,729

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.

Table 9.—Pennsylvania anthracite produced in 1970, classified as fresh-mined, culm-bank, and river coal, by fields and regions

(Thousand short tons)

Source	Fresh-mined coal: Underground mines: Mechanically loaded	Fresh-mined coal: Underground mines: Hand loaded	Fresh-mined coal: Underground mines: Total [1]	Fresh-mined coal: Strip pits	From culm banks	From river dredging	Total [1]
FIELDS							
Eastern Middle	16	3	19	857	635	--------	1,511
Western Middle	93	214	307	1,088	1,145	W	W
Southern	485	375	860	1,591	733	W	W
Northern [2]	556	--------	556	1,006	524	--------	2,086
Total [1]	1,151	591	1,742	4,541	3,036	409	9,729
REGIONS							
Lehigh	35	3	38	1,431	921	--------	2,390
Schuylkill	560	588	1,148	2,104	1,591	409	5,253
Wyoming [2]	556	--------	556	1,006	524	--------	2,086
Total	1,151	591	1,742	4,541	3,036	409	9,729

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 coal	Number of men employed	Average number of days worked
1966	5,253	56.2	2,085	225
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:				
Lehigh region	1,431	97.4	517	300
Schuylkill region	2,104	64.7	783	244
Wyoming region [1]	1,006	64.4	509	264
Total or average	4,541	72.3	[p] 1,809	[p] 265

[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	1968			1969			1970		
	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	6	5	11	3	3	6	4	2	6
Electric	26	40	66	27	37	64	18	40	58
Diesel	81	144	225	74	124	198	72	104	176
Diesel-electric	-------	1	1	-------	1	1	-------	-------	-------
Total	113	190	303	104	165	269	94	146	240

Table 12.—Production of Pennsylvania anthracite from culm banks, by regions

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total [1]
1966	971	1,390	578	2,938
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

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

Table 13.—Pennsylvania anthracite produced by dredges, by rivers, including tributaries

(Thousand short tons and thousand dollars)

Year	Schuylkill River			Susquehanna River			Total [1]		
	Quantity	Value	Average value (per ton)	Quantity	Value	Average value (per ton)	Quantity	Value	Average value (per ton)
1966	57	$180	$3.16	605	$2,107	$3.48	662	$2,287	$3.46
1967	39	116	3.00	593	2,140	3.61	632	2,257	3.57
1968	45	157	3.50	561	2,066	3.68	606	2,224	3.67
1969	53	185	3.50	483	2,091	4.33	535	2,276	4.25
1970	W	W	W	W	W	W	409	2,493	6.09

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

Table 14.—Estimated production of Pennsylvania anthracite, by weeks, in 1970 [1]

Week ended—	Thousand short tons	Week ended—	Thousand short tons	Week ended—	Thousand short tons
Jan. 3	[2] 31	May 9	168	Sept. 12	161
10	183	16	171	19	232
17	218	23	202	26	215
24	182	30	189	Oct. 3	229
31	194	June 6	184	10	204
Feb. 7	204	13	195	17	199
14	198	20	222	24	215
21	193	27	186	31	176
28	174	July 4	76	Nov. 7	199
Mar. 7	188	11	81	14	182
14	194	18	194	21	210
21	165	25	191	28	192
28	188	Aug. 1	199	Dec. 5	198
Apr. 4	177	8	193	12	152
11	167	15	231	19	178
18	170	22	208	26	163
25	185	29	208	Jan. 2	[2] 153
May 2	171	Sept. 5	191		
				Total	9,729

[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 15.—Estimated monthly production of Pennsylvania anthracite [1]

(Thousand short tons)

Month	1966	1967	1968	1969	1970
January	1,108	1,101	965	973	808
February	1,091	939	962	911	770
March	1,033	979	960	898	814
April	1,058	952	926	916	759
May	1,103	1,102	986	869	763
June	998	995	824	812	809
July	745	899	853	704	707
August	1,191	1,132	1,016	877	898
September	1,145	1,071	953	947	880
October	1,221	1,073	1,136	985	895
November	1,145	1,017	994	831	815
December	1,103	996	886	750	811
Total	12,941	12,256	11,461	10,473	9,729

[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 16.—Pennsylvania anthracite loaded mechanically underground, by fields

(Thousand short tons)

Field	Scraper loaders [1]		Pit-car loaders		Hand-loaded face conveyors, all types [2]		Total mechanically loaded [3]	
	1969	1970	1969	1970	1969	1970	1969	1970
Northern	452	393	14	4	329	159	795	556
Eastern Middle	4	8	------	------	10	8	14	16
Western Middle	24	35	------	------	83	58	108	93
Southern	276	238	------	------	134	248	410	485
Total [3]	757	674	14	4	556	472	1,327	1,151

[1] Includes mobile loaders.
[2] Shaker chutes, including those equipped with duckbills.
[3] Data may not add to totals shown because of independent rounding.

Table 17.—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
1966	151	788	30	328	383	1,474	564	2,591
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

[1] Includes duckbills and other self-loading conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 18.—Trends in mechanical loading,[1] hand loading, and stripping of Pennsylvania anthracite

(Thousand short tons)

Year	Fresh-mined coal							
	Underground					Strip pits		Total [2]
	Mechanical loading	Percent of total underground	Hand loading	Percent of total underground	Total [2]	Quantity	Percent of total fresh-mined	
1966	2,591	63.4	1,498	36.6	4,088	5,253	56.2	9,342
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

[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 19.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by regions and sizes

(Per short ton)

Size	Lehigh region					Schuylkill region				
	1966	1967	1968	1969	1970	1966	1967	1968	1969	1970
Lump [1] and broken	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Egg	$12.46	$12.68	$12.99	$14.16	$14.90	$12.42	$12.49	$13.26	$13.66	$14.27
Stove	12.03	12.51	12.93	14.05	14.98	11.30	11.80	12.82	13.92	15.35
Chestnut	11.95	12.46	12.93	14.08	15.19	11.04	11.53	12.66	13.84	15.29
Pea	9.00	9.42	10.33	11.75	13.56	8.66	9.15	10.44	11.91	13.46
Total pea and larger	11.37	11.76	12.18	13.43	14.65	10.51	11.00	12.15	13.38	14.81
Buckwheat No. 1	8.45	9.01	9.70	11.18	12.78	8.68	9.02	10.03	11.56	13.26
Buckwheat No. 2 (rice)	9.32	9.62	10.24	11.49	12.94	8.28	8.67	9.80	11.30	12.99
Buckwheat No. 3 (barley)	7.53	7.78	8.29	9.42	11.07	7.19	7.43	8.13	9.54	11.05
Buckwheat No. 4	5.59	5.48	5.72	5.92	7.16	5.32	5.50	5.91	6.67	7.60
Buckwheat No. 5	5.38	5.46	5.54	5.80	6.20	4.61	4.70	4.95	5.34	5.54
Other [2]	2.99	3.13	3.36	3.55	4.14	3.57	3.95	3.56	3.73	3.68
Total buckwheat No. 1 and smaller	6.26	6.49	7.20	8.39	8.51	6.23	6.18	6.65	7.76	8.77
Total all sizes	7.98	8.42	9.08	10.33	10.74	7.53	7.60	8.26	9.43	10.72
	Wyoming region [3]					Total				
Lump [1] and broken	12.50	14.96	14.80	-----	-----	12.50	14.96	14.80	-----	-----
Egg	12.51	12.74	13.24	13.86	15.62	12.48	12.65	13.12	13.95	14.93
Stove	12.17	12.66	13.40	14.32	16.00	11.77	12.25	13.02	14.06	15.41
Chestnut	12.04	12.31	13.58	14.58	16.75	11.59	12.03	13.02	14.12	15.67
Pea	10.34	10.73	11.61	12.81	14.83	9.35	9.75	10.80	12.14	13.87
Total pea and larger	11.65	11.99	12.93	13.96	15.93	11.11	11.53	12.40	13.56	15.06
Buckwheat No. 1	9.01	9.60	10.56	11.77	13.62	8.74	9.19	10.13	11.53	13.26
Buckwheat No. 2 (rice)	9.18	9.59	10.59	11.79	13.77	8.77	9.16	10.11	11.47	13.14
Buckwheat No. 3 (barley)	7.30	7.44	8.26	9.43	11.07	7.28	7.51	8.20	9.49	11.06
Buckwheat No. 4	6.16	5.65	5.80	7.55	7.16	5.56	5.51	5.84	6.56	7.40
Buckwheat No. 5	5.43	4.55	4.17	4.65	4.41	4.93	4.95	5.06	5.47	5.65
Other [2]	2.04	2.45	2.45	1.98	4.50	3.09	3.43	3.22	3.16	4.00
Total buckwheat No. 1 and smaller	6.96	6.58	7.04	7.88	9.56	6.40	6.35	6.87	7.93	8.92
Total all sizes	9.13	8.91	9.48	10.51	12.09	8.08	8.15	8.78	9.91	11.03

[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 20.—Average value of Pennsylvania anthracite from all sources, by regions [1]

(Per short ton)

Region	1969				1970			
	Shipped by rail	Shipped by truck	Colliery fuel	Total	Shipped by rail	Shipped by truck	Colliery fuel	Total
Lehigh	$9.89	$10.89	$12.05	$10.34	$10.87	$10.63	$13.30	$10.75
Schuylkill	7.96	9.89	11.11	8.94	9.61	10.94	11.91	10.36
Wyoming [2]	11.87	9.84	10.11	10.51	13.32	11.66	11.58	12.09
Total	9.11	10.07	11.23	9.62	10.47	11.06	12.34	10.83

[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 21.—Wholesale prices of Pennsylvania anthracite, in 1970, by sizes [1]

(Per short ton)

Size	Winter	Spring discount	Summer-fall	End of year
Egg and Stove	$16.25–$16.75	$15.75–$16.75	$16.25–$17.25	$16.75–$17.95
Chestnut	16.00– 16.50	15.50– 16.50	16.00– 17.00	16.50– 17.90
Pea	13.10– 14.00	13.50– 13.60	14.00– 14.10	14.50– 15.40
Buckwheat No. 1	12.65– 13.60	13.00– 13.10	13.50– 13.60	14.00– 15.00
Buckwheat No. 2 (rice)	12.60– 13.60	13.00– 13.10	13.50– 13.60	14.00– 15.00
Buckwheat No. 3 (barley)	11.50– 12.10	12.00	12.50	13.00– 13.25

[1] As quoted in the Black Diamond Magazine. All prices are per short ton f.o.b. at mines.

Table 22.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1970

	Lehigh region	Schuylkill region	Wyoming region [1]	Total 1970 [p]	Total 1969
Average number of men working daily:					
Underground	25	789	600	1,414	1,397
In strip pits	517	783	509	1,809	1,787
At culm banks	140	251	103	494	488
At preparation plants	521	805	329	1,655	1,635
Other surface	13	225	328	566	559
Total excluding dredge operations	1,216	2,853	1,869	5,938	5,866
Dredge operations	---------	62	---------	62	61
Total	1,216	2,915	1,869	6,000	5,927
Average number of days active:					
All operations except dredges	246	238	241	241	232
Dredge operations	---------	303	---------	303	293
Average, all operations	246	239	241	240	232
Man-days of labor:					
All operations except dredges	299,222	677,833	451,150	1,428,205	1,358,774
Dredge operations	---------	18,795	---------	18,795	17,881
Total, all operations	299,222	696,628	451,150	1,447,000	1,376,655
Average tons per man-day:					
All operations except dredges	7.10	6.92	4.81	6.29	7.15
Dredge operations	---------	26.34	---------	26.34	29.94
Average, all operations	7.10	7.45	4.81	6.55	7.45

[p] Preliminary.
[1] Includes Sullivan County.

Table 23.—Employment at operations producing Pennsylvania anthracite (including strip contractors) by counties

County	1969	1970 [p]	County	1969	1970 [p]
Berks, Lancaster, Lebanon, Snyder, and Susquehanna	59	57	Luzerne	2,076	2,102
Carbon	217	220	Northumberland	718	727
Columbia	143	145	Schuylkill	2,244	2,273
Dauphin	73	74	Sullivan	26	26
Lackawanna	371	376	Total	5,927	6,000

[p] Preliminary.

Table 24.—Distribution of Pennsylvania anthracite, April 1, 1969 to March 31, 1970, by States, Provinces, and countries of destination

(Short tons)

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		
United States:												
New England States:												
Connecticut	107	4,367	7,551	158	12,183	819	1,393	17	660	2,889	15,072	0.1
Maine	-------	5,804	6,182	-------	11,986	630	3,895	-------	44	4,569	16,555	.2
Massachusetts	700	20,085	16,050	1,633	38,468	5,163	10,056	877	1,325	17,421	55,889	.6
New Hampshire	-------	3,342	2,911	85	6,338	1,938	1,981	-------	30	3,949	10,287	.1
Rhode Island	80	1,238	1,264	25	2,607	18	177	-------	-------	195	2,802	(1)
Vermont	35	7,443	6,095	1,396	14,969	3,126	7,690	-------	-------	10,816	25,785	.3
Total	922	42,279	40,053	3,297	86,551	11,694	25,192	894	2,059	39,839	126,390	1.3
Middle Atlantic States:												
New Jersey	1,366	33,365	77,751	21,575	134,057	49,671	22,736	113,013	324,067	509,487	643,544	6.7
New York	6,936	134,932	107,472	218,468	467,808	121,642	61,922	64,077	224,013	471,654	939,462	9.8
Pennsylvania [2]	6,871	332,692	716,687	569,217	1,625,467	801,132	762,707	1,000,937	1,312,522	3,877,298	5,502,765	57.6
Total	15,173	500,989	901,910	809,260	2,227,332	972,445	847,365	1,178,027	1,860,602	4,858,439	7,085,771	74.1
South Atlantic States:[3]												
Delaware	913	5,648	8,348	371	15,280	780	1,622	2,388	61	4,851	20,131	.2
District of Columbia	50	1,346	1,483	347	3,226	772	776	-------	-------	1,548	4,774	(1)
Maryland	248	18,229	11,968	1,162	31,607	37,703	1,798	2	47,003	86,506	118,113	1.3
Virginia	-------	4,191	4,671	3	8,865	211	125	20	10,488	10,844	19,709	.2
Total	1,211	29,414	26,470	1,883	58,978	39,466	4,321	2,410	57,552	103,749	162,727	1.7
Lake States:												
Illinois	-------	17	683	53	753	56,808	12,148	1,019	23,520	93,495	94,248	1.0
Indiana	-------	-------	1,924	19,905	21,829	71	488	271	48,039	48,869	70,698	.8
Michigan	-------	729	788	147	1,664	8,330	924	28	78,364	87,646	89,310	.9
Minnesota	-------	34	4	2	40	3	-------	3	37,842	37,848	37,888	.4
Ohio	-------	21,559	600	4,512	26,671	17,926	12,157	119	165,553	195,755	222,426	2.3
Wisconsin	-------	2,568	2,899	308	5,775	42	399	45	1,288	1,774	7,549	.1
Total	-------	24,907	6,898	24,927	56,732	83,180	26,116	1,485	354,606	465,387	522,119	5.5
Other States	1,630	42	641	23,222	25,535	52,584	1,368	20,512	208,952	283,416	308,951	3.2
Total United States	18,936	597,631	975,972	862,589	2,455,128	1,159,369	904,362	1,203,328	2,483,771	5,750,830	8,205,958	85.8
Canada:												
Ontario	47	32,824	34,937	15,096	82,904	25,045	6,843	3,487	5,849	41,224	124,128	1.3
Quebec	45	5,779	5,229	2,431	13,484	20,376	39,021	100,108	59,198	218,703	232,187	2.4
Other Provinces	-------	985	797	10	1,792	11	75	16	201	303	2,095	(1)
Total Canada	92	39,588	40,963	17,537	98,180	45,432	45,939	103,611	65,248	260,230	358,410	3.7
Other countries	202,354	388,172	248,439	41,026	879,991	16,646	1,585	115	104,176	122,522	1,002,513	10.5
Grand total	221,382	1,025,391	1,265,374	921,152	3,433,299	1,221,447	951,886	1,307,054	2,653,195	6,133,582	9,566,881	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."

Table 25.—Truck shipments of Pennsylvania anthracite in 1970, by months, 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	192	166	154	123	114	123	122	163	164	195	151	180	1,847	40.8
Outside region	240	210	206	101	178	148	124	131	145	154	147	195	1,979	43.7
New York	34	35	38	20	37	32	27	37	36	39	45	37	418	9.2
New Jersey	21	20	24	8	20	17	12	15	12	18	13	17	198	4.4
Delaware	2	2	2	1	1	2	1	1	2	2	1	2	18	.4
Maryland	8	8	7	4	2	3	2	2	3	3	3	4	50	1.1
District of Columbia	(3)	(3)	(3)	(3)	---	---	---	(3)	(3)	(3)	(3)	(3)	2	.1
Other States	2	2	1	(3)	1	1	1	2	1	2	1	2	15	.3
Total:[2] 1970	499	443	432	257	353	326	289	352	363	413	362	437	4,527	100.0
1969	544	509	463	396	333	360	261	336	363	430	393	433	4,821	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 26.—Shipments of Pennsylvania anthracite, by destinations [1]

(Thousand short tons)

Destination	1966	1967	1968	1969	1970
TRUCK SHIPMENTS					
Pennsylvania:					
Within region	2,343	1,986	2,021	1,918	1,847
Outside region	2,685	2,485	2,269	2,151	1,979
New York	477	418	409	369	418
New Jersey	392	286	248	247	198
Delaware	26	23	26	22	18
Maryland	69	89	188	94	50
District of Columbia	8	6	2	2	2
Other States	21	20	18	17	15
Total [2]	6,021	5,312	5,181	4,821	4,527
RAIL SHIPMENTS					
New England States	221	174	163	107	102
New York	957	703	606	645	455
New Jersey	399	323	263	291	173
Pennsylvania	1,247	1,052	846	940	847
Delaware	4	5	1	(3)	1
Maryland	210	83	32	34	19
District of Columbia	9	10	9	4	7
Virginia	29	13	6	6	9
Ohio	121	85	98	215	151
Indiana	67	51	43	70	66
Illinois	103	114	108	102	93
Wisconsin	19	16	14	6	12
Minnesota	25	22	13	25	51
Michigan	54	41	42	33	53
Other States	305	244	233	312	408
Total United States [2]	3,768	2,936	2,476	2,792	2,447
Canada	434	306	308	373	384
Other countries	741	894	697	853	691
Grand total [2]	4,943	4,136	3,481	4,018	3,522

[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 27.—Consumption of Pennsylvania anthracite in the United States, by consumer categories

(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]
1966	5,622	141	2,192	187	515	897	1,715	131
1967	5,035	143	2,186	239	528	819	1,800	50
1968	4,759	56	2,203	281	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	------------

[e] Estimate. 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 28.—U.S. exports of anthracite by countries and customs districts

(Thousand short tons and thousand dollars)

	1969 Quantity	1969 Value	1970 Quantity	1970 Value
COUNTRY				
Argentina	(1)	$1	2	$24
Australia	5	105	4	207
Brazil	4	197	1	53
Canada	473	6,117	438	5,851
Chile	1	17	1	17
France	1	14	229	3,226
Germany, West	41	423	8	79
India	3	36	(1)	11
Ireland	1	39	2	43
Italy	40	419	61	733
Mexico	8	123	5	115
Netherlands	23	454	1	8
Peru	3	49	6	121
Philippines	1	22	1	25
Surinam	(1)	6	1	42
United Kingdom	(1)	1	1	39
Venezuela	9	197	16	377
Vietnam, South	-------	-------	11	128
Yugoslavia	14	183	(1)	15
Other	(1)	17	1	101
Total	627	8,420	789	11,215
CUSTOMS DISTRICT				
Baltimore	2	78	2	50
Buffalo	137	2,120	95	1,443
Cleveland	-------	-------	10	155
Detroit	20	399	5	274
Houston	2	86	5	293
Laredo	8	123	5	115
Mobile	(1)	4	1	23
New Orleans	3	75	1	68
New York City	3	78	3	126
Norfolk	2	40	41	569
Ogdensburg	68	855	62	1,144
Philadelphia	377	4,485	558	6,906
San Francisco	1	19	(1)	16
St. Albans	1	17	(1)	3
Other	3	41	1	30
Total	627	8,420	789	11,215

[1] Less than ½ unit.

NOTE: According to the Association of American Railroads, 976,501 short tons of anthracite was exported to Europe during 1970, compared with 1,111,967 tons for 1969. Of this total 685,599 tons was consigned to West Germany and the Netherlands, including exports to the U.S. Military forces. This compares with 1,037,470 tons for 1969.

Table 29.—Anthracite:[1] World production, by countries

(Thousand short tons)

Country [2]	1968	1969	1970 [p]
Belgium	5,409	4,863	4,063
Bulgaria	194	198	[e] 198
China, mainland [e]	[r] 22,000	22,000	22,000
France	11,688	11,116	10,850
Germany, West	[r] 12,507	11,692	10,700
Ireland	114	[e] 110	87
Japan	1,641	1,350	1,145
Korea, North [e]	[r] 20,400	22,200	24,000
Korea, Republic of	11,290	11,324	13,662
Morocco	497	438	477
Netherlands	6,191	6,098	5,010
Peru	8	8	[e] 8
Portugal	438	398	299
Romania [e]	17	17	17
South Africa, Republic of	1,505	1,699	1,850
Spain	3,155	3,050	3,166
U.S.S.R.	[r] 84,763	84,684	[e] 87,000
United Kingdom	4,345	4,002	4,061
United States (Pennsylvania)	11,461	10,473	9,729
Vietnam, North [e]	3,300	3,300	3,300
Total	[r] 200,923	199,020	201,622

[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 Colombia output may total 100,000 tons per year; in New Zealand and South Vietnam (and possibly in other countries) output is insignificant.

Cobalt

By John D. Corrick [1]

The unusually high demand for cobalt in 1969, which resulted from a serious shortage of nickel, began to ease in 1970. Consumption of cobalt in the United States in 1970 was 13 percent below that of the previous year, and closely approximated the consumption reported for 1968. The weakened market for cobalt was emphasized by the fact that Government sales through December 1970 totaled 2,484,730 pounds of contained cobalt, down 72 percent from the 8,899,200 pounds sold in a similar period in 1969.

Legislation and Government Programs.—On July 10, 1970, the President signed Public Law 91–317 authorizing the release of 40.2 million pounds of cobalt from the national and supplemental stockpiles. On August 27, the General Services Administration (GSA) announced that it was offering cobalt metal for sale in various forms at the rate of approximately 2 million pounds per month. Sale to individual purchasers was limited to 500,000 pounds per month. Total sales for the year were 2,484,730 pounds of cobalt metal. Off-the-shelf sales of cobalt were made by the Government through July. Beginning in August 1970. Government stocks were offered on a competitive-bid basis.

As of December 31, 1970, total U.S. Government inventory of cobalt was 79,127,330 pounds. Of this quantity, 72,747,581 pounds was stockpile grade.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1966	1967	1968	1969	1970
United States:					
Consumption	14,205	13,976	12,998	15,608	13,367
Imports for consumption	18,823	8,215	9,068	11,475	12,414
Stocks, Dec. 31: Consumer	1,996	2,471	2,139	2,191	1,890
Price: Metal, per pound	$1.65	$1.85	$1.85	$1.85–$2.20	$2.20
World: Production, mine	46,782	44,028	41,968	43,338	52,052

DOMESTIC PRODUCTION

Cobalt continued to be produced in the United States in a concentrate, a byproduct of iron ore mining. The cobalt-bearing concentrate was processed by Pyrities Co., Inc. of Delaware, which developed a totally new solvent extraction process for the recovery and refinement of copper and cobalt from sulfate solutions generated as a result of hydrometallurgical treatment of pyrite concentrates. The process was introduced in April 1970. The Blackbird cobalt-copper deposit of The Hanna Mining Co. remained inactive during the year. Idaho Mining Co. completed an exploration and development program at cobalt properties in the south-central part of Idaho which it obtained in 1967. The program included more than a mile of drift, 400 feet of incline shaft, and several thousand feet of diamond drilling. The results were being evaluated at yearend.

[1] Physical scientist, Division of Ferrous Metals.

CONSUMPTION AND USES

Consumption of cobalt in the United States in 1970 was well below the high rate of 1969, which resulted from cobalt's use as a substitute for nickel in electroplating. Principal uses in 1970 were as shown in table 4, in magnetic alloys, superalloys, salts and driers, and cutting and wear-resistant materials. Total U.S. cobalt consumption was approximately 13 million pounds in 1970.

Table 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1966	1967	1968	1969	1970
Alloy and concentrate	1,214	1,168	1,184	r 516	274
Metal	1,699	1,618	1,831	2,819	2,639
Hydrate	35	18	14	25	32
Other	6	2	11	1	9

r Revised.
[1] Total consumption is not shown because some metal and hydrate originated from alloy and concentrate, and a total would involve duplication.

Table 3.—Cobalt products [1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

	1969				1970			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	604	425	590	415	458	322	434	305
Hydrate	759	421	576	316	585	338	584	330
Salts [2]	5,890	1,658	5,836	1,654	6,355	1,677	6,184	1,620
Driers	9,017	631	8,662	607	8,662	662	8,691	666
Total	16,270	3,135	15,664	2,992	16,060	2,999	15,893	2,921

[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 uses

(Thousand pounds of contained cobalt)

Use	1970
Steel:	
Carbon	W
Stainless and heat-resisting	114
Alloy (excludes stainless and tool)	136
Tool	534
Cast irons	W
Superalloys	2,322
Alloys (excludes alloy steels and superalloys):	
Cutting and wear-resistant materials [1]	1,395
Welding and alloy hard-facing rods and materials	181
Magnetic alloys	2,374
Nonferrous alloys	549
Other alloys	981
Mill products made from metal powder	W
Chemical and ceramic uses:	
Pigments	155
Catalysts	402
Ground coat frit	129
Glass decolorizer	69
Other	7
Miscellaneous and unspecified	1,403
Total	10,751
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (est.)	2,616
Grand total	13,367

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.

Table 5.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1966	1967	1968	1969	1970
Metal	11,768	11,610	10,456	r 12,057	10,056
Oxide	768	654	573	646	626
Purchased scrap	48	120	r 143	328	69
Salts and driers	1,621	1,592	1,826	2,577	2,616
Total	14,205	13,976	r 12,998	r 15,608	13,367

r Revised.

PRICES

The producer price for metal granules (shot) containing 99 percent or more cobalt in 500-pound kegs, and that for electrolytic cathodes (broken) containing approximately 99.9 percent cobalt in 551-pound (250-kg) drums, remained at $2.20 per pound, f.o.b. New York or Chicago, throughout the year.

The free market price for cobalt that developed in the last half of 1969 steadied by the middle of 1970. This price, which reached $3 per pound domestically and as much as $3.15 to $3.50 per pound abroad, approached or equaled the producer price by August 1970.

Cobalt metals sold off-the-shelf by GSA in the first part of the year were priced at $2.20 per pound of contained cobalt, f.o.b. carriers conveyance at Government storage locations. On August 27, GSA announced that it was offering cobalt metal for sale on a competitive-bid basis. The competitive-bid price obtained throughout the remainder of the year was $2.15 per pound.

FOREIGN TRADE

Exports of unwrought cobalt metal and alloys and of waste and scrap totaled 2,136,309 pounds, gross weight, having a value of $3,252,568. These exports went to 23 countries. Japan and the United Kingdom received the greater part, 894,166 pounds ($1,673,063) and 494,239 pounds ($396,258), respectively. Exports of wrought cobalt metal and alloys, 563,293 pounds, gross weight, having a value of $2,544,766, went to 29 countries. The imports of cobalt salts and compounds totaled in table 7 came principally from the United Kingdom and West Germany.

Table 6.—U.S. imports for consumption of cobalt metal and oxides, by countries

(Thousand pounds and thousand dollars)

Country	Metal				Oxide			
	1969		1970		1969		1970	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Belgium-Luxembourg	3,047	$6,001	2,914	$7,114	1,152	$1,980	710	$1,393
Canada	814	1,505	463	1,093	---	---	---	---
Congo (Kinshasa)	5,832	9,937	6,930	14,308	8	16	---	---
Finland	383	724	452	1,103	---	---	---	---
France	163	340	33	72	---	---	---	---
Germany, West	12	19	110	325	15	26	---	---
Japan	5	6	---	---	(1)	(1)	---	---
Netherlands	10	11	45	70	---	---	---	---
Norway	1,686	3,084	794	1,748	---	---	---	---
United Kingdom	85	98	132	187	(1)	1	(1)	1
Total	12,037	21,725	11,873	26,020	1,175	2,023	710	1,394

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]
1968	9,219	$16,285	1,186	$2,113	107	$90	10,512	9,068
1969	12,037	21,725	1,175	2,023	131	67	13,343	[r] 11,475
1970	11,873	26,020	710	1,394	157	92	12,740	12,414

[e] Estimate. [r] Revised.

WORLD REVIEW

The format for table 8 has been changed in 1970 to show both mine and refinery cobalt figures separately by country.

The quantity of cobalt produced in the free world in 1970 increased about 24 percent over the preceding year. The Congo (Kinshasa) showed the largest increase. Production in Canada, Finland, and Zambia also increased, but production from Morocco decreased.

Australia.—Western Mining Corp. Ltd. announced in May the first shipment of nickel briquets refined from Kambalda concentrates at the company's Kwinana refinery, Western Australia. In addition to nickel briquets, the plant will produce 700 tons per year of cobalt plus nickel sulfide. Sherritt Gordon Mines Ltd.'s ammonia-leach process was used at the refinery. The refinery is unique in that all incoming concentrate was dry and arrived in covered tank cars from Western Mining's Kambalda flotation mill. The concentrate was transferred pneumatically from the tank cars to leach tanks. Central Austin Pty. Ltd. announced the discovery of cobalt deposits with an estimated value of $598

Table 8.—Cobalt: World production, by countries

(Short tons)

Country	Mine output, cobalt content [1]			Metal [2]		
	1968	1969	1970 [p]	1968	1969	1970 [p]
Australia	263	260	[e] 260	-----	-----	-----
Canada [3]	2,015	1,628	2,614	1,306	818	1,752
Congo (Kinshasa)	11,462	[4] 11,680	15,386	11,628	11,680	14,742
Cuba [e]	1,400	1,700	1,700	-----	-----	-----
Finland	[e r] 1,100	[e] 1,200	[e] 1,300	557	858	1,111
France [5]	-----	-----	-----	882	[e] 900	[e] 900
Germany, West [5]	-----	-----	-----	[r] 893	937	911
Morocco	1,662	1,554	666	-----	-----	-----
Norway	NA	NA	NA	[6] 709	[6] 810	[6] 862
U.S.S.R. [e] [7]	[r] 1,600	1,650	1,700	1,600	1,650	1,700
Zambia	1,482	1,997	[e] 2,400	1,319	1,983	2,262
Total	[r] 20,984	21,669	26,026	[r] 18,894	19,636	24,240

[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. The United States also produces cobalt-bearing ores, but data are withheld to avoid disclosing individual company data. 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 are 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. Total U.S. output is not available. 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 show cobalt content of all products, including nickel oxide sinter shipped to the United Kingdom and nickel-copper matte shipped to Norway for further processing. Data presented for metal production show 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.

[4] Mine output not available; data presented show metal production.

[5] Domestic mine output if any, is negligible.

[6] Produced entirely from nickel-copper matte imported from Canada; domestic mine output is recovered abroad.

[7] Insufficient data are available to permit separate estimates for mine and metal production.

million in Western New South Wales, 18 miles west of Broken Hill. The deposit was composed mainly of cobalt-bearing pyrites. Discovery of another ore body with significant cobalt and copper values was announced by Tasman Minerals N.L. from drillings at its Federal Leases in N.W. Queensland. Freeport Sulphur Company's subsidiary, Freeport Queensland Nickel, reached agreement with Queensland authorities for a 140-mile railroad linking its Greenvale property with a plant site near Townsville, Queensland. The Greenvale area was estimated to contain 45 million tons of lateritic material averaging more than 1.5 percent nickel and 0.1 percent cobalt. Freeport operated a pilot plant in Louisiana for adapting an ammonia-leach process to Australian laterites. Startup of the Greenvale venture was planned for 1974. The eventual capacity will be 3 million pounds of cobalt per year.

Canada.—Following settlement of a lengthy strike in 1969 at the Ontario operations of International Nickel Company of Canada, Ltd. (Inco) and Falconbridge Nickel Mines Ltd., cobalt production attained prestrike levels in 1970. Cobalt deliveries by Inco were 1,980,000 pounds in 1970, compared with 1,870,000 pounds in 1969 and 1,790,000 pounds in 1968. Falconbridge produced 1,984,140 pounds of cobalt in 1970, compared with 1,873,910 pounds in 1969. Falconbridge continued to ship its nickel-copper matte to its refinery in Kristiansand, Norway, where the cobalt content was recovered. Cobalt deliveries by Falconbridge in 1970 were lower than in 1969. Part of the increased production replenished cobalt stocks partly depleted during 1969. Production of cobalt by Sherritt Gordon Mines Ltd. was 828,930 pounds in 1970, compared with 668,000 pounds in 1969. Sales of cobalt for the 2 years were 706,000 and 725,000 pounds, respectively. Sherritt Gordon completed extensive tests at their Fort Saskatchewan demonstration plant on Le Nickel's laterite ore from New Caledonia. The company reported satisfactory results.

Congo (Kinshasa).—Following an agreement reached in 1969 between the Union Minière S.A. affiliate, Société Générale des Minerais (SGM) and the Government company La Générale Congolaise des Minerais (GÉCOMIN), the new name of GÉCOMIN became Générale Congolaise des Mines (GÉCOMINES), as of March 11, 1970. GÉCOMINES operated a total of eight mines in the Congo's Katanga Province. The largest proportion of GÉCOMINES copper-cobalt ore production was from the western area near Kolwezi. There were three open pits, Kamoto, Musonoi, and Ruwe, along with one developing underground mine, Kamoto. The Congo's cobalt production increased 32 percent in 1970 over 1969, reaching 30,772,000 pounds. Total ore feed from the various mines of GÉCOMINES to concentrators and washing plants amounted to about 10 million tons annually. GÉCOMINES operated two hydrometallurgical plants in the Congo (Kinshasa) for the recovery of cobalt and copper. Approximately 75 percent of the copper and all of the cobalt was electrowon. The Luilu plant is essentially a modern version of the Shituru plant. Basically the ore was roasted and leached to extract copper and cobalt. The cobalt was precipitated from solution following the precipitation of iron and copper. The cobalt precipitate was redissolved and the cobalt electrodeposited. A third Dorr Fluo-Solids roaster was being installed at the Luilu plant and was expected on stream by January 1972. The new roaster will about double the plant's throughput of copper-cobalt concentrates from the present 408 tons per day to 794 tons per day. Main feeds to Luilu were sulfide and oxide concentrates from Kamoto and Kolwezi concentrators. The sulfide concentrate contained 43.0 percent copper and 2.5 percent cobalt, whereas the oxide concentrate contained 24.0 percent copper and 2.0 percent cobalt.[2]

Finland.—Outokumpu Oy, located at Kokkola, Finland, has produced pure cobalt since 1968, using its own leaching process and Sherritt Gordon's hydrogen reduction process under a licensing agreement. Over 95 percent of the cobalt produced in Finland was exported. Cobalt metal production was 1,111 tons in 1970, compared with 858 tons in 1969.

Japan.—In 1970 Japan again ranked as one of the leading consumers of cobalt in the world. Consumption was reported as

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[2] World Mining. V. 6, No. 10, September 1970, pp. 30–35.

2,467,000 tons of cobalt. The Natural Resources Association announced that a Japanese seabed mining venture, operating northwest of Tahiti, successfully collected manganese nodules containing cobalt and nickel of commercial value, on a continuous basis from a depth of 3,760 meters.

Morocco.—Production of cobalt was reported as 666 tons in 1970, down 57 percent from the previous year. Ugine Kuhlmann, although experiencing difficulties in the production of cobalt in Morocco, expected to maintain or slightly increase output in 1971.

Philippines.—Marinduque Mining and Industrial Corp. announced plans to proceed with development and construction of a nickel mine and refinery on Nonoc Island in the Philippines. Annual capacity was estimated at 75 million pounds of nickel; 70 million pounds will be in the form of pure nickel powder or briquets, the remaining 5 million pounds will be mixed with 3 million pounds of cobalt in a semirefined form. Commercial operation was planned for July 1972.

Southern Rhodesia.—According to reliable sources, extensive exploration was taking place in Southern Rhodesia. Preliminary indications suggested cobalt-nickel deposits of considerable size.

Uganda.—Kilembe Copper Cobalt Ltd. was asked to sell half of its 70-percent interest in Kilembe Mines Ltd. to the Government-owned Uganda Development Corp. Ltd. as part of Ugandian President Obotee's announced nationalization of the country's manufacturing, mining, transportation, and plantation industries. The immediate effect of this announcement on Kilembe Copper Cobalt's plans to construct a new cobalt processing plant in Uganda were not known. The new plant was to be part of the company's copper mining complex at Jimja.

Zambia.—The Zambian Government, through the Industrial Development Corporation of Zambia (INDECO), acquired 51 percent of Roan Selection Trust Ltd. properties and assets in Zambia. The major portion of cobalt shipped from Rhokana Corporation's cobalt plant in Zambia was in the form of crushed cathodes. A vacuum degassing plant installed at Rhokana 2 years ago made it possible for the metal to meet stricter market demands. Roan Consolidated Mines Ltd.'s plant at Chambishi produced 358 tons of contained cobalt as cobalt hydroxide from Chibuluma concentrate, which it sold to Rhokana. Estimated reserves at Chibuluma as of June 30, 1970, were 6,712,000 tons of ore containing 4.8 percent copper and 0.21 percent cobalt. The output of copper-leach cathodes decreased in 1970, reflecting the changeover to cobalt production and the greater availability of smelter capacity for treating copper concentrates.

TECHNOLOGY

Bureau of Mines metallurgists reported the recovery of high-purity nickel and cobalt from crude nickel and ferronickel by electrochemical means.[3] A semi-pilot plant process utilized solvent extraction to remove and separate cobalt and iron from nickel, with the subsequent electrodeposition of nickel and cobalt from purified chloride-based electrolytes. The process utilized water-insoluble organic amines, which enabled the production of commercial-sized nickel and cobalt cathodes of a purity higher than commercial electrolytic metals. The cobalt metal product contained about 1,100 parts per million (ppm) solid impurities and 200 ppm gaseous impurities.

Bureau scientists also reported on reactions of cobalt-nickel-vanadium alloys with oxygen at temperatures between 1,351° and 1,429° K.[4] The alloys tested consisted of Co-Ni master alloys (0, 22, 50, 70, 91, and 100 weight-percent Ni), with vanadium additions of 0, 0.9, and 2.7 weight-percent. The addition of vanadium to Co-Ni alloys caused a decrease in the alloy's resistance to oxidation. Mechanisms by which vanadium decreased the resistance of the alloy to oxidation were believed to be the valency effect and the formation of low-melting phases.

Powerful permanent magnets composed of cobalt, copper, and cerium having field strengths greater than cobalt-platinum

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[3] Brooks, P. T., and G. M. Potter. Electrochemical Recovery of High-Purity Nickel and Cobalt From Crude Nickel and Ferronickel. BuMines Rept. of Inv. 7402, 1970, 25 pp.

[4] Doerr, R. M., and J. W. Jensen. Reaction of Co-Ni-V Alloys With O_2 at 1,351° and 1,429° K. BuMines Rept. of Inv. 7371, 1970, 20 pp.

magnets, were introduced by Sel-Rex.[5] These magnets were designed principally to compete with the more costly cobalt-platinum magnets. Sel-Rex estimated cost savings of about 75 percent and weight savings of 50 percent, compared with cobalt-platinum magnets of comparable strength. Of three types introduced, Permaflux C had a coercive force of 4,800 oersted and an intrinsic coercive force of 6,200 oersteds. Permaflux C appeared well suited for use in miniature applications requiring high coercivity such as electron-beam focusing devices, electronic switch gear, servomechanisms, inertial guidance system components and other electronic and electromechanical devices. Research continued on the development of other combinations of cobalt-rare earth elements (cobalt-samarium and cobalt-praseodymium) to find materials with still higher energy products and coercive forces.[6]

Other developments of interest included investigations on eutectic cobalt alloys[7] and the oxygen binding ability of hemoglobin and myoglobin analogs in which cobalt was substituted for the iron.[8] A new version of the electric automobile employing novel cobalt-lead batteries was introduced by Electric Fuel Propulsion Inc. The battery had an energy density more than double that of the ordinary lead-acid battery. More significant, however, was its low internal resistance, which allowed it to accept huge recharging currents without damage. Numerous technical papers were presented on cobalt metal, alloys and alloy systems, magnetic materials, alloy steels, and microstructure analysis of alloys.[9]

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[5] Materials Engineering. V. 72, No. 5, November 1970, p. 23.

[6] Becker, J. J. Permanent Magnets. Scientific American. V. 223, No. 6, December 1970, pp. 92–100.

[7] Thompson, E. R., and F. D. Lemkey. Unidirectional Solidification of Co-Cr-C Monovariant Eutectic Alloys. Met. Trans. V. 1, No. 10, October 1970, pp. 2799–2805.

[8] Chemical & Engineering News. V. 48, No. 41, Sept. 28, 1970, pp. 40–41.

[9] Cobalt—Quarterly Publication on Cobalt and Its Uses (Cobalt Information Center, Battelle Mem. Inst., Columbus, Ohio). Nos. 46–49, March-December, 1970.

Coke and Coal Chemicals

By Eugene T. Sheridan [1]

Coke production in the United States totaled 66.5 million tons in 1970, an increase of nearly 3 percent over the output reported for 1969. Both oven- and beehive-coke production increased, but the bulk of the increased output was from oven-coke plants.

Production remained stable throughout the year; monthly output was only about 300,000 tons larger in December than in January. Peak production was in October, when output reached 5.8 million tons. All of the increased output of oven-coke plants was from furnace plants as merchant-plant production for the year declined slightly.

Demand for coke was about equivalent to production during the first 9 months of the year, and producers' stocks were approximately the same size at the end of September as when the year began. Stocks of oven coke increased, however, during the last quarter and, at the end of December, were equivalent to 22.5 days' production at the December rate of output.

Blast furnaces continued to use the bulk of the Nation's coke production, receiving 93 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 increased 6 percent, mainly because more coal was carbonized, but also because the breeze yield increased slightly. 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, 45 percent of the 1970 output was sold, mainly for use as a reductant in electric furnaces that smelt phosphate rock to produce elemental phosphorus. Sales of breeze in 1970 were 36 percent higher than in 1969.

Coal costs increased substantially in 1970. The average delivered value of coking coals at oven-coke plants increased $1.79 per ton; the value of coking coals received at beehive plants increased $1.07 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 Maryland, New Jersey, New York, and Pennsylvania.

[1] Mineral specialist, Division of Fossil Fuels.

Table 1.—Salient coke statistics

	1966	1967	1968	1969	1970
United States:					
Production:					
Oven coke___thousand short tons__	65,959	63,775	62,878	64,047	65,654
Beehive coke_______________do____	1,442	806	775	710	871
Total [1]__________________do____	67,402	64,580	63,653	64,757	66,525
Exports_____________________do____	1,066	710	792	1,629	2,514
Imports_____________________do____	96	92	94	173	153
Producers' stocks, Dec. 31_______do____	3,079	5,468	5,985	3,120	4,113
Consumption, apparent__________do____	66,019	61,572	62,438	r 66,166	63,171
Value of coal-chemical materials used or sold___________thousands__	$309,143	$292,579	r $281,250	$288,963	$293,464
Value of coke and breeze used or sold thousands__	r 1,187,595	r 1,119,288	r 1,187,402	1,402,716	1,899,116
Total value of all products used or sold thousands__	r 1,496,738	r 1,411,867	r 1,468,651	1,691,679	2,192,580
World production:					
Hard coke_______thousand short tons__	342,194	334,970	r 348,112	r 366,210	382,510
Gashouse and low-temperature coke thousand short tons__	37,043	34,273	r 31,293	r 29,857	27,619

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

Production of coke-oven gas increased about 3 percent because of the larger quantity of coal carbonized. Output of ammonia, crude tar, and crude light oil decreased because of the lower yield of these products recovered for each ton of coal carbonized. Approximately the same percentages of the production of crude tar and crude light oil were sold as in 1969.

Coke prices increased significantly during 1970. The average value of receipts of $29.97 per ton for all grades of oven coke and $19.89 per ton for all grades of beehive coke represented price increases of about 25 percent for each type of coke. Most of the oven-coke price increase was attributed to blast-furnace coke, which increased about 31 percent in value per ton at the producing plant. Prices of most coal chemicals remained at about the 1969 level throughout the year. Plant prices of both hard and soft pitch increased significantly; price decreases were recorded for ammonium sulfate and ammonia liquor.

Foreign trade in coke was relatively small, but exports were 54 percent greater than in 1969. The bulk of the coke exported was shipped to Canada, Japan, Mexico, and Romania. Imports were insignificant, amounting to less than the domestic output for 1 day.

The total value of all coals carbonized was $1,171 million, and the total value of all products of carbonization was $2,193 million. The combined value of coke and breeze, the principal products, accounted for 87 percent of the total value of all products.

COKE AND BREEZE

DOMESTIC PRODUCTION

Although varying somewhat from month to month, coke production assumed a slightly upward trend in 1970, and total production was about 3 percent greater than in 1969. Peak production for the year was recorded in October when the output of oven and beehive coke totaled 5.8 million tons. The average daily output of all plants in December 1970 was about 3,000 tons greater than in December 1969. Table 5 compares the monthly and average daily production of oven and beehive plants in 1970 and 1969.

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.

The number of merchant and furnace plants operating throughout the year remained about the same as in 1969. All of the increased output, however, came from furnace plants as merchant-plant production remained at the 1969 level. Furnace plants supplied 91 percent and merchant plants 9 percent of the total output. The monthly output of merchant and furnace plants in 1969 and 1970, as well as annual output for the past 5 years, is shown in tables 6 and 7.

Coke was produced in 20 States in 1970. 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. 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 1970 was produced in 14 States east of the Mississippi River. About 5 million tons, 7 percent of the total, was produced in California, Colorado, Minnesota, Missouri, Texas, and Utah.

Pennsylvania, the largest producer, accounted for 27 percent of the output and was followed by Indiana, Ohio, Illinois, and Alabama, in the order named. The combined output of these five States was about two-thirds of the national total. Pennsylvania had more than double the production of any other State. These data are shown in table 8.

An average of 1,379 pounds of coke was produced for each ton of coal carbonized in the United States in 1970. The 1970 yield of coke from coal, which averaged 68.95 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 about 55 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 1970 was nearly double the quantity sold in 1966.

The breeze yield varies substantially within and between States according to the coals carbonized. The lowest yield, 3.28 percent, was recorded for Pennsylvania while Indiana had the highest yield, 6.19 percent. The national average yield has not varied significantly during the past decade.

An average of 98 pounds of breeze was produced for each ton of coal carbonized at oven-coke plants in 1970. This quantity amounted to 4.91 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 State, in 1970 is 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 1970 totaled 63.2 million tons. This consumption, (domestic production plus imports, minus exports and changes in stocks) was almost 3 million tons less than the quantity consumed in 1969. Although the quantity of coke consumed per ton of pig iron and ferroalloys produced increased slightly in 1970, about two-thirds of the decrease in total demand was the result of a lower overall requirement for blast-furnace coke, caused by a nearly 4-million-ton decline in blast-furnace pig iron and ferroalloys production in 1970. Apparent consumption of coke in the United States in 1970, 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 ratios between 1966 and 1970 is shown in table 12. Except for slight increases in 1965 and 1970, the coke rate has 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 1970 was only 1,267 pounds, compared with 1,433 pounds in 1961. The net effect of this 11-percent reduction in coke rate over the 10-year period can best be emphasized by noting that if the 1970 output of 91.8 million tons of blast-furnace pig iron and ferroalloys had been produced in blast furnaces operating at the 1961 rate, total blast-furnace coke requirements for the year would have been 65.8 million tons, rather than the 58.2 million tons actually consumed.

Tables 13 and 14 show the quantities of coke used and sold in each State in 1970. A total of 66.7 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 3 million tons of coke, 35 percent of the total coke sold commercially. Fifty-six percent of the furnace-plant sales was shipped to other blast-furnace plants.

Merchant plants distributed nearly 6 million tons of coke in 1970, 96 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 4 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 and Hawaii received shipments of coke in 1970. Alabama, Illinois, 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 5 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 1970, 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 39 other States.

Coke used for miscellaneous applications was widely distributed, with 44 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, Minnesota, 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

Although production of oven coke increased 3 percent in 1970, the amount of coke distributed by producers was about 1 million tons less than in 1969, and their stocks increased accordingly. The bulk of the increase in stocks was caused by curtailment of shipments to blast-furnace plants in the latter part of the year, when demand for blast-furnace coke declined.

Oven-coke plants ended the year with an average of 22.5 days' supply in stock at the December rate of production. This was nearly 5 days more supply on hand than at the end of 1969. The bulk of the stocks was at furnace plants, which had, roughly, 24 days' supply, compared with only 5.9 days' supply at merchant plants.

Only 2,000 tons of beehive coke was on hand at the end of 1970. The total was composed entirely of blast-furnace coke.

Stocks of coke breeze at producers' plants at the end of 1970 were approximately at the same level as at the end of 1969. Small decreases were noted, though in Michigan and Pennsylvania.

Data on stocks are shown in tables 16 and 17.

VALUE AND PRICE

Coke prices increased significantly during 1970; the average value of receipts for all grades of oven coke reached $29.97 per ton, and beehive coke averaged $19.89 per ton. The 1970 values represented increases of nearly 25 percent for both types of coke.

Most of the oven-coke price increase was attributed to a 31-percent increase in the value of blast-furnace oven coke. Foundry coke and other industrial coke from oven-coke plants increased 16 percent and 24 percent, respectively, in price.

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 strong demand for U.S. coke in foreign markets in the early part of 1970, as exports increased to 2.5 million tons. This was 54 percent more coke than was exported in 1969 and more than double the quantity exported in 1968.

The principal foreign market was Romania, which received 389,000 tons, 15 percent of the coke shipped. The market in Romania was opened in 1969 with shipments of 129,035 tons. There had been no shipments to Romania in prior years because of trade restrictions with Communist countries. Other countries receiving substantial coke shipments were Mexico, Canada, Japan, Venezuela, Bulgaria, and Italy.

Shipments to Canada, which until 1967 was the principal export market, increased about 20 percent, but were less than half as large as the record quantity of 854,637 tons shipped in 1966. Shipments to Mexico, the second largest foreign market, were 40 percent less than in 1969.

About four-fifths of the coke exported was shipped from the Baltimore, Detroit, Laredo, Mobile, and Philadelphia customs districts. Shipments from Baltimore, Mobile, and Philadelphia were significantly larger than in 1969.

Table 19 shows exports of coke by country and customs district for 1968, 1969, and 1970. 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 less than 1 percent of the apparent consumption. Ninety-six percent of the imported coke came from Canada, and almost all of the remainder was from France and West Germany. Import data for 1968, 1969, and 1970 are shown in table 20.

COKING COALS

QUANTITY AND VALUE OF COAL CARBONIZED

A total of 95.1 million tons of bituminous coal was carbonized at high temperatures for the production of coke in 1970. The coke industry consumed about one-sixth of the 1970, bituminous coal output, coke production was the second largest coal market. Only the electric-utility industry, which presently consumes about one-half of the production, ranked higher in usage. In addition to bituminous coal, 472,000 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 1970 was $12.21 per ton, and the value of that received by beehive-coke plants averaged $7.31 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 coals delivered to both oven- and beehive-coke plants was about 18 percent greater than in 1969. Coals delivered to some States, however, had increases in average value per ton ranging from 25 to 30 percent. The highest coal prices were recorded for Maryland, New Jersey, and New York, where the delivered value of coals received by all plants averaged $15.63 per ton.

An overall average of 1.45 tons of coal, valued at $17.70, was required for each ton of oven coke produced in 1970. Beehive ovens required an average of 1.64 tons of coal per ton of coke output, but coal costs averaged only $11.99 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 1966–70. 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 Indiana and Tennessee were less than 100,000 tons.

Of the coals received by oven-coke plants, 34 percent was produced in West Virginia and 30 percent in Pennsylvania. West Virginia shipments were principally low-volatile coals from McDowell and Wyoming Counties, medium-volatile coal from Wyoming 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 County.

Another major supplier of coking coal was Kentucky, which supplied 14 percent of the shipments to coke plants. Virtually all was high-volatile coal produced mainly in Boyd, Floyd, Harlan, Letcher, and Pike Counties.

Illinois produced coking coals that were used 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 1970, 57 percent of the coal received by furnace plants was captive. Some merchant plants also own coal mines, but only 29 percent of the coal they received in 1970 was their own production.

The quantities of captive coal received by oven-coke plants in 1970 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 June when month-end stocks were 9.2 million tons. The lowest level, 6.6 million tons, was reported at the end of July after a curtailment in bituminous coal production because of the vacation period of coal miners.

Bituminous coal stocks at the end of 1970 were about 15 percent greater than when the year began. The 8.9 million tons on hand at all plants on December 31, 1970, was equivalent to about 34 days' supply, based upon the December rate of consumption.

Only small quantities of anthracite are stocked. Stocks at the end of 1970 totaled only 121,000 tons, about 7 percent less anthracite than was on hand at the end of 1969.

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 20 pounds. Data on production and sales of basic chemical materials and derivatives at oven-coke plants in 1970 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 1970, were roughly equivalent to the heating value of about one-fourth of the coal carbonized in slot ovens. Table 35 shows 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 is the gaseous material that remains after tar, ammonia, and light oil have been removed from the volatile matter evolved in carbonization. Because it has a relatively high calorific value, producers use most of the gas 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 1970 was 10,440 cubic feet. This was only slightly less than the yield of 10,480 cubic feet recorded for 1969. However, total gas production increased about 4 percent over that of 1969 because an additional 3 million tons of coal was carbonized in 1970.

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 88 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; only about 60 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. Over 450 billion cubic feet of coke-oven gas equivalent was so consumed, of which 84 percent was coke-oven gas, 11 percent was blast-furnace gas, and the remainder was natural gas.

Surplus coke-oven gas used and sold in 1970 was valued at $148 million. This is a 7-percent increase from the 1969 value. No value is reported by producers for coke-oven gas used to heat coke ovens, but applying the average value of $0.254 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 1970 would be $245 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 1970, 92 percent of the ammonia recovered was used to produce 595,000 tons of ammonium sulfate and 42,000 tons of diammonium phosphate, and 15,000 tons of ammonia was collected as an aqueous solution.

Table 40 shows production and sales of ammonia products and yields in 1970 in terms of sulfate equivalent. Compared with 1969 the yield of ammonia declined 5 percent, and total output fell 6 percent.

Sales of ammonium sulfate increased 1 percent and ammonia liquor sales were about the same as in 1969. The average value per ton, f.o.b. plant, of ammonium sulfate decreased $3.28 per ton to $15.44, and the average plant value of ammonia liquor decreased $9.05 per ton. The total value of all ammonia products sold was $13 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 1969, they ranged from 5.92 to 9.69 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 1970 decreased 1 percent from that of 1969. The average yield of tar decreased slightly to 8.00 gallons per ton of coal, compared with 8.33 gallons in 1969. Table 41 shows the quantities of tar produced, used by producers, sold, and in stock in the various States at the end of 1970.

Coke-plant operators used 51 percent of the tar produced in 1970. Of this quantity, 72 percent was processed (refined or "topped"), 28 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 1970 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. All 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 1970 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 2.68 gallons of light oil was recovered at the plants that extracted light oil in 1970. 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 remained at about the 1969 level at merchant plants, but increased by one-fifth of a gallon at furnace plants.

Producers sold 40 percent of their crude light-oil output in 1970. 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 most light-oil derivatives decreased in 1970. Average yields for 1970 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 96 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 benzene, as well as toluene and xylene, was lower than in 1969 because of lower recovery yields for all products, and a smaller amount of light oil was refined at coke plants.

TECHNOLOGY

New technology developed by the U.S. Steel Corp. may bring a breakthrough in coke-quenching operations and further reduce atmospheric pollution from coke-plant operations. The new quenching process [2] consists of loading hot coke into an enclosed hopper system, spraying the coke inside the closed system, and discharging the coke from the continuous quenching facility onto a conveyor belt. The coke is then conveyed to the screening station as with conventional systems. The uniform rate of steam generation in the new system permits cleaning and control of the steam exhausted to the atmosphere.

The installation of specially designed baffles in conventional quenching towers is another improvement from the standpoint of reduced atmospheric pollution. Developed by the U.S. Steel Corp., the baffles, which are located in the tower, slow down steam flow and cause most of the coke particles contained in the steam, as well as water vapor, to adhere to the baffles or remain within the tower.

A system [3] for collecting and wet-scrubbing the gases emitted from slot ovens during charging has been designed by Bethlehem Steel Co. and installed on one charging car at the company's Burns Harbor plant. This system consists of a charging car equipped with two cleaning units in parallel, each designed to handle the gases and dust evolved from two charging holes. The emissions are burned in combustion chambers with air ports that are adjustable to a maximum air-port to gas-port ratio of 1.93. Although glow plugs were provided for ignition of the gases, they proved unreliable and combustion was dependent mainly upon spontaneous ignition whenever the gas-air mixture was within combustible limits. The products of combustion then are contacted with water in two stainless steel venturi scrubbers, after which the cleaned gas is released to the atmosphere, and the contaminated water is discharged to a sump for use in coke quenching after the solids settle out.

A system [4] based upon the charging of preheated coal mixes to coke ovens through pneumatic pipelines has been developed by the Allied Chemical Corp. and installed on a 24-oven battery at its Ironton, Ohio plant. The system, which is the first major change in basic coke-oven technology in nearly 80 years, employs closed pipelines rather than charging cars to transport coal to the ovens. The new process reportedly increases oven production by decreasing coking time and permits the use of lower cost, poorer quality coals to produce acceptable metallurgical-grade coke. Initial results reveal a drastic reduction in atmospheric pollution, accompanied by an increase in coke production of up to 50 percent. The closed system eliminates air pollution from the charging operation, which represents as much as 70 percent of the total air pollution from oven-coke plant operations.

A system [5] involving control and communications equipment and providing for fully automatic operation of the quencher car, wharf gates, and quenching station has been installed at the Fairless Works of the U.S. Steel Corp. Automatic operation of the quencher locomotive results in a more evenly distributed load of coke in the quencher car to make more uniform quenching of coke possible and guarantees sequential placement of coke on the wharf. Automatic control of the wharf gates makes possible the withdrawal of coke from the wharf in a regulated manner. As a result, there are definite realized benefits in terms of reduced coke moisture variability, a lower level of coke moisture, and a longer service life of coke conveyor belting. Obviously, there are direct labor savings.

A new cupola coke,[6] made from oil by-product rather than coal, has been developed by the Republic Carbon Products Co., Inc., of Bakersfield, Calif. It is reported that the use of this coke in cupolas has increased carbon content of the iron as much as 12 percent and, because of the higher carbon content, the coke charge was reduced up to 15 percent.

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[2] Blast Furnace and Steel Plant. New Technology Breakthrough in Coke-Quenching at U.S. Steel's Clairton Works. V. 88, No. 5, May 1970, p. 339.

[3] Blast Furnace and Steel Plant. Performance of Gas-Cleaning System on Coke-Oven Larry Car at Burns Harbor. V. 59, No. 1, January 1971, pp. 22–26.

[4] Blast Furnace and Steel Plant. Charging Preheated Coal to Coke Ovens. V. 58, No. 5, May 1970, pp. 326–329.

[5] Blast Furnace and Steel Plant. Automation of Quencher Locomotive and Coke Wharf. V. 58, No. 9, September 1970, pp. 639–647.

[6] Iron Age. New Coke Fuel Developed. V. 207, No. 22, June 3, 1971.

Table 2.—Statistical summary of the coke industry in the United States in 1970

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants____thousand short tons__	5,915	[1]	[1]
At furnace plants [2]____do____	59,739	[1]	[1]
Total____do____	65,654	871	66,525
Breeze produced____do____	4,665	[3]	[3]
Coal carbonized:			
Bituminous:			
Thousand short tons	94,581	1,428	96,009
Value (thousands)	$1,154,478	$10,438	$1,164,916
Average per ton	$12.21	$7.31	$12.13
Anthracite:			
Thousand short tons	472	-	472
Value (thousands)	$5,888	-	$5,888
Average per ton	$12.47	-	$12.47
Total: [4]			
Thousand short tons	95,053	1,428	96,481
Value (thousands)	$1,160,367	$10,438	$1,170,805
Average per ton	$12.21	$7.31	$12.14
Average yield in percent of total coal carbonized:			
Coke	69.07	60.99	68.95
Breeze (at plants actually recovering)	4.91	[3]	[3]
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	56,646	-	56,646
Value (thousands)	$1,554,347	-	$1,554,347
In foundries:			
Thousand short tons	311	-	311
Value (thousands)	$12,605	-	$12,605
For other industrial uses:			
Thousand short tons	361	-	361
Value (thousands)	$8,567	-	$8,567
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	366	-	366
Value (thousands)	$2,257	-	$2,257
In agglomerating plants:			
Thousand short tons	1,948	-	1,948
Value (thousands)	$20,893	-	$20,893
For other industrial uses:			
Thousand short tons	704	-	704
Value (thousands)	$6,195	-	$6,195
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	3,709	829	4,538
Value (thousands)	$92,910	$16,383	$109,293
Average per ton	$25.05	$19.77	$24.08
To foundries:			
Thousand short tons	2,953	[5]	2,953
Value (thousands)	$120,544	[5]	$120,544
Average per ton	$40.83	[5]	$40.83
To other industrial plants:			
Thousand short tons	1,841	40	1,881
Value (thousands)	$41,862	$892	$42,754
Average per ton	$22.74	$22.30	$22.73
For residential heating:			
Thousand short tons	48	-	48
Value (thousands)	$969	-	$969
Average per ton	$20.19	-	$20.19
Breeze sold (commercial sales):			
Thousand short tons	2,067	[3]	[3]
Value (thousands)	$20,611	[3]	[3]
Average per ton	$9.97	[3]	[3]
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	760,926	-	760,926
Gallons per ton of coal	8.00	-	8.00
Ammonia: [6]			
Thousand short tons	691	-	691
Pounds per ton of coal	15.77	-	15.77
Crude light oil:			
Thousand gallons	244,107	-	244,107
Gallons per ton of coal	2.68	-	2.68
Gas:			
Million cubic feet	992,790	-	992,790
Thousand cubic feet per ton of coal	10.44	-	10.44
Percent burned in coking process	38.30	-	38.30
Percent surplus used or sold	58.89	-	58.89
Percent wasted	2.81	-	2.81

See footnotes at end of table.

Table 2.–Statistical summary of the coke industry in the United States in 1970–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..	$37,875	------------	$37,875
Sold .... do....	$56,924	------------	$56,924
Ammonia products [7] .... do....	$13,229	------------	$13,229
Crude light oil and derivatives [8]	$37,055	------------	$37,055
Surplus gas	$148,381	------------	$148,381

[1] Not separately recorded.
[2] Plants associated with iron-blast furnaces.
[3] Withheld to avoid disclosing individual company data.
[4] Data may not add to totals shown because of independent rounding.
[5] Combined with "to other industrial plants" to avoid disclosing individual company data.
[6] In terms of sulfate equivalent.
[7] Includes ammonium sulfate, ammonia liquor (NH_3 content), and diammonium phosphate.
[8] Includes intermediate light oil.

Table 3.–Summary of oven-coke operations in the United States in 1970, by States

State	Plants in existence Dec. 31	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Alabama	7	8,649	70.71	6,116
California, Colorado, Utah	3	5,116	63.23	3,235
Maryland, New Jersey, New York	5	11,536	69.52	8,020
Illinois	5	3,666	64.27	2,356
Indiana	6	13,071	68.31	8,929
Kentucky, Missouri, Tennessee, Texas	5	2,895	69.15	2,002
Michigan	3	5,117	73.36	3,754
Minnesota and Wisconsin	3	1,166	77.27	901
Ohio	12	12,697	70.10	8,900
Pennsylvania	11	26,159	69.62	18,212
West Virginia	3	4,980	64.86	3,230
Total in 1970 [1]	63	95,053	69.07	65,654
At merchant plants	15	8,208	72.06	5,915
At furnace plants	48	86,845	68.79	59,739
Total in 1969	64	92,285	69.40	64,047

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

Table 4.–Summary of beehive-coke operations in the United States in 1970, by States

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	1,428	60.99	871
Total:				
1970	6	1,428	60.99	871
1969	7	1,158	61.31	710

Table 5.—Production of oven and beehive coke in the United States, by months

(Thousand short tons)

Month	1969 Total[1]	1969 Daily average[2]	1970 Total[1]	1970 Daily average[2]
OVEN COKE				
January	5,177	167	5,332	172
February	4,873	174	5,069	181
March	5,297	171	5,655	182
April	5,312	177	5,468	182
May	5,514	178	5,603	181
June	5,347	178	5,402	180
July	5,386	174	5,442	176
August	5,412	175	5,368	173
September	5,274	176	5,425	181
October	5,552	179	5,680	183
November	5,333	178	5,537	185
December	5,570	180	5,672	183
Total	64,047	175	65,654	180
BEEHIVE COKE				
January	43	1	81	3
February	42	2	78	3
March	52	2	74	2
April	60	2	73	2
May	53	2	71	2
June	53	2	73	2
July	47	2	71	2
August	70	2	69	2
September	76	3	70	2
October	69	2	74	2
November	63	2	68	2
December	81	3	68	2
Total	710	2	871	2
TOTAL				
January	5,220	168	5,413	175
February	4,915	176	5,147	184
March	5,349	173	5,729	185
April	5,372	179	5,541	185
May	5,567	180	5,674	189
June	5,400	180	5,475	183
July	5,433	175	5,511	178
August	5,482	177	5,437	175
September	5,350	178	5,495	183
October	5,621	181	5,754	186
November	5,396	180	5,605	187
December	5,651	182	5,741	185
Total	64,757	177	66,525	182

[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	1969 Merchant plants	1969 Furnace plants	1970 Merchant plants	1970 Furnace plants
PRODUCTION				
January	496	4,681	472	4,860
February	461	4,412	467	4,602
March	504	4,793	492	5,163
April	507	4,806	469	4,999
May	514	5,000	489	5,115
June	495	4,852	494	4,908
July	482	4,906	507	4,935
August	493	4,918	495	4,873
September	470	4,803	502	4,923
October	506	5,046	512	5,169
November	485	4,848	511	5,026
December	507	5,065	505	5,167
Total [1]	5,919	58,129	5,915	59,739
DAILY AVERAGE				
January	16	151	15	157
February	16	158	17	164
March	16	155	16	167
April	17	160	16	167
May	17	161	16	165
June	16	161	17	164
July	16	158	16	159
August	16	159	16	157
September	16	160	17	164
October	16	163	17	167
November	16	156	17	168
December	16	163	16	167
Average for year	16	159	16	164

[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 [2]	Furnace plants [3]	Merchant plants	Furnace plants	Merchant plants	Furnace plants
1966	16	50	6,377	59,583	9.7	90.3
1967	16	50	6,220	57,555	9.8	90.2
1968	16	48	5,879	56,999	9.4	90.6
1969	16	49	5,919	58,129	9.2	90.8
1970	16	49	5,915	59,739	9.0	91.0

[1] Includes plants operating any part of year.
[2] Includes 1 light-oil refining plant.
[3] Includes 1 tar-refining plant.

Table 8.—Production of coke in the United States, by States

(Thousand short tons)

State	1969	1970
OVEN COKE		
Alabama	5,656	6,116
California, Colorado, Utah	3,192	3,235
Maryland, New Jersey, New York	7,664	8,020
Illinois	2,341	2,356
Indiana	8,132	8,929
Kentucky, Missouri, Tennessee, Texas	2,157	2,002
Michigan	3,582	3,754
Minnesota and Wisconsin	1,086	901
Ohio	8,638	8,900
Pennsylvania	17,989	18,212
West Virginia	3,609	3,230
Total [1]	64,047	65,654
BEEHIVE COKE		
Pennsylvania	323	444
Virginia	387	427
Total [1]	710	871
Grand total [1]	64,757	66,525

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

Table 9.—Breeze recovered at coke plants in the United States in 1970, by States

(Thousand short tons and thousand dollars)

State	Yield per ton of coal [1] (percent)	Produced	Used by producers						Sold		On hand Dec. 31
			In steam plants		In agglomerating plants		For other industrial use				
		Quantity	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	
OVEN COKE											
Alabama	5.38	465	(2)	(2)	(2)	(2)	32	$405	288	$3,392	35
California, Colorado, Utah	5.04	258	---	-----	200	$1,904	18	131	(2)	(2)	25
Maryland, New Jersey, New York	5.98	690	150	$992	(2)	(2)	(2)	(2)	168	1,323	440
Illinois	5.62	206	(2)	(2)	(2)	(2)	30	191	(2)	(2)	48
Indiana	6.19	809	---	-----	(2)	(2)	157	1,944	375	3,410	119
Kentucky, Missouri, Tennessee, Texas	5.80	168	(2)	(2)	-----	------	(2)	(2)	93	1,034	20
Michigan	4.49	230	---	-----	(2)	(2)	(2)	(2)	213	1,902	69
Minnesota and Wisconsin	8.58	100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	87
Ohio	4.88	620	(2)	(2)	25	156	87	548	453	4,220	64
Pennsylvania	3.28	858	(2)	(2)	653	7,279	94	938	270	2,647	107
West Virginia	5.22	260	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	16
Undistributed	----	-----	216	1,265	1,070	11,554	286	2,037	208	2,683	-----
Total 1970 [3]	4.91	4,665	366	2,257	1,948	20,893	704	6,195	2,067	20,611	1,030
At merchant plants	6.94	570	115	676	-----	------	157	1,123	383	4,366	193
At furnace plants	4.71	4,093	250	1,581	1,948	20,893	547	5,072	1,684	16,245	838
Total 1969	4.77	4,401	439	3,365	1,650	14,863	775	5,224	1,518	12,369	1,080
BEEHIVE COKE											
Pennsylvania and Virginia, 1970	(4)	(4)	---	-----	-----	------	---	-----	(4)	(4)	-----
Total 1969	8.36	20	---	-----	-----	------	---	-----	20	140	(5)

[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.
[4] Withheld to avoid disclosing individual company data.
[5] Less than ½ unit.

Table 10.—Oven- and beehive-coke breeze used and sold in the United States, by uses

(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
1966	644	1,873	505	1,172	7.27
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

[1] To avoid disclosing individual company data, this figure does not include beehive-coke breeze sold.

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
1966	67,402	96	1,102	+376	66,019	59,637	90.3	6,383	9.7
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	r 66,166	60,176	90.9	5,990	9.1
1970	66,525	153	2,514	+993	63,171	58,151	92.1	5,020	7.9

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)
1966	1,300.6	69.9	1,860.7
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

[1] American Iron and Steel Institute; consumption of pig iron only, excluding furnaces making ferroalloys, was 1,282 in 1966, 1,262 in 1967, 1,248 in 1968, 1,252 in 1969 and 1,260 in 1970.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1970, by States

(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	6,116	4,119	$100,319	192	$5,086	(2)	(2)
California, Colorado, Utah	3,235	3,135	82,857	(2)	(2)	------	------
Maryland, New Jersey, New York	8,020	6,877	198,862	(2)	(2)	(2)	(2)
Illinois	2,356	2,299	52,251	41	2,159	(2)	(2)
Indiana	8,929	8,457	168,469	(2)	(2)	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	2,002	(2)	(2)	(2)	(2)	(2)	(2)
Michigan	3,754	(2)	(2)	(2)	(2)	(2)	(2)
Minnesota and Wisconsin	901	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	8,900	7,430	199,312	(2)	(2)	1,145	$32,239
Pennsylvania	18,212	16,790	548,641	14	406	622	18,552
West Virginia	3,230	(2)	(2)	(2)	(2)	------	------
Undistributed	------	7,539	203,636	426	13,520	1,942	42,119
Total 1970 [3]	65,654	56,646	1,554,347	672	21,172	3,709	92,910
At merchant plants	5,915	------	---------	204	7,223	2,042	43,719
At furnace plants	59,739	56,646	1,554,347	468	13,949	1,667	49,191
Total 1969	64,047	57,289	1,112,745	845	23,183	3,409	65,247

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)	501	$9,978	(2)	(2)	1,645	$47,002
California, Colorado, Utah	(2)	(2)	(2)	(2)	-----	-----	(2)	(2)
Maryland, New Jersey, New York	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Illinois	-----	-------	8	158	1	$21	(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)	(2)	(2)
Minnesota and Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	(2)	(2)	119	2,699	(2)	(2)	1,516	45,100
Pennsylvania	(2)	(2)	399	8,452	(2)	(2)	1,334	39,498
West Virginia	-----	-------	98	2,027	-----	-----	98	2,027
Undistributed	2,953	$120,544	717	18,548	51	1,028	3,961	122,738
Total 1970 [3]	2,953	120,544	1,841	41,862	52	1,050	8,554	256,365
At merchant plants	2,607	106,770	875	22,718	45	951	5,568	174,158
At furnace plants	346	13,774	966	19,144	7	99	2,986	82,207
Total 1969	3,103	109,509	2,393	43,680	48	896	8,953	219,332

[1] Comprises 311,000 tons valued at $12,605,000 used in foundries; 361,000 tons valued at $8,567,000 for other purposes.
[2] Included with "Undistributed" to avoid disclosing individual company data.
[3] Data may not add to totals shown because of independent rounding.

Table 14.—Production and sales of beehive coke in the United States, in 1970

(Thousand short tons and thousand dollars)

State	Produced	Commercial sales			
		To blast-furnace plants		To foundries	
	Quantity	Quantity	Value	Quantity	Value
Pennsylvania and Virginia	871	829	$16,383	(2)	(2)
Total:					
1970	871	829	16,383	(2)	(2)
1969	710	557	9,084	20	$244

State	Commercial sales—Continued					
	To other industrial plants		For residential heating		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Pensylvania and Virginia	40	$892	----------	----------	868	$17,275
Total:						
1970	40	892	----------	----------	868	17,275
1969	131	2,164	----------	----------	709	11,492

[1] Data may not add to totals shown because of independent rounding.
[2] Included with beehive-coke sold "to other industrial plants" to avoid disclosing individual company data.

Table 15.—Distribution of oven and beehive coke and breeze in 1970 [1]

(Thousand short tons)

Consuming State	Coke					Breeze
	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total	
Alabama	3,583	349	135	5	4,072	270
Arizona	----------	1	3	----------	4	(2)
Arkansas	----------	3	1	----------	4	(2)
California	1,318	52	58	----------	1,428	61
Colorado	660	8	24	----------	692	78
Connecticut	----------	18	1	(2)	19	(2)
Delaware	----------	(2)	(2)	----------	(2)	(2)
Florida	----------	2	43	(2)	44	32
Georgia	----------	12	3	(2)	15	3
Idaho	----------	(2)	144	----------	144	(2)
Illinois	3,705	183	27	3	3,917	461
Indiana	8,044	167	69	17	8,298	745
Iowa	----------	82	2	(2)	85	(2)
Kansas	----------	13	(2)	----------	13	1
Kentucky	979	23	58	(2)	1,059	116
Louisiana	----------	19	60	----------	80	1
Maine	----------	1	(2)	----------	2	----------
Maryland	3,799	18	14	----------	3,831	291
Massachusetts	----------	32	1	(2)	34	(2)
Michigan	4,457	706	75	3	5,242	295
Minnesota	318	20	100	----------	438	29
Mississippi	----------	(2)	(2)	----------	1	2
Missouri	----------	12	103	----------	114	4
Montana	----------	1	23	----------	24	43
Nebraska	----------	4	9	----------	13	(2)
Nevada	----------	(2)	----------	----------	(2)	----------
New Hampshire	----------	1	----------	----------	1	----------
New Jersey	----------	112	56	7	176	90
New Mexico	----------	----------	----------	1	1	----------
New York	3,673	172	47	3	3,895	321
North Carolina	----------	15	5	(2)	20	20
North Dakota	----------	(2)	5	----------	6	(2)
Ohio	8,330	422	133	2	8,887	511
Oklahoma	----------	9	1	----------	10	4
Oregon	----------	5	22	----------	27	(2)
Pennsylvania	16,934	270	331	5	17,540	998
Rhode Island	----------	11	9	----------	20	(2)
South Carolina	----------	7	46	(2)	55	6
South Dakota	----------	(2)	----------	----------	(2)	----------
Tennessee	38	52	46	1	136	105
Texas	1,083	79	84	(2)	1,246	104
Utah	1,156	22	24	----------	1,202	85
Vermont	----------	3	(2)	----------	3	----------
Virginia	----------	74	68	(2)	143	35
Washington	----------	4	5	----------	9	(2)
West Virginia	2,875	7	51	----------	2,933	237
Wisconsin	----------	143	4	2	149	59
Wyoming	----------	----------	6	----------	6	(2)
Total [3]	60,954	3,136	1,896	52	66,038	5,007
Exported	230	133	341	----------	703	138
Grand total	61,184	3,269	2,237	52	66,741	5,145

[1] Based upon reports from producers showing destination and principal end use of coke used and sold. Does not include imported coke which totaled 153,000 tons in 1970.
[2] Less than ½ unit.
[3] Data may not add to totals shown because of independent rounding.

Table 16.—Producers' stocks of coke and breeze in the United States on Dec. 31, 1970, by States

(Thousand short tons)

State	Coke: Blast furnace	Coke: Foundry	Coke: Residential heating and other	Coke: Total	Breeze
OVEN COKE					
Alabama	786	7	1	794	35
California, Colorado, Utah	106	----------	----------	106	25
Maryland, New Jersey, New York	377	3	8	388	440
Illinois	71	----------	----------	71	48
Indiana	417	16	(1)	434	119
Kentucky, Missouri, Tennessee, Texas	18	13	7	37	20
Michigan	153	13	2	167	69
Minnesota and Wisconsin	52	11	4	67	87
Ohio	285	3	2	291	64
Pennsylvania	1,640	18	11	1,668	107
West Virginia	90	----------	----------	90	16
Total 1970 [2]	3,995	83	35	4,113	1,030
At merchant plants	6	67	22	95	193
At furnace plants	3,989	16	14	4,018	838
Total 1969	3,000	83	37	3,120	1,080
BEEHIVE COKE					
Pennsylvania	2	----------	----------	2	----------
Virginia	----------	----------	----------	----------	----------
Total:					
1970	2	----------	----------	2	----------
1969	1	----------	1	2	----------

[1] Less than ½ unit.
[2] 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: 1969	At merchant plants: 1970	At furnace plants: 1969	At furnace plants: 1970	Total [1]: 1969	Total [1]: 1970
January	323	86	5,542	2,946	5,865	3,032
February	283	65	5,278	2,969	5,562	3,034
March	223	63	4,792	3,025	5,015	3,088
April	197	55	4,310	3,043	4,507	3,100
May	193	58	3,969	3,040	4,162	3,098
June	167	47	3,729	2,907	3,896	2,954
July	193	54	3,594	2,952	3,787	3,006
August	186	49	3,629	2,914	3,816	2,963
September	146	37	3,553	3,019	3,699	3,057
October	121	46	3,309	3,388	3,430	3,433
November	119	86	3,202	3,691	3,320	3,777
December	99	95	3,020	4,018	3,120	4,113

[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 uses

Year	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total
OVEN COKE					
1966	$16.33	$31.75	$16.90	$17.39	r $22.22
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
BEEHIVE COKE					
1966	$13.58	$15.30	$16.77	$16.77	$14.60
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

r Revised.

Table 19.—Coke exported from the United States, by country and by customs district

	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Angola	-	-	-	-	13,632	$714
Argentina	-	-	12,233	$535	7,390	453
Australia	175	$4	-	-	30	1
Belgium-Luxembourg	-	-	6,212	132	45,453	1,694
Brazil	8,205	267	29,285	1,027	76,978	3,564
Bulgaria	-	-	-	-	141,147	7,719
Canada	247,515	6,840	292,223	8,189	347,122	10,698
Chile	(1)	(1)	3,517	37	23,063	1,228
Congo, (Kinshasa)	-	-	-	-	3,049	162
Dominican Republic	349	9	195	5	373	12
Finland	-	-	-	-	16,609	276
France	-	-	-	-	5,621	275
Germany, West	468	10	14,882	631	42,636	1,348
India	1,697	47	655	19	745	29
Italy	28	1	-	-	134,790	1,938
Japan	39,010	451	55,640	648	310,487	4,233
Mexico	346,547	8,776	629,816	15,253	375,996	9,827
Netherlands	-	-	234,460	4,929	102,217	1,242
Norway	-	-	-	-	6,017	219
Peru	-	-	64,394	1,595	38,985	1,731
Philippines	1,038	31	-	-	-	-
Romania	-	-	129,035	3,192	388,983	14,002
Spain	-	-	13,552	164	78,180	1,303
Tunisia	-	-	-	-	19,522	1,077
United Kingdom	188	4	447	10	371	7
Venezuela	145,919	2,128	141,920	2,098	244,588	11,616
Yugoslavia	-	-	-	-	8,075	391
Other	770	45	1,022	46	81,619	3,126
Total	791,909	18,613	1,629,488	38,510	2,513,678	78,885
CUSTOMS DISTRICT						
Baltimore	1,185	35	278,311	6,334	501,485	16,438
Buffalo	125,296	3,316	106,831	2,873	153,427	5,012
Cleveland	-	-	-	-	18,769	160
Chicago	-	-	-	-	13,965	183
Detroit	85,231	2,372	152,431	4,316	242,292	5,296
Duluth	4,000	132	4,690	166	1,322	54
El Paso	9,060	233	29,361	762	1,532	41
Great Falls	-	-	-	-	1,340	36
Houston	2,565	71	1,276	37	1,235	49
Laredo	336,964	8,523	598,579	14,438	372,724	9,728
Los Angeles	39,164	450	55,565	646	37,707	475
Mobile	145,036	2,102	230,044	4,455	436,360	11,097
New Orleans	150	29	13,869	179	30,080	721
New York City	5,233	174	667	21	223	9
Nogales	239	11	845	25	223	11
Norfolk	-	-	9,729	169	181,936	8,059
Ogdensburg	5,358	124	11,915	337	20,546	586
Pembina	15,730	492	15,815	550	22,692	874
Philadelphia	4,550	137	90,117	2,374	465,180	19,687
Portland, Maine	-	-	16,359	376	-	-
St. Albans	-	-	-	-	1,370	22
San Diego	248	8	1,072	29	1,517	47
Seattle	11,520	390	11,741	408	7,589	296
Other	380	14	271	15	164	4
Total	791,909	18,613	1,629,488	38,510	2,513,678	78,885

[1] 39 short tons ($11,063) reported by the Bureau of the Census, has been deleted.

Table 20.—U.S. imports for consumption of coke by country and customs district

	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Canada	90,580	$1,630	169,341	$2,989	146,275	$2,784
France	52	6	858	102	2,498	255
Germany, West	2,668	186	2,758	248	3,888	456
Japan	-----	-----	13	(1)	-----	-----
Netherlands	785	82	82	15	218	36
Total	94,085	1,904	173,052	3,354	152,879	3,531
CUSTOMS DISTRICT						
Buffalo	2,362	23	2,703	38	9,339	171
Chicago	-----	-----	19,085	124	-----	-----
Detroit	4,083	44	43,475	882	22,102	408
Duluth	-----	-----	-----	-----	8,156	53
Great Falls	78,285	1,462	92,795	1,776	93,504	1,964
Honolulu	218	7	345	15	274	14
Miami	-----	-----	74	9	-----	-----
Mobile	-----	-----	777	93	1,810	176
New Orleans	3,078	249	2,428	246	3,870	484
Nogales	492	9	-----	-----	-----	-----
Ogdensburg	-----	-----	5,440	43	214	10
Pembina	-----	-----	-----	-----	7,204	63
Portland, Maine	17	(1)	55	1	14	(1)
St. Albans	35	1	34	1	21	(1)
San Juan	529	21	105	4	-----	-----
Savannah	-----	-----	-----	-----	650	74
Seattle	4,986	88	5,736	122	5,721	114
Total	94,085	1,904	173,052	3,354	152,879	3,531

1 Less than ½ unit.

Table 21.—Coke: World production by type and country

(Thousand short tons)

Kind of coke and country [1]	1968	1969	1970 p
METALLURGICAL COKE [2]			
North America:			
Canada [3] [4]	5,311	5,002	5,668
Mexico	1,271	1,258	1,433
United States	63,653	64,757	66,525
South America:			
Argentina [3]	402	398	e 397
Brazil	1,550	1,661	1,797
Chile	r 335	349	e 350
Colombia	e 480	513	549
Peru	r 46	53	e 55
Europe:			
Austria [3]	r 1,790	1,907	1,949
Belgium	r 7,983	7,992	7,722
Bulgaria	901	876	e 880
Czechoslovakia	10,410	11,037	11,316
Finland [4]	132	157	131
France [3]	r 13,604	14,924	15,597
Germany, East	2,812	2,636	3,034
Germany, West	r 39,950	43,002	44,023
Hungary	551	564	724
Italy	r 7,012	7,314	7,767
Netherlands [3]	r 3,230	2,238	2,201
Norway	342	353	343
Poland	r 15,890	16,336	e 16,747
Romania	1,249	1,035	1,179
Spain [5]	3,882	4,063	4,422
Sweden	577	588	584
U.S.S.R. [3]	78,821	81,020	83,114
United Kingdom	r 18,197	18,564	18,287
Yugoslavia	r 1,293	1,284	1,351
Africa:			
Rhodesia, Southern	244	268	e 270
South Africa, Republic of e	r 3,500	r 3,700	4,000
United Arab Republic	344	344	e 350
Asia:			
China, mainland e	r 17,000	r 19,000	20,000
India [6]	8,122	9,854	e 9,600
Iran [7]	r 49	57	60
Japan	28,810	34,186	40,095
Korea, North e	r 2,200	2,200	2,400
Taiwan	227	217	308
Turkey	1,576	1,591	e 1,790

See footnotes at end of table.

Table 21.—Coke: World production by type and country—Continued

Kind of coke and country [1]	1968	1969	1970 p
METALLURGICAL COKE—Continued			
Oceania:			
Australia	4,360	4,906	5,485
New Zealand	6	6	7
Subtotal—Metallurgical coke	r 348,112	366,210	382,510
GASHOUSE COKE [8]			
South America:			
Brazil	218	192	e 200
Uruguay	22	18	e 17
Europe:			
Austria	r 218	94	----
Czechoslovakia	98	32	e 33
Denmark	r 324	177	e 175
France	9	9	10
Greece	17	15	e 15
Germany, West	r 2,565	2,652	2,795
Hungary	r 477	475	e 475
Ireland [3]	r 60	40	e 40
Italy	297	212	138
Netherlands	3	3	----
Poland	r 1,430	1,486	e 1,490
Spain	7	7	4
Sweden	543	443	e 440
Switzerland	r 336	308	181
United Kingdom	r 5,146	3,344	2,097
Yugoslavia	2	----	----
Africa:			
South Africa, Republic of	r 117	e 110	e 110
Asia:			
India	e 55	71	e 82
Japan	4,927	5,521	5,267
Taiwan	55	62	10
Turkey e	200	200	200
Oceania:			
Australia	r 700	772	e 772
New Zealand [9]	e 66	53	40
Subtotal—Gashouse coke	r 17,892	16,296	14,591
ALL OTHER TYPES [10]			
North America:			
United States	174	----	----
Europe:			
Czechoslovakia	r 1,813	1,540	e 1,540
France	241	----	----
Germany, East [11]	7,489	7,092	6,918
Hungary	314	301	e 90
Asia:			
India	3,290	4,548	e 4,400
Turkey e	80	80	80
Subtotal—All other types	r 13,401	13,561	13,028
Grand total—All types	r 379,405	396,067	410,129

e Estimate. p Preliminary. r Revised.

1 In addition to the countries listed, Algeria, Ceylon, Malaysia, mainland China, Mexico, Norway, Romania, U.S.S.R. and United Arab Republic 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 collieries 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 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 1970, by States

State	Coal carbonized: Thousand short tons	Value: Total (thousands)	Value: Average	Coal per ton of coke: Short tons	Coal per ton of coke: Value
OVEN COKE					
Alabama	8,649	$98,417	$11.38	1.41	$16.05
California, Colorado, Utah	5,116	59,387	11.61	1.58	18.34
Maryland, New Jersey, New York	11,536	180,337	15.63	1.44	22.51
Illinois	3,666	40,895	11.16	1.56	17.41
Indiana	13,071	154,720	11.84	1.46	17.29
Kentucky, Missouri, Tennessee, Texas	2,895	29,592	10.22	1.45	14.82
Michigan	5,117	75,140	14.68	1.36	19.96
Minnesota and Wisconsin	1,166	16,498	14.15	1.29	18.25
Ohio	12,697	144,164	11.35	1.43	16.23
Pennsylvania	26,159	307,634	11.76	1.44	16.93
West Virginia	4,980	53,584	10.76	1.54	16.57
Total 1970 [1]	95,053	1,160,367	12.21	1.45	17.70
At merchant plants	8,208	100,680	12.27	1.39	17.06
At furnace plants	86,845	1,059,687	12.20	1.45	17.69
Total 1969	92,285	961,265	10.42	1.44	15.01
BEEHIVE COKE					
Pennsylvania and Virginia	1,428	10,438	7.31	1.64	11.99
Total:					
1970	1,428	10,438	7.31	1.64	11.99
1969	1,158	7,226	6.24	1.63	10.18

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

Table 23.—Bituminous coal carbonized in coke ovens in the United States, by months

(Thousand short tons)

Month	1969 Slot	1969 Beehive	1969 Total [1]	1970 Slot	1970 Beehive	1970 Total [1]
January	7,379	73	7,452	7,659	133	7,792
February	6,937	70	7,007	7,238	126	7,364
March	7,579	86	7,665	8,116	123	8,239
April	7,581	97	7,679	7,853	123	7,976
May	7,866	88	7,954	8,099	114	8,213
June	7,656	87	7,743	7,786	114	7,900
July	7,755	78	7,833	7,841	117	7,958
August	7,729	111	7,840	7,822	114	7,936
September	7,594	120	7,714	7,808	117	7,925
October	7,981	111	8,092	8,216	122	8,338
November	7,664	105	7,769	7,957	113	8,070
December	8,022	132	8,154	8,185	113	8,298
Total [1]	91,743	1,158	92,901	94,581	1,428	96,009

[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 months

(Thousand short tons)

Month	1969	1970
January	49	47
February	46	45
March	46	43
April	43	39
May	44	44
June	41	38
July	40	38
August	40	33
September	49	36
October	48	35
November	44	38
December	53	35
Total [1]	542	472

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

Table 25.—Average value per short ton of coal carbonized at oven-coke plants in the United States, by States

State	1969	1970
Alabama	$10.22	$11.38
California, Colorado, Utah	10.98	11.61
Maryland, New Jersey, New York	12.52	15.63
Illinois	9.74	11.16
Indiana	11.11	11.84
Kentucky, Missouri, Tennessee, Texas	8.28	10.22
Michigan	11.38	14.68
Minnesota and Wisconsin	13.66	14.15
Ohio	10.07	11.35
Pennsylvania	9.68	11.76
West Virginia	8.57	10.76
Average	10.42	12.21
Value of coal per ton of coke	15.01	17.70

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)
1966	63,061	34.6	10,395	26.2	20,067	17.8	93,523	30.1
1967 [1]	59,787	35.1	12,470	26.4	18,644	18.2	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 [1]	62,703	34.0	11,660	26.3	20,217	17.2	94,581	29.4

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

Table 27.—Coal received by oven-coke plants in the United States in 1970 by consuming States and volatile content [1]

(Thousand short tons)

Consuming state	High-volatile		Medium-volatile		Low-volatile		Total coal receipts [2]
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
Alabama	1,889	21.8	6,069	69.9	719	8.3	8,678
California, Colorado, Utah	4,354	83.1	813	15.5	70	1.4	5,238
Maryland, New Jersey, New York	8,136	71.5	491	4.3	2,757	24.2	11,385
Illinois	2,913	79.0	39	1.0	736	20.0	3,688
Indiana	8,211	63.8	1,619	12.6	3,041	23.6	12,872
Kentucky, Missouri, Tennessee, Texas	1,146	41.1	336	12.2	1,280	46.3	2,762
Michigan	3,356	66.1	246	4.9	1,473	29.0	5,076
Minnesota and Wisconsin	299	29.0	308	30.0	424	41.0	1,032
Ohio	9,889	78.7	163	1.3	2,513	20.0	12,566
Pennsylvania	18,657	70.8	1,733	6.6	5,962	22.6	26,352
West Virginia	4,221	83.0	------	------	865	17.0	5,087
Total 1970 [2]	63,073	66.6	11,819	12.5	19,843	20.9	94,735
At merchant plants	3,599	45.8	954	12.1	3,313	42.1	7,866
At furnace plants	59,474	68.5	10,865	12.5	16,530	19.0	86,869
Total 1969	60,074	65.5	12,187	13.3	19,387	21.2	91,648

[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 1970, by producing county and volatile content

(Thousand short tons)

State and county where coal was produced	Volatile content [1]			Total [2]
	High	Medium	Low	
Alabama:				
Blount	8	----------	----------	8
Bibb	285	----------	----------	285
Jefferson	816	5,575	----------	6,390
Tuscaloosa	6	----------	----------	6
Walker	30	39	----------	69
Colorado:				
Gunnison	825			825
Las Animas	1,062	----------	----------	1,062
Moffat	(3)	----------	----------	(3)
Pitkin	----------	803	----------	803
Illinois:				
Franklin	3,105	----------	----------	3,105
Jefferson	1,305	----------	----------	1,305
Saline	234	----------	----------	234
Williamson	31	----------	----------	31
Indiana:				
Lake	8	----------	----------	8
Kentucky:				
Boyd	2,156	----------	----------	2,156
Floyd	1,017	----------	----------	1,017
Harlan	3,560	----------	----------	3,560
Knott	107	----------	----------	107
Letcher	2,691	----------	----------	2,691
Perry	100	----------	----------	100
Pike	3,462	113	22	3,598
New Mexico:				
Colfax	763	----------	----------	763
Oklahoma:				
Haskell	----------	218	----------	218
Le Flore	----------	----------	179	179
Rogers	153	----------	----------	153
Pennsylvania:				
Anthracite	----------	----------	219	219
Bituminous:				
Allegheny	2,434	----------	1	2,435
Beaver	10	----------	----------	10
Cambria	----------	280	3,337	3,617
Greene	6,835	----------	13	6,848
Somerset	----------	----------	680	680
Washington	12,306	----------	107	12,413
Westmoreland	1,594	1	----------	1,595
Tennessee:				
Clairborne	29	60	----------	89
Utah:				
Carbon	1,704	----------	----------	1,704
Virginia:				
Buchanan	477	354	1,012	1,844
Dickenson	554	3	----------	557
Russell	32	830	----------	862
Wise	956	----------	2	958
West Virginia:				
Barbour	191	----------	----------	191
Boone	1,477	82	----------	1,559
Fayette	2,465	119	860	3,445
Greenbrier	49	58	----------	107
Kanawha	1,622	----------	----------	1,622
Logan	4,048	365	----------	4,412
McDowell	----------	1,827	8,597	10,424
Marion	1,988	----------	----------	1,988
Mercer	8	----------	939	946
Mingo	1,497	90	10	1,597
Monongalia	----------	4	----------	4
Nicholas	480	718	----------	1,198
Raleigh	151	6	1,843	2,000
Russell	15	----------	----------	15
Webster	----------	53	----------	53
Wyoming	425	221	2,023	2,669
Total [2]	63,073	11,819	19,843	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.
[3] Less than ½ unit.

Table 29.—Origin of coal received by oven-coke plants in the United States in 1970, by States

(Thousand short tons)

Consuming State	Producing State: Alabama	Colorado	Illinois	Indiana	Kentucky	New Mexico	Oklahoma
Alabama	6,744	------	------	------	------	------	------
California, Colorado, Utah	------	2,691	------	------	------	763	------
Maryland, New Jersey, New York	------	------	------	------	2,772	------	------
Illinois	------	------	1,644	8	1,162	------	------
Indiana	14	------	3,031	------	3,161	------	------
Kentucky, Missouri, Tennessee, Texas	------	------	------	------	38	------	550
Michigan	------	------	------	------	1,659	------	------
Minnesota and Wisconsin	------	------	------	------	26	------	------
Ohio	------	------	------	------	1,248	------	------
Pennsylvania	------	------	------	------	2,807	------	------
West Virginia	------	------	------	------	354	------	------
Total 1970 [1]	6,758	2,691	4,675	8	13,227	763	550
At merchant plants	1,010	------	------	------	141	------	------
At furnace plants	5,748	2,691	4,675	8	13,087	763	550
Total 1969	6,053	2,412	3,392	------	12,582	742	503

Consuming State	Producing State—Continued: Pennsylvania	Utah	Virginia	Tennessee	West Virginia	Total
Alabama	36	------	1,146	--------	752	8,678
California, Colorado, Utah	------	1,704	--------	--------	80	5,238
Maryland, New Jersey, New York	4,660	------	406	--------	3,546	11,385
Illinois	16	------	39	--------	819	3,688
Indiana	480	------	395	--------	5,791	12,872
Kentucky, Missouri, Tennessee, Texas	24	------	197	--------	1,952	2,762
Michigan	12	------	67	--------	3,338	5,076
Minnesota and Wisconsin	25	------	235	60	686	1,032
Ohio	4,983	------	1,004	29	5,302	12,566
Pennsylvania	14,830	------	699	--------	8,016	26,352
West Virginia	2,762	------	49	--------	1,920	5,087
Total 1970 [1]	27,826	1,704	4,237	89	32,203	94,735
At merchant plants	136	------	800	--------	5,779	7,866
At furnace plants	27,691	1,704	3,437	89	26,426	86,869
Total 1969	26,435	1,911	4,214	--------	33,405	91,648

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

Table 30.—Quantity and percentage of captive coal received by oven-coke plants in the United States

(Thousand short tons)

Year	At merchant plants: Total coal received	Captive coal: Quantity	Captive coal: Percent	At furnace plants: Total coal received	Captive coal: Quantity	Captive coal: Percent	Total [1]: Total coal received	Captive coal: Quantity	Captive coal: Percent
1966	8,670	3,006	34.7	85,694	54,155	63.2	94,364	57,161	60.6
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	29.3	86,869	51,379	59.2	94,735	53,699	56.7

[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	1969	1970
January	8,654	7,712
February	8,222	7,796
March	7,422	8,390
April	8,001	8,678
May	8,743	9,093
June	8,822	9,235
July	6,553	6,591
August	6,618	6,719
September	7,338	7,112
October	8,376	8,180
November	8,807	8,674
December	8,962	8,924

Table 32.—Month-end stocks of anthracite at oven-coke plants in the United States

(Thousand short tons)

Month	1969	1970
January	125	101
February	95	81
March	74	71
April	73	65
May	85	77
June	100	82
July	99	78
August	110	88
September	119	96
October	122	113
November	137	112
December	130	121

Table 33.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1970 [1]

Product	Produced	Sold: Quantity (thousands)	Sold: Value: Total (thousands)	Sold: Value: Average per unit	On hand Dec. 31
Tar, crude thousand gallons	760,926	371,203	$35,804	$0.097	47,174
Tar derivatives:					
Sodium phenolate or carbolate do	3,263	3,208	284	.089	199
Crude chemical oil (tar acid oil) do	18,989	18,804	3,195	.170	701
Pitch-of-tar: [2]					
Soft thousand short tons	547	239	5,908	24.702	15
Hard do	219	118	4,428	37.524	3
Other tar derivatives: [3]	--------	--------	7,305	--------	--------
Ammonia products:					
Sulfate thousand short tons	595	611	9,438	15.438	156
Liquor (NH_3 content) do	14	16	813	51.087	2
Diammonium phosphate do	42	36	2,979	82.582	7
Total [4] do	--------	--------	13,229	--------	--------
Sulfate equivalent of all forms do	691	709	--------	--------	172
NH_3 equivalent of all forms do	178	183	--------	--------	44
Gas:					
Used under boilers, etc. million cubic feet	--------	111,979	26,367	.235	--------
Used in steel or allied plants do	--------	390,686	104,480	.268	--------
Distributed through city mains do	[5] 992,790	10,996	4,056	.369	--------
Sold for industrial use do	--------	71,023	13,478	.190	--------
Total [4] do	[5] 992,790	584,684	148,381	.254	--------
Crude light oil thousand gallons	[6] 244,107	98,060	11,888	.121	9,027
Light-oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90%) do	89,517	88,432	19,237	.218	4,144
Other industrial grades do	3,975	3,685	556	.151	48
Toluene (all grades) do	17,041	16,765	3,093	.184	1,377
Xylene (all grades) do	4,501	4,752	945	.199	408
Solvent naphtha (all grades) do	3,707	3,288	536	.163	509
Other light-oil derivatives do	4,693	3,019	698	.231	366
Total [4] do	123,433	119,942	25,065	.209	6,852
Intermediate light oil do	5,066	1,187	102	.086	169
Grand total [4]	--------	--------	255,592	--------	--------

[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, naphthaline, phenol, pyridine, refined tar, tar paint.
[4] Data may not add to totals shown because of independent rounding.
[5] Includes gas used for heating ovens and gas wasted.
[6] 142,017,000 gallons refined by coke-oven operators to make derived products shown.

Table 34.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced: Coke breeze (thousand short tons)	Surplus gas (billion cubic feet)	Tar (thousand gallons)	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)
1966	4,102	630	801,867	262,640	80,240	346,300	120,280	34,143	580,963	22,174
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	21,346

[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

	1966	1967	1968	1969	1970
Ammonia products	$0.280	$0.254	$0.194	$0.173	$0.151
Light oil and its derivatives	.481	.441	.427	.435	.405
Surplus gas used or sold	1.522	1.512	1.483	1.502	1.561
Tar and its derivatives (including naphthalene):					
Tar burned by producers [1]	.328	.318	.311	.317	.398
Sold	.677	.675	.727	.685	.623
Total	3.288	3.200	3.142	3.112	3.138
Coke produced	12.167	12.152	12.246	[2] 12.560	[2] 19.208
Breeze produced	.292	.318	.314	.388	.481
Grand total	15.747	15.670	15.702	16.060	22.827

[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

	1966	1967	1968	1969	1970
Product:					
Ammonia products	2.9	2.5	1.9	1.8	1.3
Light oil and its derivatives	4.9	4.4	4.3	4.4	4.3
Surplus gas used or sold	15.6	15.1	15.1	14.4	12.8
Tar and its derivatives used or sold (including naphthalene)	10.3	11.4	10.4	10.5	9.0
Total	33.7	33.4	31.7	31.1	27.4
Value of coal per short ton	$9.78	$10.02	$10.01	$10.42	$12.21

Table 37.—Production and disposal of coke-oven gas in the United States in 1970, by States

(Million cubic feet)

State	Produced		Used in heating ovens	Surplus used or sold			Wasted
	Total	Thousand cubic feet per ton of coal		Quantity	Value: Thousands	Value: Average per thousand cubic feet	
Alabama	82,433	9.53	39,036	38,033	$6,488	$0.168	5,364
California, Colorado, Utah	59,854	11.70	18,216	41,341	7,512	.182	297
Maryland, New Jersey, New York	123,986	10.75	42,606	78,022	27,084	.347	3,358
Illinois	36,470	9.95	13,882	20,165	9,249	.504	2,423
Indiana	138,340	10.53	53,170	83,812	18,332	.219	1,357
Kentucky, Missouri, Tennessee, Texas	27,305	9.43	12,882	12,018	1,801	.150	2,405
Michigan	50,250	9.82	12,246	34,919	9,704	.278	3,085
Minnesota and Wisconsin	11,392	8.14	5,872	5,488	1,012	.186	32
Ohio	128,210	10.10	51,003	73,875	21,799	.295	3,333
Pennsylvania	280,522	10.72	114,855	159,668	36,375	.228	6,000
West Virginia	54,027	10.85	16,403	37,342	9,024	.242	282
Total 1970 [1]	992,790	10.44	380,171	584,684	148,381	.254	27,935
At merchant plants	72,275	8.81	36,352	27,603	5,758	.209	8,319
At furnace plants	920,515	10.60	343,819	557,080	142,623	.256	19,617
Total 1969	962,048	10.48	347,940	594,746	137,983	.232	19,362

[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 1970, by States

(Million cubic feet)

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
	Quantity	Value		Quantity	Value	
		Thousands	Average per thousand cubic feet		Thousands	Average per thousand cubic feet
Alabama	17,867	$2,889	$0.162	19,427	$3,499	$0.180
California, Colorado, Utah	(1)	(1)	(1)	(1)	(1)	(1)
Maryland, New Jersey, New York	2,952	573	.193	67,528	23,637	.350
Illinois	4,986	777	.156	13,119	8,167	.623
Indiana	12,422	3,742	.301	68,108	13,295	.195
Kentucky, Missouri, Tennessee, Texas	6,051	789	.130	(1)	(1)	(1)
Michigan	(1)	(1)	(1)	(1)	(1)	(1)
Minnesota and Wisconsin	3,344	657	.196	(1)	(1)	(1)
Ohio	12,473	6,421	.514	54,863	14,012	.255
Pennsylvania	20,339	4,299	.211	83,178	21,425	.258
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	31,545	6,222	.197	84,463	20,443	.242
Total 1970 [2]	111,979	26,367	.235	390,686	104,480	.267
At merchant plants	12,521	1,871	.149	708	159	.223
At furnace plants	99,459	24,496	.246	389,978	104.321	.268
Total 1969	104,861	22,272	.212	391,591	95,902	.245

State	Sold					
	Distributed through city mains			For industrial use		
	Quantity	Value		Quantity	Value	
		Thousands	Average per thousand cubic feet		Thousands	Average per thousand cubic feet
Alabama	--------	--------	--------	739	$100	$0.136
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	--------	--------	--------	(1)	(1)	(1)
Ohio	--------	--------	--------	6,539	1,367	.209
Pennsylvania	(1)	(1)	(1)	(1)	(1)	(1)
West Virginia	--------	--------	--------	(1)	(1)	(1)
Undistributed	10,996	$4,056	$.369	63,746	12,011	.188
Total 1970 [2]	10,996	4,056	.369	71,023	13,478	.190
At merchant plants	5,536	2,060	.372	8,840	1,669	.189
At furnace plants	5,460	1,996	.366	62,183	11,809	.190
Total 1969	13,818	4,589	.332	84,476	15,220	.180

[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 1970, by States [1]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Total coke-oven gas equivalent
Alabama	39,036	----------	----------	39,036
California, Colorado, Utah	18,216	----------	43	18,259
Maryland, New Jersey, New York	42,606	9,196	384	52,185
Illinois	13,882	4,943	----------	18,825
Indiana	53,170	----------	22,898	76,068
Kentucky, Missouri, Tennessee, Texas	12,881	----------	----------	12,881
Michigan	12,246	11,848	----------	24,094
Minnesota and Wisconsin	5,872	----------	38	5,910
Ohio	51,003	3,475	----------	54,478
Pennsylvania	114,855	12,092	----------	126,947
West Virginia	16,403	6,019	----------	22,422
Total 1970 [2]	380,171	47,573	23,363	451,104
At merchant plants	36,352	----------	38	36,390
At furnace plants	343,819	47,573	23,325	414,717
Total 1969	347,940	100,571	1,997	450,509

[1] Adjusted to an equivalent of 550 Btu per cubic foot.
[2] Data may not add to totals shown because of independent rounding.

Table 40.—Coke-oven ammonia produced in the United States and sold in 1970, by States

(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	73	16.88	73	----
California, Colorado, Utah	3	73	28.55	49	(3)
Maryland, New Jersey, New York	3	107	20.79	102	(3)
Illinois	4	28	15.39	28	----
Indiana	5	108	14.18	100	(3)
Kentucky, Tennessee, Texas Minnesota	4	17	13.39	9	(3)
Michigan	(4)	(4)	(4)	(4)	----
Ohio	11	96	15.69	87	(3)
Pennsylvania	9	148	11.85	148	----
West Virginia	3	41	16.50	41	----
Undistributed	----	----	----	----	15
Total 1970 [5]	51	691	15.77	[6] 636	15
At merchant plants	6	32	15.02	16	4
At furnace plants	45	659	15.81	620	10
Total 1969	55	732	16.68	676	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: Liquor (NH_3 content)
Alabama	83	$1,386	----	----	3	----
California, Colorado, Utah	49	2,366	(3)	(3)	10	(7)
Maryland, New Jersey, New York	87	1,274	(3)	(3)	40	(7)
Illinois	25	643	----	----	13	----
Indiana	109	2,477	(3)	(3)	20	(3)
Kentucky, Tennessee, Texas, Minnesota	10	117	(3)	(3)	1	(3)
Michigan	(4)	(4)	----	----	(4)	----
Ohio	91	1,464	(3)	(3)	15	(3)
Pennsylvania	151	2,120	----	----	58	----
West Virginia	43	569	----	----	3	----
Undistributed	----	----	16	$813	----	2
Total 1970 [5]	[8] 647	12,416	16	813	163	2
At merchant plants	19	252	6	260	1	2
At furnace plants	628	12,164	10	553	162	1
Total 1969	636	14,306	15	902	177	2

[1] Number of plants that recovered ammonia.
[2] Includes diammonium phosphate.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Included with Indiana to avoid disclosing individual company confidential data.
[5] Data may not add to totals shown because of independent rounding.
[6] Comprises 595,000 tons of ammonium sulfate and 42,000 tons of diammonium phosphate.
[7] Less than ½ unit.
[8] Comprises 611,000 tons of ammonium sulfate valued at $9,438,000 and 36,000 tons of diammonium phosphate valued at $2,979,000.

Table 41.—Coke-oven tar produced in the United States, used by producers, and sold in 1970, by States

(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	60,530	6.99	(1)	(1)	(1)
California, Colorado, Utah	49,617	9.69	(1)	(1)	(1)
Maryland, New Jersey, New York	90,338	7.83	(1)	(1)	(1)
Illinois	25,284	6.89	(1)	(1)	(1)
Indiana	89,555	6.85	(1)	(1)	(1)
Kentucky, Missouri, Tennessee, Texas	18,270	6.31	(1)	(1)	(1)
Michigan	34,983	6.83	(1)	(1)	(1)
Minnesota and Wisconsin	6,907	5.92	(1)	(1)	(1)
Ohio	109,517	8.62	(1)	43,457	(1)
Pennsylvania	233,513	8.92	117,685	36,078	(1)
West Virginia	42,412	8.51	(1)	(1)	(1)
Undistributed	--------	--------	163,207	28,432	1,601
Total 1970 [2]	760,926	8.00	280,892	107,967	1,601
At merchant plants	45,392	5.53	693	--------	--------
At furnace plants	715,534	8.23	280,199	107,967	1,601
Total 1969	768,766	8.33	282,785	98,065	671

State	Sold for refining into tar products: Quantity	Value: Thousands	Value: Average per gallon	On hand Dec. 31
Alabama	36,329	$3,761	$0.104	2,595
California, Colorado, Utah	32,858	3,852	.117	3,231
Connecticut, Maryland, New Jersey, New York	19,154	1,914	.100	4,559
Illinois	25,491	2,193	.086	1,302
Indiana	33,452	3,027	.090	3,233
Kentucky, Missouri, Tennessee, Texas	18,271	1,583	.087	507
Michigan	27,011	2,469	.091	3,544
Minnesota and Wisconsin	7,087	1,001	.141	584
Ohio	64,650	5,555	.086	6,108
Pennsylvania	82,592	8,371	.101	19,428
West Virginia	24,307	2,078	.085	2,083
Undistributed	----------	----------	----------	----------
Total 1970 [2]	371,203	35,804	.097	47,174
At merchant plants	45,142	4,094	.091	1,112
At furnace plants	326,062	31,710	.097	46,063
Total 1969	377,229	36,551	.097	50,270

[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 1970, by States

(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	18,173	2.10	17,525	1,057	13,763	12,254	$2,574
California, Colorado, Utah	3	18,516	3.62	11,694	243	8,948	7,007	1,404
Maryland, New Jersey, New York	5	32,418	2.81	16,272	1,402	14,291	15,267	3,413
Illinois, Indiana, Michigan	10	45,070	2.34	2,225	1,413	2,044	1,764	445
Kentucky, Missouri, Tennessee, Texas, West Virginia	8	20,467	2.60	2,339	955	2,406	2,336	350
Ohio	11	32,470	2.59	20,276	1,142	17,346	17,019	3,188
Pennsylvania	11	76,993	2.94	71,689	2,814	64,637	64,296	13,691
Total 1970 [4]	55	244,107	2.68	142,016	9,027	123,433	119,942	25,065
At merchant plants	9	12,277	1.99	5,062	927	3,812	3,800	772
At furnace plants	46	231,830	2.73	136,955	8,100	119,622	116,142	24,292
Total 1969	56	258,910	2.87	151,788	8,588	136,282	132,058	30,225

[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 98,060,000 gallons of crude light oil valued at $11,888,000 sold as such.
[4] 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
1966	63.4	12.7	3.4	1.8	3.5
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

Table 44.—Benzene and toluene produced at oven-coke plants in the United States, by grades

(Thousand gallons)

Year	Benzene		Toluene (all grades)
	Specification grades (1°, 2°, 90 percent)	Other industrial grades	
1966	110,223	3,709	22,791
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

Table 45.—Light-oil derivatives produced at oven-coke plants in the United States and sold in 1970, by States

(Thousand gallons and thousand dollars)

State	Benzene (all grades)				Toluene (all grades)			
	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value
Alabama	10,216	58.3	8,849	$1,995	2,339	14.2	2,037	$372
Colorado, Illinois, Utah	7,820	57.8	6,914	1,477	1,698	12.5	947	185
Indiana, Maryland, New York	13,519	81.3	14,285	3,230	534	3.2	697	133
Ohio	13,063	64.4	12,854	2,458	2,918	14.4	2,831	511
Pennsylvania	47,243	65.9	47,630	10,369	9,299	13.0	9,970	1,847
Tennessee and Texas	1,632	69.9	1,584	264	254	10.9	283	43
Total 1970 [1]	93,492	63.0	92,117	19,793	17,041	12.1	16,765	3,093
At merchant plants	2,687	54.0	2,676	578	623	12.6	598	117
At furnace plants	90,805	63.4	89,441	19,215	16,418	12.1	16,167	2,975
Total 1969	101,695	67.0	100,842	21,961	19,603	13.1	18,713	5,084

State	Xylene (all grades)				Solvent naphtha (crude and refined)			
	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value
Alabama	539	3.3	685	$139	231	2.5	236	$24
Colorado, Illinois, Utah	346	2.6	310	64	241	1.8	136	32
Indiana, Maryland, New York	85	0.5	132	28	(2)	(2)	(2)	(2)
Ohio	733	3.6	704	137	633	3.4	631	81
Pennsylvania	2,734	3.8	2,871	560	2,166	3.9	2,158	387
Tennessee and Texas	64	2.7	51	17	436	2.7	128	12
Total 1970 [1]	4,501	3.2	4,752	944	3,707	3.3	3,288	536
At merchant plants	162	3.3	178	39	26	0.7	22	5
At furnace plants	4,339	3.2	4,575	905	3,681	3.4	3,266	531
Total 1969	5,245	3.5	5,381	1,109	3,567	2.9	3,539	r577

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] Included with Tennessee and Texas to avoid disclosing individual company confidential data.

Columbium and Tantalum

By Joseph A. Sutton [1]

Demand for columbium and tantalum in steelmaking decreased in 1970. Consumption of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials for this purpose totaled 2.6 million pounds, compared with 3.3 million pounds in 1969. Industry inventories of columbium and tantalum raw materials increased along with an increase in imports for consumption. Tantalum continued to be used by the electronics industry; its primary end-use was in capacitors. Approximately 1 million pounds of combined pentoxides ($Cb_2O_5+Ta_2O_5$) were released to the industry from Government stocks on sealed bid sales. A promising new steel was being evaluated by the steel industry, and if results should prove favorable, future demand for columbium could be greatly increased.

Legislation and Government Programs.—During 1970 the Office of Mineral Exploration (OME), U.S. Geological Survey continued to offer financial assistance of 50 percent (columbium) and 75 percent (tantalum) for the exploration and development of approved columbium and tantalum resources. The General Services Administration (GSA) continued its columbite disposal program during 1970. It sold to industry 1,004,215 pounds of combined pentoxides containing 616,698 pounds of columbium (Cb) and 99,744 pounds of tantalum (Ta) from the Defense Production Act (DPA) inventory in March, May, June, July, September, and October at prices ranging from $1.125 to

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1966	1967	1968	1969	1970
United States:					
Mine production of columbite-tantalite concentrates	W	W	W	W	W
Releases from Government stocks (Cb content) [1 2]	1,659	779	1,191	1,573	617
Consumption of concentrate: Columbium metal contained in all raw materials consumed (Cb content) [1]	3,873	4,519	3,997	2,918	3,289
Production of primary products:					
Columbium metal (Cb content)	W	W	W	W	W
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	3,664	1,960	2,380	2,554	1,430
Consumption of primary products:					
Columbium metal (Cb content)	100	111	92	179	261
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	2,697	3,192	3,094	3,328	2,591
Exports:					
Columbium ore and concentrate (gross weight)	NA	NA	NA	NA	NA
Columbium metal, compounds, and alloys (gross weight)	7	6	7	41	46
Imports for consumption:					
Columbium mineral concentrate (gross weight)	9,278	7,431	3,657	4,161	5,719
Columbium metal and columbium-bearing alloys (Cb content)	4	(3)	1	5	2
Ferrocolumbium (gross weight) [e]	1,280	629	1,171	NA	NA
World: Production of columbium-tantalum concentrates (gross weight)	23,031	20,551	23,857	34,557	43,898

[e] Estimate. NA Not available. W Withheld to avoid disclosing individual 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)

	1966	1967	1968	1969	1970
United States:					
Mine production of columbium-tantalum concentrates	W	W	W	W	W
Releases from Government stocks (Ta content) [1] [2]	634	307	163	171	100
Consumption of concentrate: Tantalum metal contained in all raw materials consumed (Ta content) [1]	1,392	1,730	1,060	928	1,733
Production of primary products:					
Tantalum metal (Ta content)	1,064	1,021	692	1,046	916
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	3,664	1,960	2,380	2,554	1,430
Consumption of primary products: Tantalum metal (Ta content)	493	443	423	751	417
Ferrocolumbium and ferrotantalum-columbium (Cb + Ta content)	2,697	3,192	3,094	3,328	2,591
Exports:					
Tantalum ore and concentrate (gross weight)	163	75	65	85	122
Tantalum metal, compounds, and alloys (gross weight)	35	59	106	124	640
Tantalum and tantalum alloy powder (Ta content)	51	51	84	100	139
Imports for consumption:					
Tantalum mineral concentrates (gross weight)	2,143	1,675	1,230	975	1,046
Tantalum metal and tantalum-bearing alloys (Ta content)	48	55	18	11	51
World: Production of columbium-tantalum concentrates (gross weight)	23,031	20,551	23,857	34,557	43,898

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, 1970

(Thousand pounds, columbium and tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
COLUMBIUM					
Concentrates	----------	7,445	1,683	358	9,486
Carbide powder: Stockpile grade	20	21	----------	----------	21
Ferrocolumbium:					
Stockpile grade	930	192	----------	----------	192
Nonstockpile grade	----------	738	----------	----------	738
Metal: Stockpile grade	45	45	----------	----------	45
Oxide powder: Stockpile	----------	86	----------	----------	86
TANTALUM					
Tantalum minerals: Stockpile grade	2,947	3,151	762	6	3,919
Carbide powder: Stockpile grade	27	29	----------	----------	29
Metal: Stockpile grade	360	201	----------	----------	201

$1.39 per pound of the mixed oxides. The total value of these sales amounted to $1,242,480.

The companies that purchased columbium and tantalum concentrate from GSA during 1970 are listed below.

Company	Pounds of combined pentoxides ($Cb_2O_5 + Ta_2O_5$)	Approximate columbium content (pounds of Cb)	Approximate tantalum content (pounds of Ta)
Kawecki Berylco Industries, Inc	95,263	57,682	10,437
Kennametal, Inc	205,148	134,668	10,223
Norton Company	47,426	28,562	5,276
Metada Metals and Chemicals Ltd	52,995	36,197	990
Philipp Brothers Division of Engelhard Minerals and Chemicals Corp	102,685	63,691	9,443
South American Minerals and Merchandising Corp. (SAMINCORP)	293,619	174,645	35,843
Socomet Inc	76,109	47,531	6,647
Stainless Processing Co	11,565	7,915	197
Teledyne Wah Chang Albany	119,405	65,807	20,688

DOMESTIC PRODUCTION

Domestic mining activity was insignificant during the year. One company reported shipment of small quantities of columbium-tantalum specimen crystals.

Production of columbium metal powder increased 79 percent in 1970, but data continued to be withheld to avoid disclosing individual company confidential data. Production of columbium metal ingot increased during the year, but again specific information was withheld. Production of tantalum metal powder (including capacitor-grade powder) decreased 12 percent to 458 tons in 1970; production of tantalum metal ingot increased 57 percent to 210 tons.

Ferrocolumbium, ferrotantalum-columbium, and /or columbium-base master alloys were produced by the thermite process by the Kawecki Division of Kawecki Berylco Industries, Inc. (formerly Kawecki Chemical Co.), Reading Alloys Co., Inc., and Shieldalloy Corp. Molybdenum Corporation of America (Molycorp.) Union Carbide Corp., and the Metallurgical Products Division of Foote Mineral Co. produced these ferroalloys in electric furnaces.

Kawecki Berylco Industries installed a versatile 60-inch, four-high reversing mill in its Reading, Pa., plant. The new mill rolls tantalum into sheets 4-1/2 feet wide. One of the striking technical feature of the new mill was that it operates as either a hot mill for beryllium or a cold mill for tantalum and other special metals.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1970

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium
Fansteel Inc	Muskogee, Okla	X	X	------	------
General Electric Co	Euclid, Ohio	------	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	X	X	------	X
Molybdenum Corporation of America	Washington, Pa	X	------	------	X
Metals Division, Norton Co	Newton, Mass	X	X	------	------
Reading Alloys Co., Inc	Robesonia, Pa	X	------	------	X
Shieldalloy Corp	Newfield, N. J	X	X	X	X
Metallurgical Products Division, Foote Mineral Co	Vancoram, Ohio; Exton, Pa	X	------	------	------
Wah Chang Albany (A Teledyne Company)	Albany, Oreg	X	X	X	------

CONSUMPTION AND USES

Columbium consumption in the form of high-purity metal totaled 260,532 pounds, an increase of 45 percent over the total for 1969. Tantalum metal (including capacitor-grade powder) consumed during the year decreased 45 percent and totaled 416,620 pounds.

Use of columbium in ferroalloy additions to steel continued to account for approximately 90 percent of the metal consumed. Total consumption of columbium plus tantalum in ferroalloys decreased to 2.6 million pounds compared with the 1969 consumption figures of 3.3 million pounds. Domestic consumption of ferrocolumbium (FeCb) during the year, by major use categories, was as follows: Alloy steel other than stainless and heat-resisting alloys (32 percent), superalloys (18 percent), carbon steels (27 percent), and stainless and heat-resisting steels (20 percent).

Consumption of ferrotantalum-columbium (FeTa-Cb) continued to be small and amounted to about 3 percent of the total FeCb plus FeTa-Cb consumption, compared with approximately 1 percent in 1969. The major uses of ferrotantalum-columbium in 1970 were in the production of stainless and heat-resisting steel (67 percent), carbon steels (15 percent), and unspecified (15 percent). Additional data on ferrocolumbium and ferrotantalum-columbium are contained in the "Ferroalloy" chapter.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1969	1970	Percent change
Columbium products:			
Compounds, including alloys	1,651,750	1,098,600	−33.5
Metal, including worked products	109,898	203,600	+85.3
All other	4,700	15,600	+231.9
Total Cb	1,766,348	1,317,800	−25.4
Tantalum products:			
Oxides and salts	57,400	90,200	+57.1
Alloy additive	13,700	28,200	+105.8
Carbide	174,300	145,600	−16.5
Powder and anodes	474,742	498,700	+5.0
Ingot (unworked consolidated metal)	21,600	54,400	+151.9
Mill products	206,035	213,300	+3.5
Scrap	37,000	78,600	+112.4
Other	----------	9,200	---------
Total Ta	984,777	1,118,200	+13.5

General Technologics Corp., a subsidiary of Cities Service Co., acquired exclusive license for Union Carbide Corp.'s patented electrodeposition process for the refractory metal tantalum. The process was available under the trade name "Matalating."

The Nuclear Metals Division of Whittaker Corporation developed a multifilament superconducting wire that will qualify for such commercial applications as electric power generation and distribution. The new wire consists of many continuous filaments of columbium-tin distributed in a copper matrix.

The Advanced Structures Division of Fansteel Inc. announced development of chemical vapor deposited tantalum thermowells with an integral hexagon-shaped flange for use in the chemical process industries. The thin layer of pure tantalum metal is deposited by the chemical vapor and forms an impenetrable surface on steel thermowells that resist physical damage or gas infiltration. The advantage of chemical vapor depositing of metal as opposed to electroplating was the ability of the vapor process to evenly coat variable geometric surfaces.

Table 6.—Consumption of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials in the United States by end use, 1970

End use	Pounds of contained columbium plus tantalum
Steel:	
Carbon	705,621
Stainless and heat-resisting	522,007
Alloy (excludes stainless and heat-resisting)	829,416
Superalloys	472,321
Alloys (excludes alloy steels and superalloys)	36,370
Miscellaneous and unspecified [1]	24,793
Total	2,590,528

[1] Includes tool steel.

STOCKS

The following yearend columbium and tantalum materials (given in pounds) were reported in inventories:

Material	Dec. 31, 1969	Dec. 31, 1970
COLUMBIUM		
Primary metal	46,451	71,200
Ingot	40,845	34,581
Scrap	122,132	70,390
Oxide	712,959	1,076,671
Other compounds	20,753	558,352
TANTALUM		
Primary metal	92,233	244,622
Capacitor-grade powder	123,595	157,702
Ingot	89,067	114,279
Scrap	260,935	206,776
Oxide	117,963	168,895
Potassium tantalum fluoride (K_2TaF_7)	138,779	251,591
Other compounds	48,346	41,857

Stocks of columbium and tantalum raw materials, as reported by consumers and dealers at yearend 1970, were as follows (in short tons—1969 figures in parentheses): Columbite, 714 (432); Tantalite, 1,461 (2,147); pyrochlore, 767 (392); tin slag, 31,055 (30,397); and other, 172 (226).

Consumer inventories of ferrocolumbium and ferrotantalum-columbium as of December 31, 1970, were as follows (with 1969 yearend stocks in parentheses): Ferrocolumbium, 820,458 pounds contained columbium plus tantalum (849,189); and ferrotantalum-columbium, 17,108 pounds contained columbium plus tantalum (15,736). Producer stocks of ferrocolumbium at yearend 1970 were 852,000 pounds contained Cb (658,000).

PRICES

Prices for columbite ores, as reported by Metals Week, decreased during the year. Columbite ore, c.i.f. U.S. ports decreased from \$1.12–\$1.17 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 1970 to \$1–\$1.05 per pound at yearend. Long-term contracts were negotiated and no quotations were published. During the year, the quoted price of Brazilian pyrochlore concentrate, f.o.b. shipping point, increased from \$0.955 to \$1.15 per pound of Cb_2O_5. The price of Canadian pyrochlore concentrate, f.o.b. mine or mill, increased from \$1–\$1.05 per pound to \$1.15–\$1.20. The price for tantalite ore and concentrate, 60-percent basis, remained constant during the year at \$6.75–\$7.50 per pound Ta_2O_5, c.i.f. U.S. ports.

The price quotations of 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 \$3.52; high-purity grades, \$4.28 to \$5.53. Quotation at yearend increased to \$2.85–\$4.12 for the low-alloy grades and to \$4.79–\$6.76 for the high-purity grades.

Early in January the price of tantalum metal was quoted at \$26–\$36 per pounds for powder, \$36–\$60 per pound for sheet, and \$36–\$50 per pound for rod. From mid-January to yearend the prices were then quoted at \$28.50–\$38.50 for powder, \$36–\$60 for sheet, and \$36–\$50 for rod.

Throughout the year the price of columbium metal remained unchanged. Columbium powder roundels, 99.5 to 99.8 percent purity, was quoted \$11 to \$22 per pound for metallurgical-grade material. Columbium ingots were quoted at \$16 to \$27 per pound for metallurgical-grade material, and at \$17.50 to \$28 per pound for reactor-grade material.

Table 7.—Average grade of concentrate received by U.S. consumers and dealers in 1970 by country of origin

(Percent of contained pentoxides)

Country	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Argentina	52	12	43:1	--------	--------
Australia	--------	--------	--------	42	26
Belgium	--------	--------	--------	45	25
Brazil [1] [2]	60	.3	200:1	17	2
Burundi	--------	--------	--------	33	42
Canada [2]	52	.099	53:1	33	26
Congo (Kinshasa)	--------	--------		35	34
Malaysia	62	16	3.9:1	40	44
Mozambique	--------	--------		63	18
Nigeria [1]	65	7	93:1	16	20
Norway	--------	--------		10	51
Portugal	--------	--------		35	39
Rwanda	64	15	4.3:1	31	43
Spain	--------	--------		37	38

[1] Excludes tin slag.
[2] Material reported from Brazil or Canada as columbite represents primarily pyrochlore.

FOREIGN TRADE

Most of the columbium and tantalum exports were shipped to Western Europe, Japan, and Italy. The largest item by volume, unwrought tantalum and tantalum alloys in crude form and scrap, were exported primarily to West Germany (65 percent), Italy (17 percent), the United Kingdom (9 percent), and Japan (6 percent). Tantalum and tantalum alloy powder, the largest value item, was exported primarily to West Germany (30 percent), the United Kingdom (27 percent), Japan (21 percent), France (10 percent), and the Netherlands (5 percent). Wrought tantalum and tantalum alloys, which was the smallest tantalum item by volume, were

Table 8.—U.S. exports of columbium and tantalum, by classes

(Thousand pounds, gross weight, and thousand dollars)

Class	1969		1970	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys, unwrought, and waste and scrap	5	$94	38	$153
Columbium and columbium alloys, wrought	36	507	8	409
Tantalum ores and concentrates	85	357	122	422
Tantalum and tantalum alloys, wrought	29	1,391	31	1,461
Tantalum metals and alloys in crude form and scrap	95	904	609	2,001
Tantalum and tantalum alloy powder	100	2,952	139	4,367

exported primarily to Belgium-Luxembourg (39 percent), Japan (16 percent), France (14 percent), West Germany (7 percent), and the United Kingdom (7 percent). Tantalum ore and concentrate, believed not to be of domestic origin, was shipped to West Germany (46 percent), Japan (30 percent), the United Kingdom (14 percent), and Austria (10 percent).

Imports for consumption of unwrought columbium metal, waste, and scrap, increased by a factor of almost 24 and totaled 1,553 pounds valued at $7,135. This material was imported primarily from Japan (52 percent), the Netherlands (32 percent), and West Germany (16 percent). Imports of unwrought columbium metal alloys were reported to total only 217 pounds, columbium content, primarily from the United Kingdom, and were valued at $12,477. This represented a significant change from the 5,119 pounds valued at $7,823 reported in 1969. A small quantity of wrought columbium, totaling 7 pounds and valued at $1,011, was received from the United Kingdom. Imports for consumption of unwrought tantalum metal, including waste and scrap, increased by a factor of 4.7 during the year and totaled 51,386 pounds valued at $479,685. This material was imported primarily from the United Kingdom (66 percent), Mexico (22 percent), and the Netherlands (5 percent). Imports of unwrought tantalum alloy, all from West Germany, decreased by a factor of 2.8 and totaled 20 pounds valued at $700. Imports of wrought tantalum, all from Japan, increased by a factor of 5.5 and totaled 22 pounds valued at $818 in 1970

Table 9.—Receipts of tin slags reported by consumers

(Thousand pounds)

Year	Gross weight	Cb_2O_5 content	Ta_2O_5 content
1967	28,913	2,902	1,572
1968	8,709	541	510
1969	8,327	649	453
1970	10,275	713	573

Table 10.—U.S. imports for consumption of columbium-mineral concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	33	$94	22	$42	19	$47
Argentina	2	6	--------	--------	8	14
Belgium-Luxembourg [1]	--------	--------	41	72	37	68
Brazil	2,163	1,348	2,462	1,440	3,312	2,430
Burundi-Rwanda	8	12	48	62	21	38
Canada	295	157	920	473	1,271	669
Congo (Kinshasa)	207	542	90	182	143	282
Gabon	7	4	--------	--------	--------	--------
Germany, West	--------	--------	--------	--------	7	23
Kenya	6	6	--------	--------	--------	--------
Malaysia	133	122	59	49	104	103
Mozambique	18	34	4	7	10	19
Netherlands [1]	13	19	69	48	--------	--------
Nigeria	737	431	423	267	682	478
Portugal	16	30	--------	--------	32	75
Rhodesia, Southern	3	11	--------	--------	--------	--------
Singapore	--------	--------	--------	--------	19	21
Spain	9	26	20	37	--------	--------
Uganda	7	6	3	2	4	3
United Kingdom	--------	--------	--------	--------	50	75
Total	3,657	2,848	4,161	2,681	5,719	4,345

[1] Presumably country of transshipment rather than original source.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	7	$25	--------	--------	2	$10
Australia	71	247	75	$170	13	31
Belgium-Luxembourg [1]	15	42	30	97	17	42
Brazil	342	1,472	253	767	178	624
Burundi-Rwanda	62	144	31	47	31	58
Cameroon	--------	--------	--------	--------	4	12
Canada	--------	--------	220	1,195	477	1,724
Congo (Kinshasa)	242	845	179	394	222	521
Cyprus	1	1	--------	--------	--------	--------
French Guiana	--------	--------	--------	--------	2	6
Germany, West	22	108	--------	--------	--------	--------
Japan	--------	--------	--------	--------	5	8
Kenya	5	9	--------	--------	--------	--------
Malaysia	15	10	25	15	--------	--------
Mozambique	306	869	77	350	--------	--------
Netherlands [1]	41	65	--------	--------	--------	--------
Nigeria	20	77	8	23	4	10
Portugal	24	76	--------	--------	10	22
Rhodesia, Southern	17	72	--------	--------	--------	--------
South Africa, Republic of	14	25	19	36	--------	--------
Spain	14	30	27	40	52	105
Tanzania	--------	--------	9	22	--------	--------
Thailand	--------	--------	22	40	--------	--------
Uganda	12	47	--------	--------	--------	--------
United Kingdom	--------	--------	--------	--------	22	45
Western Africa, n.e.c	--------	--------	--------	--------	7	13
Total	1,230	4,164	975	3,196	1,046	3,231

[1] Presumably country of transshipment rather than country of origin.

Table 12.—U.S. import duties

Tariff classification number	Article	Rate of duty per pound [1]	
		Effective Jan. 1, 1970	Effective Jan. 1, 1971
601.21	Columbium concentrate	Free	Free.
601.42	Tantalum concentrate	do	Do.
607.80	Ferrocolumbium and ferro-tantalum-columbium	7 percent ad valorem	6 percent ad valorem.
	Columbium:		
628.15	Unwrought, waste, scrap	do	Do.
628.20	Wrought	12.5 percent ad valorem	10.5 percent ad valorem.
628.17	Unwrought Cb alloys	10 percent ad valorem	9 percent ad valorem.
	Tantalum:		
629.05	Unwrought, waste, scrap	7 percent ad valorem	6 percent ad valorem.
629.10	Wrought	12.5 percent ad valorem	10.5 percent ad valorem.
629.07	Unwrought Ta alloys	10 percent ad valorem	9 percent ad valorem.
423.00	Columbium and tantalum chemicals	7 percent ad valorem	6 percent ad valorem.

[1] Not applicable to Communist countries.

WORLD REVIEW

Australia.—The Tantalum Mining Corporation of Canada Ltd. (TMCC) acquired a 70-percent interest in the Goldrim Mining tantalum prospects in Western Australia where a zone of mineralization 1,000 to 2,000 feet long has been outlined on the Wodgina deposit.[2]

Brazil.—During 1970 Brazil maintained its standing as the major world producer of columbium minerals. Companhia Brasileira de Metalúrgia e Mineraçao (CBMM), which is 33 percent owned by Molybdenum Corporation of America, continued to be the world's largest producer of columbium.

Mining by CBMM continues to be a simple process of removing by bulldozer a thin soil cover over the widespread deposit of 3.5 percent Cb_2O_5 ore. The ore is then pushed to a stockpile where front-end loaders load the ore on trucks that haul it a short distance to the mill.

[2] Tron, A.R. Columbium (Niobium) and Tantalum. Min. Ann. Rev. June 1970, p. 81.

The CBMM ferroalloy plant adjoining the mine uses four refractory-lined open-ended pots placed on sand to produce ferrocolumbium and the columbium content of the ferrocolumbium varies from 40 to 65 percent depending upon customer requirements.

Canada.—St. Lawrence Columbium and Metals Corp. produced pyrochlore concentrates from its underground mining operations and mill facilities near Oka, Quebec, and continued to be Canada's sole columbium producer. The combined mining and milling operation in fiscal 1970 (ended Sept. 30, 1970) resulted in milling 724,345 tons of ore that yielded 4,886,957 pounds of columbium pentoxide, an increase of 60 percent over the 3,059,000 pounds produced in fiscal 1969.

Studies conducted at the Quebec Department of Mines and the Lakefield Research Laboratories in Toronto indicate that a salable pyrochlore concentrate can be produced from an ore deposit located in the Lake St. John area about 150 miles from Quebec City. Copperfields Mining Corp. Ltd. reported that ample reserves exist in the deposit for supporting a mining operation in which the company can earn a working interest of 50 percent by the expenditure of $1,400,000.

It was reported that a production decision for the James Bay columbium deposit may be expected some time in 1971. At the present time, Imperial Oil Enterprises has a 60-percent interest in the project, and Consolidated Morrison Explorations Ltd. holds 25.9 percent.

Lawsuits and counterlawsuits between the co-owners, Goldfield Corporation of New York and Chemalloy Minerals Ltd. of Toronto, resulted in receivership of the only commercial tantalum mine in North America and almost led to the closing of the mine. Chemalloy Minerals Ltd. of Toronto recently purchased the Goldfield Corporation's 60 percent share of the Manitoba-based producing company, Tantalum Mining Corporation of Canada Ltd., in which it already held 40 percent.

Congo (Kinshasa).—The Belgian Company, Compagnie Géologique et Minière des Ingénieurs et Industriels Belges (GÉOMINES) was reorganized at the request of the Congolese Government. A new firm, Congo-Etain, was formed; it is 50

Table 13.—Columbium and tantalum: Mineral concentrates production, by countries [1] [2]

(Pounds, gross weight)

Country [3]	1968			1969			1970 p		
	Columbium		Tantalum	Columbium		Tantalum	Columbium		Tantalum
Argentina		r 4,012,408			3,560,461			NA	
Australia		231,134			e 95,000			NA	
Brazil:									
Columbite-tantalite [4]	138,428		598,828	152,119		448,023	NA		NA
Pyrochlore	11,020,895		--------	19,098,623		--------	29,288,377		--------
Canada:									
Pyrochlore e	r 4,363,000		--------	6,829,000		--------	9,838,000		--------
Tantalite e	--------		--------	--------		245,850	--------		594,300
Congo (Kinshasa) [5]		249,122			183,645			322,512	
Ivory Coast		1,393			465			NA	
Malagasy Republic		2,985			--------			--------	
Malaysia		114,199			e 132,000			NA	
Mozambique:									
Columbite-tantalite		135,906			p 141,000			e 77,400	
Microlite	--------		199,375	--------		182,000	--------		e 64,800
Nigeria	2,527,817		25,133	3,340,065		13,351	3,564,221		9,744
Portugal		26,455			e 20,900			6,614	
Rwanda		61,729			48,502			NA	
South Africa, Republic of	--------		39,683	--------		8,818	--------		6,614
Thailand		88,185			57,320			125,663	
Uganda		19,842			NA			NA	
Total [6]		r 23,856,517			34,557,142			43,898,245	

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

[1] Excludes columbium and tantalum-bearing tin slag.

[2] When the content of neither Cb_2O_5 nor Ta_2O_5 predominates, or when insufficient identification is available, the production figure is given in the center column under each year.

[3] Columbium and tantalum mineral concentrates are also produced in Spain, South-West Africa, Southern Rhodesia and the U.S.S.R., but quantitative data are not available.

[4] Exports.

[5] In addition, some columbite-tantalite may occur as a component of tin-concentrates produced but no data are available on columbite-tantalite content.

[6] Total is of listed figures in all three columns under each year.

percent owned by the Congolese Government and 50 percent by GÉOMINES. Under the terms of the reorganization, GÉOMINES provides management, personnel recruitment and marketing services to the new firm.

Mozambique.—In 1969 Mozambique's production of tantalite and microlite was reported to be 71 and 91 tons, respectively. The main pegmatite deposits, which have been the source of Mozambique's tantalum ores (columbo-tantalite), occur in the Alto Ligonha region.

Nigeria.—Columbium continued to be recovered almost exclusively as a coproduct of tin mining. The major columbite-producing companies in Nigeria during 1969 were Bisichi Tin Co. Ltd., Jantor Ltd., and Tin and Associated Minerals Ltd. These companies produced 68 percent of the 3.3 million pounds of columbite produced in 1969. Nigerian columbite accounted for about 12 percent of the world's columbite production in 1970.

Rhodesia, Southern.—Kamativi Tin Mines Ltd., a Rhodesian organization in which the Dutch company, N.V. Billiton Maatschappij, holds controlling interest has been an important tin producer since the early 1950's. The company also recovers columbite-tantalite from pegmatites. Reported ore ratios average approximately 30 percent Cb_2O_5 to 70 percent Ta_2O_5.

TECHNOLOGY

Studies of columbium refactory metal alloys were continued by the Bureau of Mines. The effects of hafnium, tungsten, and boron on the formability, strength, and oxidation resistance of columbium were studied.[3] Elements influencing the strength and oxidation of columbium were determined to be hafnium and tungsten. Boron additions cause the alloys to oxidize more readily and do not significantly improve the strength or formability of the columbium alloys.

A new alloy steel called Armco 1-F steel was developed by the Armco Steel Corp.[4] The columbium used in the new steel ties up the carbon and nitrogen in the interstitial lattice positions of the ferrite matrix, thereby eliminating aging caused by nitrogen in cold-worked sheet steel and preventing discontinuous deformation due to the carbon content. Armco 1–F steel was available in limited quantities for evaluation studies.

A new trade organization, Refractory and Reactive Metals Association (RRMA), was formed. The organization represents companies manufacturing refractory and reactive metals and products by powder metallurgy processing techniques.[5] The association will be concerned with the promotion of industry products, research and education, collecting and disseminating economic, marketing, and technical information, and dealing with Government agencies.

Kawecki Berylco Industries, Inc., developed a new tantalum powder for capacitor applications.[6] The new Type R powder can be produced in unlimited quantities.

A survey of the thermophysical and mechanical properties of the T–111 (tantalum–8 tungsten–2 hafnium) alloy was made.[7] Owing to the excellent welding characteristics of the alloy and its resistance to alkali-metal corrosion up to 2300° F, it was concluded that the alloy was a prime candidate for advanced space power applications.

A new thermomechanical process was developed by Battelle-Northwest that greatly improves the tensile strength and the creep-rupture properties of stainless steels and nickel-base alloys at high temperatures.[8] Yield strengths with good ductility up to 65,000 psi at 1292° F, 25,000

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[3] Babitzke, H. R., L. L. Oden, and H. J. Kelly. Columbium Alloy Development With Boron, Hafnium, and Tungsten. BuMines Rept. of Inv. 7388, 1970, 30 pp.

[4] Materials Engineering. More Formable Drawing-Quality Carbon Steel. V. 72, No. 7, December 1970, p. 20.

[5] American Metal Market. New Trade Association Formed for Refractory, Reactive Metals. V. 77, No. 234, Dec. 9, 1970, p. 1.

[6] Metals Week, Elsewhere In the News. V. 42, No. 13, Mar. 29, 1971, p. 8.

[7] Moorhead, Paul E., and Phillip L. Stone. Survey of Properties of T–111 (Tantalum–8 Tungsten–2 Hafnium). Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio, June 1970, pp. 1–24.

[8] American Metal Market. Columbium Boosts Strength of Nickel Base Alloys. V. 77, No. 52, Mar. 8, 1970, p. 21.

psi at 1800° F and 14,000 psi at 2000° F may be obtained with columbium-stabilized austenitic stainless steels. Creep rates of less than 0.0002 percent per hour at 40,000 psi and 1200° F may be achieved and rupture-lives of more than 1,000 hours may be obtained. This is equal to a 35-fold increase over that of AISI–347 stainless steel and a 10-fold increase over Hastelloy-X under the same list conditions.

Copper

By Harold J. Schroeder [1] and John W. Cole [1]

World mine production of copper achieved a record high for the third consecutive year. Expansion programs and new developments were in evidence in many countries.

The domestic copper industry experienced a record high production, reduced consumption, an increase in copper stocks, and a significant increase in exports of copper in concentrates. Considerable expansion of world copper productive capacity, coupled with reduced demand in the United States elsewhere during the year, resulted in a dramatic reversal in copper markets, from one of short supply to one of surplus supply. This reversal was reflected in a price increase in April followed by price reductions in October and December. The improved supply situation led to removal in September of export controls imposed in 1965.

Legislation and Government Programs.—The national stockpile on December 31, 1970, contained 60,112 tons of oxygen-free, high-conductivity (OFHC) copper, 7,067 tons of copper in beryllium-copper master alloy, and 193,288 tons of copper in "other" classifications, for a total of 260,467 tons, 34 percent of the objective of 775,000 tons.

The U.S. 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 1970 that involved copper.

On January 9, the President directed the Cabinet Committee on Economic Policy to make a study of market conditions and pricing procedures in the U.S. copper industry, and to make recommendations about any needed action by the Government. A subcommittee, composed of representatives from several Government cabinet departments and offices, and chaired by Hendrik S. Houthakker, a member of the Council of Economic Advisors, was formed to implement the assignment.

The study was undertaken because of an apparent malfunctioning of the copper market as evidenced by a sharp price rise, existence of a dual pricing system, and the failure of supply to keep pace with demand. The subcommittee proceeded in its investigation by obtaining background reports from a number of government agencies and by informal interviews with producers, fabricators, and merchants.

Findings and conclusions of the subcommittee were released in a report dated May 18, 1970. From a study of the supply-demand-price relationships, a number of factors were identified as obstacles to the expansion of domestic primary production capacity. These included a decline in ore grade without compensating advances in technology, ecological constraints, price uncertainties, and an absence of a clearly defined national minerals policy. No recommendations were made, but alternatives were listed with an objective to increase future supplies and to reduce inequities and economic inefficiencies of the two-price system.

The listed alternatives were as follows: (1) Accept continuance of the two-price system as long as the market imbalance persists, but improve the equity of allocation, (2) maintain essentially the present system, but make substantial supplies of producer copper available to the open market, (3) permit reverse-toll refining of copper-bearing ores, concentrates, and scrap; that is, nonrestricted exports of copper raw materials to be refined abroad and returned to the United States, (4) initiate a new domestic copper expansion program, (5) promote exploration, extraction, and processing by providing appropriate incentives.

[1] Physical scientist, Division of Nonferrous Metals.

Short-supply export controls imposed in 1965 were in effect at the start of 1970. The annual export quota on refined copper from domestic sources was 50,000 tons and on scrap 60,000 tons of contained copper. However, in response to an improved supply situation, these controls were removed in September 1970.

Set-asides of refined copper for defense purposes were 14 percent at the start of the year, reduced to 13 percent in August, and eliminated, effective January 1, 1971.

The excise tax on imported copper was reduced to 1.1 cents per pound, effective January 1. 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.

Table 1.—Salient copper statistics

	1966	1967	1968	1969	1970
United States:					
Ore produced ______ thousand short tons__	186,966	127,066	170,054	223,752	257,729
Average yield of copper, percent_____	0.67	0.63	0.60	0.60	0.59
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines ____________ short tons__	1,429,152	954,064	1,204,621	1,544,579	1,719,657
Value _________ thousands__	$1,033,850	$729,401	$1,008,195	$1,468,400	$1,984,484
Smelters ___________ short tons__	1,429,863	841,343	1,234,724	1,547,496	1,605,265
Percent of world total ________	r 25	r 15	r 20	r 23	23
Refineries __________ short tons__	1,353,087	846,551	1,160,925	1,468,889	1,521,183
From foreign ores, matte, etc., as reported by refineries ___ short tons__	357,897	286,431	276,461	273,926	243,911
Total new refined, domestic and foreign ___________ short tons__	1,710,984	1,132,982	1,437,386	1,742,815	1,765,094
Secondary copper recovered from old scrap only _______________ short tons__	534,860	482,659	520,772	574,890	504,071
Exports:					
Metallic copper _____________ do____	319,314	221,066	313,741	241,254	273,577
Refined ____________________ do____	273,071	159,353	240,745	200,269	221,211
Imports, general:					
Unmanufactured ____________ do____	594,704	649,227	709,975	413,860	392,480
Refined ____________________ do____	164,328	330,571	400,278	131,171	132,143
Stocks Dec. 31: Producers:					
Refined ____________________ do____	43,000	27,000	48,000	39,000	130,000
Blister and materials in solution short tons__	270,000	220,000	272,000	291,000	340,000
Total ____________________ do____	313,000	247,000	320,000	330,000	470,000
Withdrawals (apparent) from total supply on domestic account:					
Primary copper _________ short tons__	1,594,000	1,320,000	1,576,000	1,683,000	1,585,000
Primary and old copper (old scrap only) _______________ short tons__	2,128,000	1,803,000	2,097,000	2,258,000	2,089,000
Price: Weighted average, cents per pound_	36.6	38.6	42.2	47.9	58.2
World:					
Production:					
Mine _________________ short tons__	r 5,485,341	r 5,224,361	5,640,921	6,212,998	6,566,643
Smelter ____________________ do____	r 5,708,899	r 5,582,801	6,050,822	6,621,556	6,863,947
Price: London, average cents per pound__	69.04	51.19	56.13	66.24	62.96

r Revised.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—Domestic mine production was 1.72 million tons, an increase of 11 percent and a record high quantity for the second consecutive year. Arizona was the leading State, with 53 percent of the total, followed by Utah, New Mexico, Montana, Nevada, and Michigan, in ranked order. These six States accounted for 97 percent of the total production.

Open pit mines accounted for 84 percent of mine output, and underground mines accounted for 16 percent. The production of copper from dump and in-place leaching, largely recovered by precipitation with iron, was 172,000 tons, or 10 percent of mine output. Total copper recovered by leaching methods was 245,000 tons, of which 210,000 tons was precipitated with iron; 35,000 tons was electrowon.

The Duval Sierrita mine in Arizona, operated by Duval Corp., a subsidiary of Pennzoil United Corp., was dedicated in June and achieved the scheduled production rate of 65,000 tons of ore per day in October. Development of this mine was partly financed by loans from the Government under a copper production expansion program that will be repaid by deliveries of refined copper to the national stockpile. Duval also operated the Esperanza open pit copper-molybdenum mine adjacent to Sierrita, another copper-molybdenum mine at Mineral Park, Ariz., and a copper-gold-silver property at Battle Mountain, Nev.

Operations of The Anaconda Company at Butte, Mont., produced 118,300 tons of copper, compared with 104,600 tons in 1969. The precipitation plant was expanded, doubling capacity for production of precipitate copper. Anaconda's new Twin Buttes mine at Sahuarita, Ariz., completed its first full year of operation and produced 81,300 tons of copper. Production at the Yerington mine at Weed Heights, Nev., declined 17 percent to 42,400 tons, from a record high output in 1969.

Kennecott Copper Corp., operated mines in Arizona, Nevada, New Mexico, and Utah that produced a combined total of 518,900 tons of copper, a record high output for the second consecutive year. The Utah Copper Division accounted for 298,700 tons of the total and achieved a record 112,200 tons of ore per day through the mine-mill operation.

American Smelting and Refining Company (Asarco) operated three copper mines in the vicinity of Tucson, Ariz. The Mission unit mined and milled an average of 22,500 tons of ore per day to produce 47,700 tons of copper in concentrates in 1970. The Silver Bell Unit mined and milled nearly 3.8 million tons of ore, which yielded 19,700 tons of copper in concentrates. Copper precipitates, containing 2,800 tons of copper, were also produced at the Silver Bell Unit and 64,000 tons of copper-bearing, siliceous flux ore was mined at the San Xavier mine. As a result of further drilling at the Sacaton project near Casa Grande, Ariz., ore reserves increased to 48 million tons assaying 0.95 percent copper.

Mines of the Phelps Dodge Corp., at Morenci, Ajo, and Bisbee, Ariz., and Tyrone, N. Mex., produced 315,500 tons of copper, 10 percent above 1969, and a record high for the second consecutive year. The increased output reflects the first full year of production at the new Tyrone mine. In December the company announced deferment of the development program at its Metcalf property near Morenci, Ariz., and production was rescheduled to begin in late 1974, or early 1975. Meanwhile, to offset the production loss anticipated in 1972 because of exhaustion of Bisbee reserves, the capacity of the Tyrone mine will be increased from about 55,000 to 90,000 tons of copper per year.

Cities Service Co., through its North American Chemicals and Metals Group, operated copper mines in Arizona and Tennessee that produced 49,200 tons of copper, compared with 43,600 tons in 1969. An expansion program to increase output by approximately 40 percent is scheduled for completion in 1972 at the Copperhill, Tenn., mining and chemical complex. Feasibility studies were in progress for mining two large copper deposits in the Miami, Ariz., area.

Adverse ground conditions and a decline in ore grade reduced output of copper by 13 percent, to 67,800 tons, at the White Pine, Mich., operations of White Pine Copper Co. The problems causing the reduced output have been overcome, and the existing facilities are considered to have an annual productive capacity of 87,500 tons.

The San Manuel and Superior Divisions of Magma Copper Co. produced 112,300 tons of copper. An expansion program is in progress to increase mine output from 40,000 to 60,000 tons of ore per day at San Manuel, Ariz., and to approximately double mine capacity to 3,300 tons at the Superior operation.

The Inspiration Consolidated Copper Co. operated the Thornton, Live Oak, Red Hill, and Black Copper mines in the Inspiration area Arizona; 14 million tons of waste and 9.4 million tons of ore were mined. The ore processed in the plant yielded 44,459 tons of copper. An additional 10,091 tons was recovered from leaching dumps and mined-out areas and by heap leaching at the Black Copper mine. At the Ox Hide mine, 797,000 tons of waste was removed, 3.8 million tons of oxide ore was mined, and 6,720 tons of copper was recovered by leaching. At the Christmas open pit mine, southeast of Miami, Ariz., 9.4 million tons of waste and 1.8 million tons of ore was mined; 8,640 tons of copper was recovered. Total production of copper by the company was 69,910 tons, 6 percent more than in 1969. Exploration work was suspended at the Sanchez project near Safford, Ariz., pending formulation of plans for mining and treating the ore. The basic ore reserve indicated by drilling is 39 million tons, containing 0.413 percent copper.

Pima Mining Co. produced 63,500 tons of copper in concentrates from its copper-molybdenum mine south of Tucson, Ariz. Construction was underway to increase milling capacity from 40,000 to 53,000 tons per day by late 1971, or approximately 80,000 tons of copper in concentrates per year.

Bagdad Copper Corp. produced 11,000 tons of copper in concentrates and 6,200 tons in precipitates from its Arizona copper mine. Reserves are estimated to be 43 million tons averaging 0.69 percent total copper, with a stripping ratio of about 1 to 1. Part of the waste stripping contains a significant copper content suitable for dump leach operations. The company is evaluating the feasibility of mining an adjacent ore deposit that contains at least 228 million tons of 0.47 percent copper.

Ranchers Exploration and Development Corp. moved about 1.6 million tons of overburden and 2.3 million tons of ore at its 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 was 5,300 tons in 1970. The company opened the Big Mike copper property near Winnemucca, Nev. in January and during the year, mined about half of the approximately 95,000 tons of 9 percent copper reserve as a direct smelting ore. The deposit also contains an estimated 675,000 tons of a lower grade sulfide ore. Further production has been deferred pending feasibility studies and additional exploration of the area in a joint venture with Cerro Corp.

Hecla Mining Co. continued driving two declines toward a planned slope length of 7,500 feet in developing its Arizona Lakeshore Copper mine. Metallurgical process and engineering studies to mine the deposit were also conducted.

Smelter Production.—Output of copper from all raw material sources, at primary smelters in the United States was 1.72 million tons, an increase of 4 percent and a record high quantity.

Conformance to new air quality regulations caused Asarco to curtail operations at its Arizona, Texas, and Washington smelters and to declare a condition of force majeure, and shippers of copper concentrates were placed on a quota system beginning June 1. Installation of electrostatic precipitators and other facilities for reduction of in-plant fume conditions at the El Paso, Tex., smelter was nearing completion. The Tacoma, Wash., plant was shut down for a 7-week period during the first quarter as a result of a flue collapse.

The Anaconda Company smelter at Anaconda, Mont., was undergoing extensive renovation to improve operations and environmental conditions.

The San Manuel, Ariz., smelter of Magma Copper Co. was being expanded in anticipation of greater company mine production and closure of the Superior, Ariz., smelter scheduled for late 1971.

Refinery Production.—Production of refined copper from all materials processed at primary refineries was 2.22 million tons, an increase of 3 percent and a record high for the second consecutive year. Refined copper produced at secondary plants was 58,000 tons, compared with 78,000 tons in 1969. The total production of refined copper produced from scrap in the United States was 509,000 tons, equal to 23 percent of total refined copper production.

The Tacoma, Wash., refinery of Asarco completed the second phase of a two-stage expansion, providing an additional 50,000 tons per year of electrolytic copper refining capacity, raising total capacity to 156,000 tons per year. Magma Copper Co. was constructing a copper refinery at San Manuel, Ariz., which had a rated annual capacity of 200,000 tons, for scheduled operation in late 1971.

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.
Copper Pigments & Chemical Co	Sewaren, N.J.
Eastern Rare Metals, Inc	Baltimore, Md.
Phelps Dodge Refining Corp	Laurel Hill, N.Y., El Paso, Tex.
Sherwin-Williams Co	Cleveland, Ohio
Van Waters & Rogers Inc. English & Bagby Co. Division	Wallace, Idaho, Midvale, Utah, Metaline Falls, Wash.

Copper sulfate production decreased 10 percent to 45,350 tons (11,300 tons contained copper). Shipments were 11 percent below production, and stocks doubled during the year to 8,800 tons, the largest yearend quantity since 1948. Of the total 40,300 tons shipped, producer's reports indicated that 14,400 tons was for agricultural uses, 23,500 tons was for industrial uses, and 2,400 tons was for other uses (chiefly exports).

Byproduct Sulfuric Acid.—Sulfuric acid was produced by five copper smelters from the sulfur contained in off-gases, and output increased for the third consecutive year, to a record 748,000 tons, on a 100-percent acid basis. Kennecott brought a sixth acid plant at its Utah operations on stream in the fourth quarter 1970. Under optimum conditions, this new plant can convert 163 tons of sulfur into 500 tons of sulfuric acid per day. Sulfuric acid facilities were being constructed at the Hayden, Ariz. smelter of Asarco for scheduled production by fall of 1971. The company also announced plans to build a 500-ton-per-day sulfuric acid plant at its El Paso smelter.

SECONDARY COPPER AND BRASS

Domestic recovery of copper in unalloyed and alloyed form from all classes of purchased scrap totaled 1.25 million tons in 1970, 9 percent less than in 1969. Recovery from copper-base scrap decreased 9 percent, to 1.23 million tons. Primary copper producers reported an increase of 9 percent; however, production by secondary smelters and brass mills declined 24 and 13 percent, respectively.

Consumption of purchased copper-base scrap in 1970, dropped 7 percent to 1.7 million tons. Primary producers increased their usage by 14 percent, to 705,000 tons. Conversely, consumption dropped 23 percent at secondary smelters, 14 percent at brass mills, and 17 percent at foundries and other plants.

CONSUMPTION

Apparent withdrawals of primary refined copper on domestic account decreased 6 percent, to 1.59 million tons. Reported consumption of refined copper was 2.04 million tons, compared with 2.14 million tons in 1969. Consumption of refined copper is based on consumers reports of quantities entering processing with no adjustments for changes in stocks.

As far as can be ascertained, only new or primary copper is included in table 27, but table 28 includes all refined copper.

STOCKS

Stocks of refined copper at primary producing operations increased from 39,000 to 130,000 tons during the year, the largest yearend quantity since 1938. During the same period, fabricators' stocks of copper in all forms increased from 502,000 to 515,000 tons.

PRICES

The domestic producer price for refined copper was increased from 52 to 56 cents per pound, effective January 1, 1970. It was further raised to a record high of 60 cents per pound on April 1 but reduced to 56 cents per pound on October 23, and further reduced to 53 cents per pound on December 1. The average weighted price of copper deliveries in 1970 was 58.2 cents per pound, compared with 47.9 cents per pound in 1969.

Prices on the London Metal Exchange

(LME) averaged 72.6 cents per pound during January, moved upward to 78.5 cents per pound in March, and then declined to an average of 46.5 cents per pound for December. The 1970 average was 63.0 cents per pound, compared with 66.2 cents per pound for 1969. In early August, the LME copper price fell below the domestic producer quotation for the first time since February 1964.

FOREIGN TRADE

U.S. exports of copper including manufactures totaled 324,600 tons, an increase of 31 percent, but 15 percent below the 1968 quantity. All classes of unmanufactured copper increased; however, the advance in the ore, concentrates, and matte class was the most outstanding. Significant exports in this class began in June and totaled 61,500 tons for the year, compared with 1,200 tons for 1969. This changed trade pattern results from a rapid increase in mine production capacity, curtailment of production at some domestic smelters owing to enforcement of new air pollution regulations, and delay in construction of new smelter facilities pending a resolution of uncertainties surrounding new pollution standards and the proper technology to meet the anticipated requirements.

U.S. imports of unmanufactured copper decreased 5 percent, to 392,500 tons. Most of the loss was in the largest category, blister copper, which declined 6 percent to 224,400 tons. The second largest category, refined copper, increased slightly, to 132,100 tons. Chile, Peru, and Canada supplied 82 percent of total imports, unchanged from 1969.

WORLD REVIEW

World mine production of copper attained 6.6 million tons, a record high for the third consecutive year. Most major producing countries contributed to the increase with the exceptions of a small decline for Chile and a 9 percent drop for Zambia, as a result of a serious cave-in at the Mufulira mine. Expansion programs and developments in many countries presages a continuation in the rise of copper output.

The United States continued to lead the world in mine production with 26 percent of the total, followed by Chile and Zambia, with 12 percent and Canada and the Soviet Union, 10 percent.

Argentina.—Bids were opened on June 22, 1970, by an Argentine Government agency for concessions on copper prospects developed by Plan Cordillerano (a joint Government of Argentina-United Nations Special Fund project). Out of 54 copper prospects developed by Plan Cordillerano, bids on only three were received from five mining companies. The five firms and areas for which they bid are as follows:

Firm	Area
Falconbridge Nickel Mines, Ltd	54
Cia. Minera Aguilar, S.A. (Argentina subsidiary of St. Joe Minerals Corp.).	41, 45
Union Corp. (Republic of South Africa)	54
Vial Hidráulica (Argentina)	54
Bay Hall Trust (United Kingdom)	54

Area 54 was awarded to Falconbridge Nickel Mines Ltd. but details still are being negotiated. One difficulty is that the Government agency is apparently unable to guarantee the concessionaire more than a 4-year lease on the area.

Australia.—Mine production of copper in Australia was 160,551 tons, an increase of 11 percent. Mount Isa Mines Ltd., 53-percent owned by Asarco increased output 14 percent to 92,800 tons of copper contained in products for the fiscal year ended June 30, 1970. The company announced a substantial increase in reserves to 134.4 million tons of ore with an average 3 percent copper content. As a result of this increase in reserves, Mount Isa has begun an expansion program to increase productive capacity from about 110,000 to 170,000 tons per year.

Mount Lyell Mining and Railway Co., Ltd., closed its copper smelter at Queenstown in Tasmania, after 73 years of operation. Open pit operations are continuing and copper concentrates are being sent to other smelters for treatment. Shaft sinking and development for underground mining was underway, and is scheduled for March 1972 to facilitate a copper production rate of 25,000 tons per year in 1973.

Exploration for copper in Australia, including the Trust Territory of Papua, and New Guinea, continued at a high level of activity. Companies with large exploration efforts included Eastern Copper Mines, Carpentaria Exploration Pty., Ltd., (subsidiary of Mount Isa), Jadodex Australia Pty., Ltd (St. Joe Minerals Corp. and Phelps Dodge Corp.), Pacific Copper Explorations Ltd., and Unimin (Australian subsidiary of Union Minière).

Botswana.—Bamangwato Concessions, Ltd. (BCL), was working on plans to develop nickel-copper deposits in the Selebi-Pikwe area. BCL is 61-percent owned by Botswana Roan Selection Trust Ltd. and (BRST) 43.3-percent owned by AMAX. If a decision to mine is reached, the Botswana Government will receive a 15-percent interest in BCL, proportionately reducing the other interests. The envisaged production for the first 10 years would be at an annual rate of approximately 2 million tons of ore yielding 13,000 tons of refined nickel, 16,000 tons of refined copper, and 100,000 tons of sulfur. Proven and probable reserves for the two deposits are estimated to total 45.7 million tons, grading 1.20 percent nickel and 1.26 percent copper.

Brazil.—Late in the year, Caraíba Metais, S.A., developing a copper mining project in northeast Brazil, sent invitations to firms in the United States, Europe, and Japan to bid on supplying equipment for the mine, mill, and smelter. Caraíba hopes to start purchases in April 1971 in order to have the operation ready by mid-1973. The Caraíba copper project has been approved by the Brazilian Government. The sponsors of the project estimate that the mine will produce 77,000 tons of copper per year. The investment is estimated at $97.7 million.

Canada.—Production of copper in Canada rebounded from the strike-curtailed output of 1969, to achieve record highs of 676,000 tons for mine production and 543,000 tons for smelter output. Ontario produced 43 percent of the total followed by Quebec, 26 percent; British Columbia, 16 percent; Manitoba, 8 percent; and the remaining Provinces, 7 percent.

Hudson Bay Mining and Smelting Co. Ltd. milled 1.7 million tons of ore yielding 42,178 tons of refined copper plus quantities of zinc, cadmium, selenium, gold, and silver. The company brought the Anderson Lake and the Dickstone Copper mines into operation and raised the total number of mines operated along the Manitoba-Saskatchewan boundary to eight. In addition, the White Lake and the Ghost Lake copper-zinc-silver mines were under development for planned production in 1972.

Sherritt-Gordon Mines Ltd. continued operating the Lynn Lake mine in Manitoba, and brought the nearby Fox mine into production in September. Combined output for the year more than doubled to 15,400 tons of copper contained in concentrates. Reserves at the Lynn Lake property were estimated at 12.6 million tons of 0.77 percent nickel and 0.38 percent copper and at the Fox property were 13.1 million tons averaging 1.84 percent copper and 2.70 percent zinc. Exploration and engineering studies continued at the Ruttan Lake property. Reserves were substantially increased to 51 million tons grading 1.43 percent copper and 1.59 percent zinc.

Mattabi Mines Ltd., 60-percent owned by Mattagami Lake Mines and 40-percent owned by Abiti Paper Co., was incorporated in September to develop a base-metals mine in the Sturgeon Lake district, Northwestern Ontario. Planned production is at a rate of 3,000 tons of ore per day scheduled for startup by mid-1972. The operation is a result of exploration by Mattagami, which outlined an ore body estimated to contain 12.9 million tons of ore grading 7.6 percent zinc, 0.91 percent copper, 0.84 percent lead, and 3.13 ounces of silver per ton. Intensive exploration by Mattagami and other companies continues in the Sturgeon Lake area.

Production of copper concentrates at the Granduc mine, north of Stewart, British Columbia, began on a limited basis in November with a contemplated buildup to the rated capacity of 7,500 tons of ore per day by late 1971. Start of operations were delayed owing to a 2-year period of labor disputes that had suspended construction of facilities for approximately 10 months. Ore reserves were calculated to be 43 million tons averaging 1.73 percent copper.

Similkameen Mining Co. Ltd., a subsidiary of Newmont Mining Corp., began construction of a mining venture near Princeton, British Columbia. Facilities, estimated to cost $73 million, will permit open pit mining and milling of two deposits at a rate of 15,000 tons per day. Ore reserves at the two properties are estimated at 76 million tons averaging 0.53 percent copper.

Anaconda Britannia Mines Ltd. produced 2,700 tons of copper in concentrates from its mine in British Columbia, compared with 6,600 tons in 1969. The reduced output resulted from utilization of part of the labor force on new development completed in 1970, which increased the annual productive capacity to 10,000 tons of copper. The Caribou Division of Anaconda constructed facilities for open pit mining of a relatively small copper deposit near Bathhurst, New Brunswick, at a rate of 1,000 tons of ore per day.

All major process facilities at the large, low-grade copper-molybdenum deposit of Brenda Mines Ltd. in British Columbia, were operational in March. Rated capacity of 24,000 tons per day was achieved by yearend.

Construction was in progress by Utah Construction & Mining Co. for initial production early in 1972, at their Island Copper Property near Port Hardy, Vancouver Island, British Columbia. Production is planned at a rate of 33,000 tons of ore per day, or 230,000 tons of copper concentrates per year. The concentrates are contracted for delivery to Japanese smelters. Reserves are estimated at 280 million tons containing 0.52 percent copper and 0.025 percent molybdenum.

Exploration by Valley Copper Mines, 80-percent owned by Consolidated Mining and Smelting Co. (Cominco) and 20 percent by Bethlehem Copper Corp., revealed an ore deposit containing approximately 1 billion tons of 0.48 percent copper. The deposit can be mined at a waste to ore ratio of about 1 to 1. A feasibility study for a large-scale operation is being made. Bethlehem is planning an increase in its mill capacity from the present 14,000 tons per day to 27,000 tons per day by 1972, to treat its portion of the anticipated Valley Copper Mine output.

Final arrangements had been completed by midyear for construction of facilities at Lornex Mining Corporation Ltd.'s copper-molybdenum property in the Highland Valley of British Columbia. Plans call for production to start in 1972 with a rated capacity of 38,000 tons of ore per day. Start of construction was delayed in the first half of 1970 pending resolution of difficulties over sales contracts and loan agreements with Japanese firms to conform with the recently passed Mineral Processing Act of British Columbia.

Chile.—Copper output by the three large producers was 589,000 tons, compared with 596,000 tons in 1969. Chuquicamata produced 290,000 tons compared with 312,000 tons in 1969; El Teniente produced 194,000 tons, down from 202,600 tons in 1969; and El Salvador produced 103,000 tons, up from 85,000 tons in 1969. The initial production from The Anaconda's new Exótica mine in December was 1,900 tons. The total Chilean production was 756,000 tons, down from 771,000 tons in 1969.

Operations at Chuquicamata were halted by a strike of supervisory personnel May 26 to 30 and by a general strike of workers from October 1 to 21.

After 3½ years of construction, the Río Blanco mine of Compañia Mineral Andina, S.A., which is 70-percent owned by Cerro Corp. and 30-percent owned by the Chilean Government began limited production in July, and is expected to reach designed capacity of 62,500 tons of copper in concentrates in 1971.

Anvil Mining Corp., which is 60-percent owned by Cyprus Mines Corp. and 40-percent owned by Dynasty Explorations, Ltd., continued its drilling program and plans for operation of the Sierra Gorda copper-molybdenum property in Antofagasta. Ore reserves are estimated at 20 million tons of sulfide ore containing 1 percent copper and 0.15 percent molybdenum sulfide.

On November 3, 1970, Dr. Salvador Allende Gossans was inaugurated President of Chile. He introduced legislation in the form of a constitutional reform bill to nationalize basic industries, including the large copper mines.

Congo (Kinshasa).—Générale Congolaise des Minerais (GECOMIN), the Government-owned mining company, accounted for the total copper mine production of 425,000 tons, an increase of 8 percent from that of 1969. Additions to the Kambove concentrator and the completion of the Ruwe washing plant in October were part of a 5-year expansion program designed to increase GECOMINES annual copper-producing capacity to 500,000 tons by 1974.

The joint Japanese-Congolese concern, Société de Developpement Industriel et Miniere du Congo (SODIMICO), announced discovery of an estimated 38 million tons of copper ore averaging 5 percent copper in the Kinsenda area of Katanga Province. Kinsenda is about 20 miles from the Mushoshi deposit scheduled to begin production in 1972 at an annual rate of 58,000 tons of copper.

A consortium of companies, which includes Amoco Minerals Co., (subsidiary of Standard Oil Co. of Indiana), Charter Consolidated Ltd., and Leon Tempelsman & Son Inc., has been granted prospecting and development rights in two areas of Katanga Province. One of the areas is an unprospected region of 25,000 square kilometers. The other area of 1,400 square kilometers contains the known copper deposits of the Tenke-Fungurume locality.

Falconbridge Nickel has established an office in Kinshasa and has been making a study of copper deposits around the Lufukwe River in southern Pweto Territory, Katanga Province.

Ecuador.—A prospecting team of Overseas Mineral Resources Development of Japan started work on a 4-year study of the Chaucha copper area about 130 miles southeast of Guayaquil to determine the commercial viability of exploiting the deposits.

Guatemala.—Basic Resources International Ltd., a Canadian company, and Sumitomo Metal Mining Co. of Japan have agreed to finance the development of the former company's Oxec copper property located 7 miles from Cahabon. The property comprises a 30-square-mile concession, on which one ore body has proven (drilled) reserves of 1.33 million tons of 2.58 percent copper ore. Under the agreement, Sumitomo will purchase all concentrates produced for a period of 7 years and will pay in advance an amount equivalent to 1 year's capacity production. The Export-Import Bank has provided a maximum credit of $1,147,080 to Basic Resources to purchase U.S. equipment and services for a mill.

India.—The privately owned Indian Copper Corp., Ltd., India's only producer of copper, was installing new equipment (including a flash smelter) to increase the current 11,000 ton-per-year capacity to 18,000 tons by 1972. The Khetri project of Hindustan Copper Ltd., a public concern, in Rajasthan, is scheduled to be producing at an annual rate of 34,000 tons of refined copper by 1974. Ore reserves upon which the project is based are estimated to be 77 million tons of 1.0-percent copper in the Madhan Kudhan deposit and 34 million tons of 2.5-percent copper in the Kolihan deposit.

Indonesia.—Development of the Ertsberg copper deposit in Irian Barat, by Freeport Sulphur Co., continued on schedule.

Iran.—A joint venture of Mahmoud Rezai, Kerman Mining Co., and Iranian Selection Trust, Ltd., owned 60 percent by Selection Trust Ltd., of England and 40 percent by African Selection Trust, Ltd., made a feasibility study of exploiting the Sar Cheshmeh copper deposit in the Kerman copper belt. Plans, contingent on financing, are to produce from the open pit mine and mill 30,000 tons of ore per day starting in 1974. Proven reserves are estimated to be 300 million tons, averaging 1.2 percent copper.

Other exploration for copper in the Kerman copper belt was being conducted by Charter Consolidated, Ltd., of the United Kingdom, Péchiney of France, and Metallgesellschaft A.G. of West Germany.

Ireland.—Avoca Mines, Ltd., began mining-milling operations in December at its copper property in County Wicklow. Rated capacity of the mill is 2,000 tons of ore per day. There are plans to increase the capacity to 3,000 tons after 2 years. Ore reserves are estimated at 7 million tons averaging 0.98 percent copper, with allowance for mining dilution.

Israel.—A second underground mine with initial output scheduled for 1973 was being developed by Timna Copper Mines Ltd., at its property in Aravah Valley, 18 miles north of Eilat. Greater emphasis will be placed on underground operations as the open pit ore nears exhaustion. However, in the interim, maintenance of copper output also requires expansion of open pit facilities, since the remaining reserves are both lower grade and have higher waste-to-ore ratios. The development program was made possible by a successful and continuing exploration program.

Mexico.—Asarco Mexicana, S.A., produced 27,100 tons of blister copper, compared with 25,900 tons in 1969. The company completed construction of the mine, mill, town site, and supporting facilities at the Inguarán mine in the State of Michoacán. Initial production was scheduled for the first quarter of 1971; a planned annual output of 12,000 tons of copper was expected. A new converter was added to the copper smelter at San Luis Potosí to handle Inguarán concentrates. A study was being made regarding the feasibility of installing a refinery to process the blister copper. Mexicana de Cobre, S.A., 49-percent owned by Asarco Mexicana, continued engineering studies at the La Caridad property near Nacozari in the State of Sonora.

Compañía Minera Nacozari, S.A., an affiliate of Anaconda, continued exploration and substantially increased reserves of a copper-molybdenum deposit in the Nacozari district. The company has also undertaken the evaluation of the Pilares mine area in the same district.

Exploration by Patino Mining Corp., for Lytton Minerals, Ltd., indicated 55 million tons of reserves averaging 0.78 percent copper at the La Verde property in Michoacán State. Further drilling and underground openings are planned to prove up the probable and possible reserves and to delimit the ore bodies for mine development.

Nicaragua.—At the Rosita mine of La Luz Mines Limited, 435,223 tons of ore was milled to produce 15,270 tons of concentrates containing 3,340 tons of copper. The average grade of ore was 1.04-percent copper, compared with 1.98-percent copper in 1969. During the year, the milling capacity was increased from 830 tons per day to over 2,000 tons per day. Recovery of metals in the mill was 77.1 percent. Proven and probable ore reserves at the end of 1970 were 1.98 million tons containing 0.85-percent copper with additional gold content. Additional possible ore reserves were 4.6 million tons containing 0.86-percent copper.

Panama.—A concession for developing the Cerro Petaquilla copper-molybdenum deposit was awarded by the Government to a consortium comprised of Duval Corp. (United States), Mitsui Mining and Smelting Corp. (Japan), and Metallgesellschaft A.G. (West Germany). Another copper-molybdenum concession on an area west of the Cerro Petaquilla was awarded by the Government to Paronia, S.A., an affiliate of Canadian Javelin.

Peru.—Copper production of 234,000 tons was higher than in 1969 and almost equaled the record production of 1968.

The principal copper producer, the Toquepala mine of Southern Peru Copper Corp., produced a record high 149,000 tons of copper. Operation of the mine and concentrator was interrupted for 20 days by three separate labor strikes. Ore treated amounted to 1.57 million tons with an average grade of 1.14 percent copper. Cerro Corp. produced 52,600 tons of copper at La Oroya, 34 percent of which was from purchased ores.

In an effort to increase metal production, the Peruvian Government published a decree on September 2, 1969. The decree states, essentially, that all ore bodies held since June 18, 1965, under exploitation concessions were to be brought to an annual production level of at least one-sixtieth of known reserves by April 1, 1975. The holders of these concessions were required to file calendars of operations by the end of 1969, showing the development schedule to be followed. The decree stated further that, with certain exceptions, concessions would expire of these schedules were not met. Dissatisfied with the progress, the Government in 1970 cancelled concessions held by United States mining companies as follows:

Company	Concession
The Anaconda Company	Cerro Verde.
American Smelting and Refining Company (Asarco)	Michiquillay.
Cerro Corp	Antamina, Chalcobamba, Ferrobamba, Tintaya.

Development of the Cuajone mine by Southern Peru Copper Corp., continued on schedule during 1970. In January 1971, the Government cancelled the Quellaveco concession, which is near the Cuajone project.

Philippines.—In 1970, thirteen mining companies produced 160,000 tons of copper in concentrates and direct shipping grade ore, an increase of 13 percent over the previous year. Drought conditions curtailed operations during the first half of the year with the result that copper output was 75,000 tons, compared with 89,000 tons for the second half. Atlas Consolidated Mining and Development Co. was the largest copper producer yielding 43,100 tons. Marcopper Mining Corp., owned 60 percent by the Philippine Government and 40 percent by Craigmont Mines Ltd., a subsidiary of Placer Development, Ltd., had initial production in 1969 and in 1970 was the second largest producer yielding an output of 34,300 tons of copper. Other major producing companies were Marinduque Mining and Industrial Corp., Lepanto Consolidated Mining Co., and Philex Mining Corp., with outputs of 33,300 tons, 26,400 tons, and 16,700 tons, respectively.

South Africa, Republic of.—O'okiep Copper Co. Ltd. milled 3.2 million tons of ore with an average grade of 1.37-percent copper from eight producing mines. This ore yielded 39,500 tons of blister copper. Despite continuation of an intensive exploration program reserves declined to 30.3 million tons of ore averaging 1.54-percent copper.

Palabora Mining Co. Ltd. increased output 17 percent to 101,300 tons of anode copper. The higher rate was made possible by an expansion program completed in December 1969. Ore milled was 20.9 million tons with an average grade of 0.54-percent copper.

Messina (Transvaal) Development Co., including subsidiary copper mines in Southern Rhodesia, produced 35,800 tons of copper.

Africa Triangle Mining Prospecting and Development Co.—a holding company formed by Anglo-Vaal, Middle Witwatersrand, and United States Steel Corp.—is developing 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. Initial plans envisage an operation of about 7,000 tons of ore processed per day yielding 30,000 tons of copper and 50,000 tons of zinc per year.

South-West Africa, Territory of.—The Tsumeb Corp. Ltd. milled 547,000 tons of ore averaging 3.51-percent copper, 12.29-percent lead, and 3.91-percent zinc from their Tsumeb mine. Resulting copper concentrates and 24,000 tons of direct shipping ore were sent to the copper smelter. At the Kombat mine, 421,000 tons of ore averaging 2.24-percent copper and 1.77-percent lead was mined and milled. The Matchless mine near Windhoeck, 225 miles south of Tsumeb, started production in mid-1970; a rated production of 500 tons of ore was expected early in 1971. Blister copper produced from the three mines was 33,100 tons, compared with 31,400 tons in 1969.

Oamites Mining Co., Ltd., substantially financed by Falconbridge Nickel, was developing the Oamites mine located 35 miles south of Windhoeck. Production was scheduled for July 1971 at a treatment rate of 50,000 tons of ore per month. Copper concentrates are to be sent to Tsumeb for smelting. Ore reserves are estimated to be 4.7 million tons of 1.45-percent copper.

Uganda.—Under terms of legislation passed by the Parliament of Uganda, Kilembe Mines, Ltd., is deemed to be owned 60 percent by the Government of Uganda and 31.1 percent by Kilembe Copper Cobalt Ltd., which is 72.5-percent owned by Falconbridge Nickel. Kilembe Mines processed 1.1 million tons of ore to produce 18,700 tons of blister copper in 1970. Ore reserves at yearend were estimated to be 7.2 million tons of 2.0-percent copper in the proven and probable category, plus 3.6 million tons of 1.72-percent copper in the possible category.

U.S.S.R.—Japanese, French, and British companies were conducting negotiations with the Soviet Union regarding exploitation of vast copper deposits in the Udokan region of Chita, which borders Mongolia, east of Lake Baikal. The contemplated large size of the venture and the remoteness of the deposits led to the conclusion that the required financial investments for development could best be met through a multinational consortium.

Zambia.—Copper mine production decreased 9 percent, to 754,000 tons, principally as a result of the disastrous cave-in at the Mufulira underground mine on September 25, which claimed the lives of 89 miners. A return to normal operation is not expected before 1972.

As part of the reorganization of the Anglo-American group, companies operating the Nchanga, Rhokana, and Bancroft mines, and the Rhokana refinery were merged into the Nchanga Consolidated Copper Mines, Ltd. (NCCM), and reincorporated in Bermuda on June 26, Output of copper by NCCM was 436,000 tons in 1970. Plans call for expansion programs to increase annual capacity to 550,000 tons by 1974. The plans included a leach precipitation plant at Chingola to treat concentrates from low-grade oxide ore and reopening of the Bwana Mkubwa and the Kansanshi mines.

Roan Consolidated Mines, Ltd. (RCM), comprised of the Mufulira, Chibuluma, Chambishi, Kalengwa, and Luanshya mines produced 377,800 tons of refined copper during 1970, compared with 368,000 tons in 1969. All mines except Mufulira recorded an increase over the previous year. Part of the refined copper production was from concentrate stockpiled in previous years during periods of fuel shortage. Production of 193,000 tons of refined cathodes at the Ndola refinery was a record high. The Kalengwa mine, in its first full year of operation, produced 4,579 tons of copper from high-grade ore treated at the Luanshya and Mufulira smelters. Lower grade ores were stockpiled for treatment in the concentrator nearing completion. Output was expected to be at the annual rate of 19,000 tons.

Baluba Mines, Ltd., owned almost entirely by RST International, Inc., and Zambia Copper Investments, Ltd., will be incorporated into the RCM group. The Baluba mine will be developed into a 55,000 ton-per-year underground operation with initial output scheduled for 1973. Ore reserves at Baluba are estimated at 60 million tons containing 2.71-percent copper and 0.17-percent cobalt. Copper concentrate will be smelted at Luanshya and Mufulira, and cobalt concentrate will be processed at Chambishi. Total copper capacity of RCM operations is planned to increase from 342,000 to 413,000 tons per year by the end of 1973.

TECHNOLOGY

Reports published on copper resources included the observed mineralized zoning of major porphyry deposits,[2] copper distribution patterns in the batholith of the Butte district,[3] geochemistry factors of ore-metal transport and deposition,[4] and tectonic control considerations related to copper mineralization in Arizona.[5]

Feasibility studies have been made on the copper resource contained in Permian red bed formations of Kansas, Oklahoma, and Texas.[6] Use of geophysics in the discovery and delineation of the Kidd Creek copper-zinc-silver ore body was described.[7] A paper compares the use of different methods for computing grade and tonnage of ore, leach, and waste material.[8]

An article described the collection and evaluation of data including the use of a computerized pit design in a feasibility study for developing the Brenda copper mine.[9] Truck haulage efficiencies related to engine horsepower, truck size, and haulage conditions at a copper mine has been assessed.[10] A theoretical study has been made on the use of nuclear explosives to fracture a copper ore body.[11]

In minerals beneficiation, a study concluded that an accurate correlation of grinding data from various samples with the geology of the ore body and with mining plans was needed to successfully apply autogenous grinding.[12]

Proceedings of the Extractive Metallurgy Division Symposium (Metallurgical Society of American Institute of Mining Metallurgical and Petroleum Engineers) on Cop-

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[3] Al-Hashimi, Abdul Razak K., and Arthur H. Brownlow. Copper Content of Biotites From the Boulder Batholith, Montana. Econ. Geol., v. 65, No. 8, December 1970, pp. 985–992.

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Batty, J. Vanve, and B. F. Andrew. Leach-Precipitation-Flotation Studies on Red Bed Copper Ore Using Controlled Atmosphere. BuMines Rept. of Inv. 7375, April 1970, 9 pp.

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[11] Hardwick, W. R. Fracturing Hard Rock With Nuclear Explosives and Extraction of Ore by a Modified Block-Caving Method. BuMines Rept. of Inv. 7391, June 1970, 18 pp.

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per Metallurgy held in Denver, in February 1970, was published. These proceedings contain many articles describing operations and research in roasting, smelting, refining, and hydrometallurgy of copper.

A review of the dimensions and possible solutions to the sulfur control problem in copper extraction indicated rapid steps towards improved stack-gas control systems and expanded research to seek a longer range solution via a hydrometallurgical approach.[13] Published articles reported on the results of research on roasting[14] and smelting [15] reactions.

The design parameters and a summary of latest developments in solvent-extraction, ion-exchange recovery methods were described.[16] Another article outlined the evolution of hydrometallurgy in treatment of both oxide and sulfide ores.[17] Research was conducted on utilization of roasting and leaching techniques for recovery of copper from sea nodules and from Minnesota copper-nickel ores.[18]

Reliable spectrographic standards to analyze for impurity levels in refined copper were established in a research effort by a number of participating laboratories.[19] The resulting standards provide an opportunity for interlaboratory comparisons by supplier and user of absolute values for trace impurities in copper, at levels critical to the properties of certain copper-bearing products.

Intricately shaped parts with excellent electrical conductivity can be made by power metallurgy from high-purity copper power using vacuum or conventional sintering techniques.[20] Use of an extrusion process to produce a weldless, defect-free, copper strip was described.[21] A continuous, hydrostatic extrusion process for making wire has claimed advantages of lower equipment costs, cheaper maintenance, reduced space and power requirements, less wire breakage, and less labor.[22] Use of copper-clad aluminum will apparently have a significant impact on the electrical building-wire market and possible other electrical applications such as communications cable and magnet wire.[23]

Table 2.—Copper produced from domestic ores, by source
(Thousand short tons)

Year	Mine	Smelter	Refinery
1966	1,429	1,430	1,353
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

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[22] Metals Week. A New Route to Wire. V. 41, No. 19, May 11, 1970, p. 3.

[23] Metals Week. Clad Wire Gets a Break. V. 41, No. 21, May 25, 1970, pp. 18–19.

Table 3.—Copper ore and recoverable copper produced, by mining method

(Percent)

Year	Open pit		Underground	
	Ore	Copper [1]	Ore	Copper [2]
1966	85	80	15	20
1967	r 86	83	14	17
1968	87	82	13	18
1969	88	84	12	16
1970	87	84	13	16

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 months

(Short tons)

Month	1969	1970
January	120,829	141,038
February	118,481	132,898
March	132,795	145,457
April	131,479	142,893
May	127,496	153,304
June	129,317	149,653
July	123,170	138,130
August	125,145	145,784
September	127,662	140,597
October	135,429	149,819
November	134,191	139,839
December	138,585	140,245
Total	1,544,579	1,719,657

Table 5.—Mine production of recoverable copper in the United States, by States

(Short tons)

State	1966	1967	1968	1969	1970
Arizona	739,569	501,741	627,961	801,363	917,918
California	1,078	788	1,182	1,129	2,308
Colorado	4,237	3,993	3,451	3,598	3,749
Idaho	4,961	4,210	3,525	3,332	3,612
Maine	----------	----------	898	1,320	2,703
Michigan	73,449	58,458	74,805	75,226	67,543
Missouri	3,913	3,215	5,494	12,664	12,134
Montana	128,061	65,483	69,480	103,314	120,412
Nevada	78,720	50,771	77,213	104,924	106,688
New Mexico	108,614	75,008	90,769	119,956	166,278
Pennsylvania	3,178	4,401	4,850	3,382	2,539
Tennessee	15,410	14,600	14,196	15,353	15,535
Utah	265,383	168,609	228,245	296,699	295,738
Other States [1]	2,579	2,787	2,552	2,319	2,500
Total	1,429,152	954,064	1,204,621	1,544,579	1,719,657

[1] Includes Alaska 1966–68; Oklahoma; Oregon 1966, 1968–70; and Wyoming 1969.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1970, 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	Ray Pit	Pinal, Ariz	Kennecott Copper Corp	Copper ore, copper precipitates.
4	San Manuel	do	Magma Copper Co	Copper ore.
5	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore, copper precipitates.
6	Twin Buttes	Pima, Ariz	The Anaconda Company	Copper ore.
7	Berkeley Pit	Silver Bow, Mont	do	Do.
8	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
9	Pima	Pima, Ariz	Pima Mining Co	Do.
10	New Cornelia	do	Phelps Dodge Corp	Copper, gold-silver ores.
11	Copper Queen-Lavender Pit	Cochise, Ariz	do	Copper ore, copper precipitates.
12	Tyrone	Grant, N. Mex	do	Copper ore.
13	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co	Copper ore, copper precipitates.
14	Mission	Pima, Ariz	American Smelting and Refining Co	Copper ore.
15	Yerington	Lyon, Nev	The Anaconda Company	Do.
16	Veteran-Tripp Pit	White Pine, Nev	Kennecott Copper Corp	Do.
17	Butte Hill Copper Mines	Silver Bow, Mont	The Anaconda Company	Copper ore, copper precipitates.
18	Sierrita	Pima, Ariz	Duval Sierrita Corp	Copper ore.
19	Mineral Park	Mohave, Ariz	Duval Corp	Copper ore, copper precipitates.
20	Copper Cities	Gila, Ariz	Tennessee Corp	Do.
21	Esperanza	Pima, Ariz	Duval Corp	Do.
22	Silver Bell	do	American Smelting and Refining Co	Do.
23	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
24	Bagdad	Yavapai, Ariz	Bagdad Copper Corp	Copper ore, copper precipitates.
25	Copperhill	Polk, Tenn	Tennessee Copper Co	Copper-zinc ore.

Table 7.—Mine production of recoverable copper in 1970, by method of treatment

Method of treatment	Ore treated (thousand short tons)	Recoverable copper: Thousand pounds	Recoverable copper: Percent yield	Remarks
Copper ore:				
By concentration	235,586	2,838,678	0.60	See table 9.
By smelting	542	38,055	3.51	See table 10.
By leaching	21,601	[1] 148,288	.34	See table 11.
	257,729	3,025,021	.59	
Dump and in-place leaching	---------	343,935	----	See table 11.
Miscellaneous from residues, tailings, and noncopper ores	---------	70,358	----	-----------
Total	XX	3,439,314	XX	-----------

XX Not applicable.
[1] Includes 70,254,000 pounds of electrowon copper.

Table 8.—Copper ore shipped directly to smelters or concentrated in the United States by States with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand short tons)	Copper: Thousand pounds	Copper: Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per ton of ore
Arizona	134,968	1,582,065	0.59	107,292	7,130,261	$0.12
Idaho	2	176	4.40	27	2,378	2.60
Michigan	7,638	135,087	.88	---------	891,579	.21
Montana	18,720	205,465	.55	19,438	3,583,016	.38
Nevada	14,183	167,563	.59	69,188	660,757	.26
New Mexico	18,592	269,246	.72	8,409	606,892	.07
Tennessee [1]	1,680	31,071	.92	124	94,770	.10
Utah	40,148	480,869	.60	347,548	2,735,671	.44
Other States	197	5,191	1.32	112	23,294	.23
Total	236,128	2,876,733	.61	552,138	15,728,618	.20

[1] Copper-zinc ore.

Table 9.—Copper ore concentrated [1] in the United States, by States in 1970, with content in terms of recoverable copper

State	Ore concentrated (thousand short tons)	Recoverable copper content: Thousand pounds	Recoverable copper content: Percent
Arizona	134,618	1,564,527	0.58
Michigan	7,638	135,087	.88
Montana	18,720	205,464	.55
Nevada	14,061	147,456	.52
New Mexico	18,525	269,102	.73
Tennessee [2]	1,680	31,071	.92
Utah	40,148	480,784	.60
Other States	196	5,187	1.32
Total	235,586	2,838,678	.60

[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 States in 1970, with content in terms of recoverable copper

State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Recoverable copper content: Percent
Arizona	350,305	17,537,600	2.50
Idaho	1,601	176,300	5.50
Montana	14	800	2.86
Nevada	121,745	20,106,800	8.26
New Mexico	67,134	144,500	[1] .11
Utah	647	85,500	6.61
Other States	73	3,600	2.46
Total	541,519	38,055,100	3.51

[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 States in 1970, 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	87,856	132,440,100	15,272,753	[1] 112,228,600	0.37
Montana	21,516	35,111,100			
Nevada	7,842	12,159,500	----	----	----
New Mexico	40,321	59,993,900	[2] 6,327,936	[2] 36,059,800	.28
Utah	62,488	104,230,600	(2)	(2)	----
			(2)	(2)	----
Total	220,023	343,935,200	21,600,689	148,288,400	.34

[1] Includes 70,254,000 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
1966	549	2.34	[2] 186,417	0.66	186,966	0.67	0.0029	0.071	$0.19
1967	303	2.52	[2] 126,763	.63	127,066	.63	.0025	.066	.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	.59	.0023	.067	.20

[1] Includes some ore classed as copper-zinc and minor amount of tailings; 1969 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
1966	1,429,863	36,573	114,671	1,581,107
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

Table 14.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1966	1967	1968	1969	1970
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,213,918	754,175	1,013,246	1,296,749	1,359,751
Lake	69,126	54,004	78,304	76,417	66,091
Casting	70,043	38,372	69,375	95,723	95,341
Total	1,353,087	846,551	1,160,925	1,468,889	1,521,183
From foreign ores, etc.:[1]					
Electrolytic	321,302	258,473	219,726	225,714	215,088
Casting and best select	36,595	27,958	56,735	48,212	28,823
Total refinery production of primary copper	1,710,984	1,132,982	1,437,386	1,742,815	1,765,094
SECONDARY					
Electrolytic[2]	409,986	318,709	327,549	410,749	433,394
Casting	27,977	24,568	15,869	2,094	17,623
Total secondary	437,963	343,277	343,418	412,843	451,017
Grand total	2,148,947	1,476,259	1,780,804	2,155,658	2,216,111

[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

	1969		1970	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	209	10	171	8
Cakes	131	6	114	5
Cathodes	234	11	265	12
Ingots and ingot bars	255	12	225	10
Wire bars	1,300	60	1,407	63
Other forms	27	1	34	2
Total	2,156	100	2,216	100

Table 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31[1]
	Quantity	Copper content		
1966	51,676	12,919	51,816	4,464
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

[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
1966	469,728	983,118	1,452,846
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	1,086,207	1,833,991

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter in 1966–68. 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)

	1966	1967	1968	1969	1970
Copper recovered as unalloyed copper	509,084	423,054	433,041	514,593	521,137
Copper recovered in alloys [1]	825,165	736,853	785,299	860,900	726,465
Total secondary copper	1,334,249	1,159,907	1,218,340	1,375,493	1,247,602
Source:					
New scrap	799,389	677,248	697,568	800,603	743,531
Old scrap	534,860	482,659	520,772	574,890	504,071
Percentage equivalent of domestic mine output	93	122	101	89	73

[1] Includes copper in chemicals, as follows: 1966—6,043; 1967—4,965; 1968—4,757; 1969—3,824; and 1970—2,525.

Table 19.—Copper recovered from scrap processed in the United States by kinds of scrap and form of recovery

(Short tons)

Kind of scrap	1969	1970	Form of recovery	1969	1970
New scrap:			As unalloyed copper:		
Copper-base	787,727	732,055	At primary plants	412,843	451,017
Aluminum-base	12,595	11,335	At other plants	101,750	70,120
Nickel-base	265	126			
Zinc-base	16	15	Total	514,593	521,137
Total	800,603	743,531	In brass and bronze	820,945	695,488
			In alloy iron and steel	2,570	2,803
Old scrap:			In aluminum alloys	32,826	25,516
Copper-base	568,769	498,765	In other alloys	735	133
Aluminum-base	4,973	4,475	In chemical compounds	3,824	2,525
Nickel-base	1,103	792			
Tin-base	15	11	Total	860,900	726,465
Zinc-base	30	28			
			Grand total	1,375,493	1,247,602
Total	574,890	504,071			
Grand total	1,375,493	1,247,602			

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	
	1969	1970	1969	1970	1969	1970
Secondary smelters	72,515	52,770	277,240	214,459	349,755	267,229
Primary copper producers	215,561	233,674	197,282	217,343	412,843	451,017
Brass mills	480,093	433,202	38,541	16,894	518,634	450,096
Foundries and manufacturers	18,687	11,760	52,856	48,195	71,543	59,955
Chemical plants	871	649	2,850	1,874	3,721	2,523
Total	787,727	732,055	568,769	498,765	1,356,496	1,230,820

Table 21.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1969	1970
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	412,843	451,017
Refined copper by secondary smelters	86,279	60,592
Copper powder	14,545	9,399
Copper castings	926	129
Total	514,593	521,137
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronze	19,225	11,659
Leaded tin bronze	17,525	11,076
Leaded red brass and semired brass	177,323	151,852
High-leaded tin bronze	35,257	29,139
Leaded yellow brass	23,627	14,814
Manganese bronze	16,866	10,890
Aluminum bronze	11,367	7,250
Nickel silver	3,804	3,725
Low brass	1,255	914
Silicon and conductor bronze	7,754	4,372
Copper-base hardeners and special alloys	12,208	10,280
Total	326,211	255,971
Brass-mill products	683,676	587,886
Brass and bronze castings	52,154	52,089
Brass powder	1,106	1,764
Copper in chemical products	3,824	2,525
Grand total	1,581,564	1,421,372

Table 22.—Composition of secondary copper-alloy production

(Short tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production: [1]							
1969	256,605	14,084	20,129	34,451	876	66	326,211
1970	201,258	11,189	16,111	26,733	616	64	255,971
Secondary metal content of brass-mill products:							
1969	518,401	739	4,650	156,550	3,321	15	683,676
1970	450,758	477	3,192	128,757	4,644	58	587,886
Secondary metal content of brass and bronze castings:							
1969	41,601	1,837	5,236	3,398	15	67	52,154
1970	41,290	1,953	5,583	3,198	10	55	52,089

[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 1970

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
SECONDARY SMELTERS						
No. 1 wire and heavy copper	2,646	22,067	4,455	18,034	22,489	2,224
No. 2 wire, mixed heavy and light copper	3,306	74,600	10,401	65,801	76,202	1,704
Composition or red brass	3,937	77,794	19,361	59,113	78,474	3,257
Railroad-car boxes	165	2,202	--------	2,107	2,107	260
Yellow brass	7,033	56,450	7,342	51,388	58,730	4,753
Cartridge cases and brass	105	329	--------	358	358	76
Auto radiators (unsweated)	2,562	48,295	--------	49,359	49,359	1,498
Bronze	2,550	28,011	4,615	23,073	27,688	2,873
Nickel silver	566	4,099	727	3,307	4,034	631
Low brass	536	4,911	3,558	977	4,535	912
Aluminum bronze	159	464	269	209	478	145
Low-grade scrap and residues	6,009	46,030	37,536	7,589	45,125	6,914
Total	29,574	365,252	88,264	281,315	369,579	25,247
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	1,969	147,965	76,030	68,147	144,177	5,757
No. 2 wire, mixed heavy and light copper	23,224	227,535	153,942	71,346	225,288	25,471
Refinery brass	398	6,814	5,415	1,125	6,540	672
Low-grade scrap and residues	29,178	342,468	50,591	278,877	329,468	42,178
Total	54,769	724,782	285,978	419,495	705,473	74,078
BRASS MILLS [1]						
No. 1 wire and heavy copper	8,567	117,567	106,167	11,400	117,567	9,209
No. 2 wire, mixed heavy and light copper	2,005	35,234	34,318	916	35,234	3,639
Yellow brass	25,382	256,618	256,618	--------	256,618	25,208
Cartridge cases and brass	8,650	116,443	109,646	6,797	116,443	11,483
Bronze	784	5,937	5,937	--------	5,937	812
Nickel silver	3,212	18,884	18,884	--------	18,884	2,932
Low brass	3,747	44,440	44,440	--------	44,440	4,568
Aluminum bronze	98	600	600	--------	600	94
Mixed alloy scrap	1,340	1,340	1,340	--------	1,340	--------
Total [1]	53,785	597,063	577,950	19,113	597,063	57,945
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	2,384	20,241	6,072	14,516	20,588	2,037
No. 2 wire, mixed heavy and light copper	1,438	9,561	2,612	6,964	9,576	1,423
Composition or red brass	565	5,904	1,554	4,235	5,789	680
Railroad-car boxes	501	25,847	--------	25,966	25,966	382
Yellow brass	643	5,895	2,701	3,082	5,783	755
Auto radiators (unsweated)	812	7,133	--------	7,354	7,354	591
Bronze	267	859	399	498	897	229
Nickel silver	8	26	24	7	31	3
Low brass	19	434	226	197	423	30
Aluminum bronze	68	378	257	148	405	41
Low-grade scrap and residues	462	830	313	416	729	563
Total	7,167	77,108	[2] 14,158	[2] 63,383	[2] 77,541	6,734
GRAND TOTAL						
No. 1 wire and heavy copper	15,566	307,840	192,724	112,097	304,821	19,227
No. 2 wire, mixed heavy and light copper	29,973	346,930	201,273	145,027	346,300	32,237
Composition or red brass	4,502	83,698	20,915	63,348	84,263	3,937
Railroad-car boxes	666	28,049	--------	28,073	28,073	642
Yellow brass	33,058	318,963	266,661	54,470	321,131	30,716
Cartridge cases and brass	8,755	116,772	109,646	7,155	116,801	11,559
Auto radiators (unsweated)	3,374	55,428	--------	56,713	56,713	2,089
Bronze	3,601	34,807	10,951	23,571	34,522	3,914
Nickel silver	3,786	23,009	19,635	3,314	22,949	3,566
Low brass	4,302	49,785	48,224	1,174	49,398	5,510
Aluminum bronze	325	1,442	1,126	357	1,483	280
Low-grade scrap and residues [3]	36,047	396,142	93,855	288,007	381,862	50,327
Mixed alloy scrap	1,340	1,340	1,340	--------	1,340	--------
Total	145,295	1,764,205	966,350	783,306	1,749,656	164,004

[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, 680 tons of new and 1,948 old; copper-base alloy scrap 66 tons of old.
[3] Includes stocks of refinery brass.

Table 24.—Consumption of copper and brass materials in the United States, by principal consuming groups

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1969:						
Copper scrap	620,966	694,950	---------	93,511	481,878	1,891,305
Refined copper [1]	---------	797,126	1,296,316	41,818	6,958	2,142,218
Brass ingot	---------	6,532	---------	[2] 330,019	---------	336,551
Slab zinc	---------	160,718	---------	2,915	15,836	179,469
Miscellaneous	---------	---------	---------	150	---------	150
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

[1] Detailed information on consumption of refined copper will be found in table 28.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries.

Table 25.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

	1966	1967	1968	1969	1970
Tin bronze	11,174	10,691	11,745	11,954	10,400
Leaded tin bronze	31,699	28,048	30,013	31,818	37,074
Leaded red brass	174,270	145,579	149,139	155,895	128,798
High-leaded tin bronze	23,595	20,928	20,021	20,278	79,960 (combined)
Leaded yellow brass	17,349	15,866	25,428	28,685	
Manganese bronze	10,331	10,254	10,274	10,680	9,749
Hardeners	4,035	4,096	3,822	4,315	5,196
Nickel silver	3,577	4,094	3,870	4,041	3,265
Aluminum bronze	8,361	7,953	10,202	8,498	7,903
Low brass	3,575	2,761	3,611	4,313	4,796
Total	287,966	250,270	268,125	280,477	287,141

Table 20.—Foundry consumption of brass ingot by types, refined copper, and copper scrap, in the United States in 1970, by geographic divisions and States

(Short tons)

Geographic division and State	Tin bronze	Leaded tin bronze	Leaded red brass	High-leaded tin bronze	Leaded yellow brass	Manganese bronze	Hardeners	Nickel silver	Aluminum bronze	Low brass	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:													
Connecticut	187	676	4,194	152	1,477	116	10		73	241	7,128	157	879
Massachusetts	891	1,850	2,948	276	123	378	71	490	40	231	7,072	454	209
Maine, New Hampshire, Rhode Island, and Vermont	45	124	1,876	96	145	286	6		12	11	2,825	40	11
Total	1,123	2,650	9,018	524	1,745	780	87	490	125	483	17,025	651	1,099
Middle Atlantic:													
New Jersey	517	395	2,198	178	43	186	14	65	84	88	3,768	2,654	1,971
New York	645	4,653	8,853	727	332	661	27	74	854	167	16,993	1,304	4,762
Pennsylvania	1,103	5,092	15,446	2,394	712	983	1,310	498	1,430	592	29,560	6,538	8,518
Total	2,265	10,140	26,497	3,299	1,087	1,830	1,351	637	2,368	847	50,321	10,496	15,251
East North Central:													
Illinois	451	2,837	14,911	552	32	731	214	158	611	570	21,067	2,005	3,803
Indiana	75	2,109	9,794	654	33	306	1,073	340	79	151	14,614	1,290	5,010
Michigan	1,337	12,328	7,428	[1] 61,744	W	1,682	340	7	1,332	1,390	104,409	3,931	1,062
Ohio	1,551		13,120			1,231	284	49	591			4,113	9,380
Wisconsin	644	362	7,127	2,459	7	584	1,346	490	299	554	13,872	7,970	613
Total	4,058	17,631	52,380	[1] 65,481	[2] W	4,534	3,257	1,044	2,912	2,665	153,962	19,309	19,868
West North Central:													
Iowa, Kansas, and Minnesota	153	1,318	3,281	99	75	482	131	12	737	204	5,837	385	1,425
Missouri, Nebraska, and South Dakota	21	217	1,141	687	1,322	177	12	------			4,232	751	9,089
Total	174	1,535	4,422	786	1,397	659	143	12	737	204	10,069	1,136	10,514
South Atlantic:													
Delaware, District of Columbia, Florida, Georgia, and Maryland	573	80	997	-------	113	91	77	446	71	24	2,397	181	371
North Carolina, South Carolina, Virginia, and West Virginia	216	3,071	5,325	367	336	166		------	368	19	9,943	1,800	4,483
Total	789	3,151	6,322	367	449	257	77	446	439	43	12,340	1,981	4,854
East South Central:													
Alabama, Kentucky, Mississippi, and Tennessee	284	483	9,010	1,007	696	680	25	164	49	372	12,770	49	6,685
West South Central:													
Arkansas, Louisiana, Oklahoma, and Texas	1,128	561	9,453	332	1,047	305	17	417	883	44	14,187	670	2,353
Mountain:													
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah	114	82	245	10	1	142	2	2	23	49	670	190	589
Pacific:													
California	436	737	11,231	105	1,503	431	237	53	218	87	15,038	215	11,736
Oregon and Washington	29	104	220	69	55	131	------	------	149	2	759		1,898
Total	465	841	11,451	174	1,558	562	237	53	367	89	15,797	215	13,634
Grand Total	10,400	37,074	128,798	[1] 79,960	[2] W	9,749	5,196	3,265	7,903	4,796	287,141	34,697	74,847

W Withheld to avoid disclosing individual company confidential data.
[1] Total includes leaded yellow brass.
[2] Total includes high leaded tin bronze.

Table 27.—Primary refined copper supply and withdrawals on domestic account

(Short tons)

	1966	1967	1968	1969	1970
Production from domestic and foreign ores, etc	1,710,984	1,132,982	1,437,386	1,742,815	1,765,094
Imports [1]	r 164,328	r 330,571	400,278	131,171	132,143
Stocks Jan. 1 [1]	35,000	43,000	27,000	48,000	39,000
Total available supply	r 1,910,312	r 1,506,553	1,864,664	1,921,986	1,936,237
Copper exports [1]	273,071	159,353	240,745	200,269	221,211
Stocks Dec. 31 [1]	43,000	27,000	48,000	39,000	130,000
Total	316,071	186,353	288,745	239,269	351,211
Apparent withdrawals on domestic account [2]	r 1,594,000	1,320,000	1,576,000	1,683,000	1,585,000

r Revised.
[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the Government stockpiles.

Table 28.—Refined copper consumed, by class of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1969:							
Wire mills	50,631	1,237,939	W	W	-------	7,746	1,296,316
Brass mills	183,644	31,847	152,529	172,264	256,714	128	797,126
Chemical plants	-------	---------	471	-------	-------	2,624	3,095
Secondary smelters	3,866	---------	3,025	-------	-------	67	6,958
Foundries	1,434	224	13,134	12	117	1,280	16,201
Miscellaneous [1]	1,574	790	10,643	226	1,542	7,747	22,522
Total	241,149	1,270,800	179,802	172,502	258,373	19,592	2,142,218
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

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]
1966	43	270
1967	27	220
1968	48	272
1969	39	291
1970	130	340

[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)
1966	558,599	134,732	407,345	361,559	−75,573
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

[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 1970

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	46.69	46.72	49.69	52.27	47.68	41.00
No. 1 composition scrap	40.69	40.33	43.19	45.86	42.78	36.09
No. 1 composition ingot	58.00	58.00	59.36	61.97	63.25	61.00
	July	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Average**
No. 2 copper scrap	38.02	35.93	33.38	30.61	26.75	24.68	39.45
No. 1 composition scrap	34.11	33.41	32.21	30.43	28.50	27.59	36.27
No. 1 composition ingot	57.46	53.56	51.00	51.00	51.00	50.61	56.35

Source: Metal Statistics, 1971.

Table 32.—Average weighted prices of copper deliveries [1]

(Cents per pound)

Year	Domestic copper	Foreign copper
1966	36.6	50.5
1967	38.6	48.2
1968	42.2	51.4
1969	47.9	63.2
1970	58.2	64.1

[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	1969			1970		
	Domestic delivered		London spot [1]	Domestic delivered		London spot [1]
	American Metal Market	Metals Week	Metals Week	American Metal Market	Metals Week	Metals Week
January	43.03	43.90	56.61	55.92	56.25	72.57
February	44.12	44.23	58.04	56.12	56.50	74.09
March	44.12	44.79	57.75	56.12	56.50	78.45
April	44.12	44.95	62.74	59.74	59.80	77.56
May	45.50	45.89	62.74	60.12	60.20	71.45
June	46.12	46.42	66.88	60.12	60.20	64.98
July	46.12	46.45	65.64	60.12	60.10	60.60
August	48.03	48.32	72.38	60.12	60.10	56.23
September	51.55	51.76	71.11	60.12	60.10	55.30
October	52.12	52.48	70.19	59.03	59.00	50.71
November	52.12	52.52	73.84	56.12	56.10	48.22
December	52.12	52.89	76.96	53.12	53.10	46.46
Average	47.43	47.93	66.24	58.07	58.20	62.96

[1] Based on average monthly rates of exchange by Federal Reserve Board.

Table 34.—U.S. exports of copper by classes and countries

Year and country	Ore, concentrates, and matte (copper content)		Refined		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	1,177	$1,195	200,269	$228,072	7,592	$6,793
1970:						
Africa	----------	----------	61	83	3	3
Argentina	----------	----------	693	871	----------	----------
Belgium-Luxembourg	331	449	4,262	5,476	4,004	3,204
Brazil	----------	----------	24,688	33,487	154	139
Canada	1,933	1,912	12,968	15,226	1,301	1,052
Chile	----------	----------	(1)	(1)	----------	----------
Colombia	----------	----------	1	1	----------	----------
France	----------	----------	18,621	26,388	26	21
Germany, West	7,056	8,493	20,113	25,741	4,242	4,045
India	----------	----------	14,687	19,316	239	257
Italy	20	13	39,067	52,995	861	692
Japan	45,364	39,411	9,295	11,180	2,133	2,069
Korea, Republic of	----------	----------	4,497	6,639	----------	----------
Mexico	2,613	2,820	29	41	17	14
Netherlands	33	46	20,529	29,848	86	94
Oceania	----------	----------	99	160	----------	----------
Peru	----------	----------	2	2	----------	----------
Philippines	----------	----------	1,810	2,133	----------	----------
Spain	2,169	2,876	2,732	3,486	496	557
Sweden	2,019	2,346	1,954	2,869	26	24
Switzerland	----------	----------	2,431	3,476	22	17
Taiwan	----------	----------	1,122	1,526	----------	----------
United Kingdom	----------	----------	25,163	34,182	712	626
Yugoslavia	----------	----------	14,593	19,371	1,077	1,319
Other	(1)	(1)	1,794	2,432	1,156	1,095
Total	61,538	58,366	221,211	296,929	16,555	15,228

Year and country	Blister		Pipes and tubing		Plates and sheets	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969	4,340	$3,918	952	$1,925	425	$763
1970:						
Africa	----------	----------	35	99	1	2
Argentina	----------	----------	(1)	1	----------	----------
Belgium-Luxembourg	5,914	5,704	6	13	----------	----------
Brazil	----------	----------	9	26	(1)	1
Canada	3	2	307	591	152	300
Chile	----------	----------	3	10	----------	----------
Colombia	----------	----------	154	343	2	3
France	2	3	128	313	5	15
Germany, West	1,878	1,787	----------	----------	(1)	1
India	----------	----------	56	141	1	1
Italy	2	2	5	15	(1)	1
Japan	----------	----------	12	42	3	7
Korea, Republic of	----------	----------	2	5	1	4
Mexico	----------	----------	25	67	1	2
Netherlands	----------	----------	4	16	(1)	1
Oceania	----------	----------	3	13	1	3
Peru	----------	----------	4	15	----------	----------
Philippines	----------	----------	11	25	----------	----------
Spain	----------	----------	7	26	10	34
Sweden	----------	----------	1	1	5	10
Switzerland	----------	----------	9	22	41	76
Taiwan	----------	----------	8	34	----------	----------
United Kingdom	5	4	110	261	6	10
Yugoslavia	----------	----------	(1)	(1)	98	114
Other	1	1	165	412	31	70
Total	7,805	7,503	1,064	2,491	358	655

See footnotes at end of table.

Table 34.—U.S. exports of copper by classes and countries—Continued

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)
1969	4,696	$6,456	22,980	$59,377	4,602	$6,160
1970:						
Africa	117	198	1,008	2,609	141	244
Argentina	177	258	159	449	29	74
Belgium-Luxembourg	19	21	82	860	48	128
Brazil	244	302	63	257	(1)	2
Canada	485	585	7,495	23,987	987	1,258
Chile	37	64	395	842	8	19
Colombia	24	31	156	433	923	1,306
France	72	96	493	640	171	394
Germany, West	80	185	385	2,601	63	98
India	----------	----------	14	78	3	4
Italy	1	3	209	1,265	75	251
Japan	5	13	222	1,021	35	79
Korea, Republic of	116	184	490	867	9	24
Mexico	109	134	2,929	7,064	9	16
Netherlands	2	5	146	586	3	11
Oceania	40	50	340	1,131	5	9
Peru	16	27	86	178	(1)	1
Philippines	90	110	2,168	3,610	402	397
Spain	3	5	71	236	(1)	(1)
Sweden	40	74	85	500	2	6
Switzerland	91	110	97	373	30	32
Taiwan	3	8	165	768	1	2
United Kingdom	68	111	250	2,101	29	53
Yugoslavia	----------	----------	14	50	203	262
Other	1,143	1,409	6,080	13,821	2,881	3,898
Total	2,982	3,983	23,602	66,327	6,057	8,568

[1] Less than ½ unit.
[2] Does not include wire cloth: 1969, 842,072 square feet ($480,389); 1970, 1,151,648 square feet ($476,767).

Table 35.—U.S. exports of copper by classes

Year	Ore, concentrate, and matte (copper content)		Blister		Refined copper and semimanufactures	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1968	64,990	$46,902	15,749	$11,579	297,992	$308,098
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

Year	Other copper manufactures [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1968	4,669	$5,681	383,400	$372,260
1969	4,602	6,160	247,033	314,659
1970	6,057	8,568	324,617	444,825

[1] Does not include wire cloth: 1969, 842,072 square feet ($480,389); 1970, 1,151,648 square feet ($476,767).

Table 36.—U.S. exports of copper-base alloy (including brass and bronze), by classes

Class	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Ingots	333	$1,030	211	$693
Scrap and waste	78,338	64,517	110,365	89,762
Bars, rods, and shapes	2,078	4,019	3,028	5,645
Plates, sheets, and strips	2,326	7,744	2,276	7,871
Pipes and tubing	1,762	3,317	1,654	3,864
Pipe fittings	3,520	10,699	2,594	8,537
Plumbers' brass goods	1,195	3,142	954	2,785
Welding rods and wire	1,228	2,723	2,016	4,755
Castings and forgings	1,110	1,620	1,684	2,746
Powder and flakes	1,751	2,837	1,502	2,811
Foil	1,162	3,566	1,309	4,544
Articles of copper and copper-base alloys, n.e.c	(1)	5,834	(1)	4,314
Total	94,803	111,048	127,593	138,327

[1] Quantity not reported.

Table 37.—U.S. exports of unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value (thousands)
1968	3,630	$8,472
1969	4,737	12,793
1970	5,515	14,209

[1] Includes brass and bronze.

Table 38.—U.S. exports of copper sulfate

(Blue vitriol)

Year	Short tons	Value (thousands)
1968	927	$718
1969	3,127	2,385
1970	2,485	1,543

Table 39.—U.S. exports of copper scrap, by countries

Country	Unalloyed copper scrap 1969 Short tons	Unalloyed 1969 Value (thousands)	Unalloyed 1970 Short tons	Unalloyed 1970 Value (thousands)	Copper alloy scrap 1969 Short tons	Alloy 1969 Value (thousands)	Alloy 1970 Short tons	Alloy 1970 Value (thousands)
Austria	-------	-------	-------	-------	692	$524	1,904	$1,361
Belgium-Luxembourg	1,593	$1,293	4,004	$3,204	15,936	12,590	17,154	13,430
Canada	1,834	1,644	1,301	1,052	4,250	3,685	3,688	3,225
France	-------	-------	26	21	43	44	244	200
Germany, West	870	788	4,242	4,045	17,494	16,260	18,751	16,676
India	27	23	239	257	98	91	210	236
Israel	-------	-------	1,134	1,072	362	262	1,991	1,686
Italy	243	177	861	692	7,740	5,576	9,149	6,998
Japan	1,204	1,068	2,133	2,069	24,702	19,131	45,309	36,232
Mexico	22	19	17	14	253	283	729	735
Netherlands	71	86	86	94	719	890	876	881
Spain	479	406	496	557	2,833	2,656	3,240	2,907
Sweden	20	27	26	24	1,931	1,319	3,322	1,968
United Kingdom	82	83	712	626	547	506	2,051	1,643
Yugoslavia	1,083	1,110	1,077	1,319	93	119	188	181
Other	64	69	201	182	645	583	1,559	1,402
Total	7,592	6,793	16,555	15,228	78,338	64,519	110,365	89,761

Table 40.—U.S. imports for consumption of copper scrap, by countries

Country	Unalloyed copper scrap (copper content)			
	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Bahamas	28	$20	36	$17
Canada	r 3,260	r 3,057	472	528
Chile	81	97	95	104
Dominican Republic	104	87	35	31
France	7	9	-----	-----
Germany, West	2	3	7	13
Guatemala	8	7	47	36
Honduras	65	64	85	87
Japan	6	7	-----	-----
Mexico	r 1,953	r 1,644	1,345	1,025
Netherlands	1	2	4	8
Panama	20	18	5	5
Spain	-----	-----	73	57
United Kingdom	r 45	r 67	82	117
Other	112	101	22	16
Total	r 5,692	r 5,183	2,308	2,044

Country	Copper alloy scrap					
	1969			1970		
	Gross weight (short tons)	Copper content (short tons)	Value (thousands)	Gross weight (short tons)	Copper content (short tons)	Value (thousands)
Bahamas	25	20	$16	36	24	$33
Canada	2,346	1,493	1,685	1,978	1,292	1,555
Dominican Republic	109	81	65	43	31	26
Guatemala	10	8	7	120	103	86
Mexico	421	385	296	303	225	188
Panama	33	22	21	21	14	14
United Kingdom	27	9	5	------	------	------
Other	23	17	14	27	22	23
Total	2,994	2,035	2,109	2,528	1,711	1,925

r Revised.

Table 41.—U.S. imports [1] of copper (unmanufactured), by classes and countries

(Short tons, copper content, and thousand dollars)

Year and country	Ore, concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1968	27,050	$26,280	509	$490	270,718	$227,814
1969:						
Australia	1,662	1,534	--------	--------	558	599
Canada	8,862	8,523	319	414	71	72
Chile	--------	--------	--------	--------	100,768	82,980
Mexico	89	80	--------	--------	2,816	2,990
Peru	9,664	12,003	--------	--------	107,385	120,367
Philippines	18,267	23,807	2	2	--------	--------
South Africa, Republic of	--------	--------	--------	--------	25,160	21,184
Other	180	128	3	3	1,191	1,673
Total	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
Japan	6	2	--------	--------	--------	--------
Mexico	135	88	--------	--------	2,504	3,011
Mozambique	--------	--------	--------	--------	--------	--------
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	53	89	5	9
Total	32,741	40,394	1,100	1,389	224,416	245,903

Year and country	Refined		Scrap		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1968	400,278	$435,257	11,420	$11,952	709,975	$701,793
1969:						
Australia	5,601	6,062	(2)	(2)	7,821	8,195
Belgium-Luxembourg	473	634	22	22	495	656
Canada	84,941	80,781	r 3,260	r 3,057	r 97,453	r 92,847
Chile	21,470	19,980	81	97	122,319	103,057
Germany, West	2,574	3,619	2	3	2,576	3,622
Mexico	248	333	r 1,953	r 1,644	r 5,106	r 5,047
Netherlands	222	320	1	2	223	322
Peru	4,372	5,658	--------	--------	121,421	138,028
Philippines	--------	--------	--------	--------	18,269	23,809
South Africa, Republic of	--------	--------	--------	--------	25,160	21,184
United Kingdom	3,950	5,217	r 45	r 67	r 3,995	r 5,284
Yugoslavia	1,663	2,145	--------	--------	1,663	2,145
Zambia	999	1,339	--------	--------	999	1,339
Other	4,658	6,485	r 328	r 291	r 6,360	r 8,580
Total	131,171	132,573	r 5,692	r 5,183	r 413,860	r 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
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
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	117	145	234	209	629	506
Total	132,143	146,093	2,080	1,841	392,480	435,620

r Revised.
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 classes

(Short tons and thousand dollars)

Year	Ore and concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1968	71,884	$66,291	8	$4	274,180	$224,013
1969	3,588	3,274	6	17	241,712	233,265
1970	64,540	77,367	247	346	224,289	245,778

Year	Refined		Scrap		Total value
	Quantity	Value	Quantity	Value	
1968	403,630	$438,608	11,571	$12,117	$741,033
1969	131,171	132,573	r 5,692	r 5,183	r 374,312
1970	132,143	146,093	2,308	2,044	471,628

r Revised.

Table 43.—Copper: World mine production, by countries [1]

(Short tons)

Country	1968	1969	1970 p
North and Central America:			
Canada [2]	r 633,312	573,244	676,006
Cuba e	5,500	3,300	3,300
Dominican Republic	r 117	526	468
Haiti	r 1,761	1,981	1,870
Mexico	67,362	72,934	68,361
Nicaragua	12,695	4,583	3,705
United States [2]	1,204,621	1,544,579	1,719,657
South America:			
Argentina	r 463	503	e 510
Bolivia [3]	7,861	8,800	9,655
Brazil e	r 3,000	r 4,500	4,870
Chile	734,870	770,593	755,700
Colombia	---------	8	220
Ecuador	614	588	e 600
Peru	234,282	219,143	233,751
Europe:			
Albania [4]	5,986	5,756	6,160
Austria	r 2,278	2,589	2,493
Bulgaria	r 41,100	43,300	e 44,000
Czechoslovakia	r 5,148	5,423	e 5,500
Finland	r 33,129	36,525	34,333
France	431	429	384
Germany, East e	r 21,000	21,000	22,000
Germany, West	1,475	1,592	1,404
Ireland	r 7,470	6,801	9,184
Italy	r 2,535	2,436	2,524
Norway [5]	18,492	23,307	21,988
Poland e	r 29,300	53,200	79,000
Portugal [5]	4,984	4,491	5,532
Romania e [2]	5,500	5,500	6,600
Spain [5] [6]	r 9,221	11,626	10,067
Sweden	20,076	27,723	25,500
U.S.S.R. e	r 570,000	r 610,000	630,000
Yugoslavia	r 77,699	90,032	100,099
Africa:			
Algeria	870	599	636
Angola	---------	222	13
Congo (Brazzaville)	863	12	---------
Congo (Kinshasa)	357,700	393,421	425,138
Kenya	42	85	87
Morocco	r 3,359	2,507	3,167
Mozambique	---------	---------	143
Rhodesia, Southern e	r 21,500	21,000	22,500
South Africa, Republic of	r 141,351	139,096	164,469
South-West Africa, Territory of [2] [7]	r 34,691	30,450	29,406
Uganda	r 20,841	21,428	21,119
Zambia	r 732,911	824,658	[4] 753,968
Asia:			
Burma e	44	44	44
China, mainland e	r 100,000	r 110,000	110,000
Cyprus [5]	r 18,780	18,996	20,019
India	r 10,221	11,373	11,312
Iran [8]	r 679	568	796
Israel e	r 11,334	11,776	12,112
Japan [5]	132,202	133,516	136,851
Korea, North e	r 13,000	r 13,000	14,000
Korea, Republic of	r 1,324	1,466	1,807
Philippines	121,557	144,872	160,303
Taiwan e	r 2,500	2,500	2,700
Turkey	r 31,772	29,072	30,010
Oceania:			
Australia	r 120,390	144,776	160,551
Fiji	653	472	---------
New Zealand	55	77	51
Total	r 5,640,921	6,212,998	6,566,643

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] COMIBOL production plus exports by medium and small mines.

[4] Smelter production.

[5] Includes copper content of cupriferous pyrites.

[6] Excludes an unreported quantity of copper in iron pyrites which may or may not be recovered.

[7] Output of Tsumeb Corporation Ltd. only for years ending June 30 of that stated.

[8] Year beginning March 21 of that stated.

Table 44.—Copper: World smelter production, by countries [1]

(Short tons)

Country	1968	1969	1970 p
North America:			
Canada	r 524,424	449,232	543,070
Mexico	r 61,532	63,264	65,360
United States [2]	r 1,266,478	1,585,491	1,641,338
South America:			
Brazil [3]	3,850	3,583	e 4,200
Chile [4]	691,646	729,496	713,415
Peru	r 205,167	186,034	194,406
Europe:			
Albania	5,986	5,756	6,160
Austria [3]	19,862	21,204	24,806
Belgium e [5]	11,000	11,000	11,000
Bulgaria	r 42,100	42,000	46,000
Czechoslovakia	r 15,525	18,123	e 19,000
Finland	39,567	37,343	37,530
Germany, East e	r 21,000	r 21,000	22,000
Germany, West [6]	r 105,500	102,400	93,000
Hungary [3]	12,600	12,000	6,917
Norway [7]	25,995	30,743	35,375
Poland	r 48,100	60,300	79,600
Romania e	5,500	5,500	6,600
Spain	r 50,460	41,469	43,899
Sweden	51,458	57,054	56,440
U.S.S.R. e	r 570,000	r 610,000	630,000
Yugoslavia	r 80,347	102,095	116,736
Africa:			
Congo (Kinshasa)	r 359,904	400,974	424,988
Rhodesia, Southern e	19,000	21,000	22,000
South Africa, Republic of	r 150,700	140,300	151,300
South-West Africa, Territory of [8]	35,706	30,297	31,519
Uganda	17,192	18,259	18,693
Zambia	r 733,153	823,959	753,968
Asia:			
China, mainland	110,000	110,000	110,000
India	10,236	10,749	10,264
Japan [3]	604,513	693,524	777,407
Korea, North e	13,000	13,000	14,000
Korea, Republic of	5,022	6,856	5,600
Taiwan	2,802	3,576	4,136
Turkey	r 27,949	25,904	20,894
Oceania: Australia	r 103,548	128,071	122,326
Total	r 6,050,822	6,621,556	6,863,947

e Estimate. p Preliminary. r Revised.

[1] Unless otherwise noted, data presented for each country represent the 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] Smelter output from domestic and foreign ores, exclusive of that produced from scrap. Production from domestic ores only was as follows: 1968—1,234,724; 1969—1,547,496; and 1970—1,605,265.

[3] Includes secondary copper (production from scrap).

[4] 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.

[5] 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.

[6] Series revised from that used in previous editions of this chapter. Data presented consist only of blister and anode copper produced from domestic and imported ores and concentrates. Figures in previous editions were refined metal production including that derived from domestically produced and imported blister and from domestic and imported scrap.

[7] 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: 1968—6,000; 1969—6,400; and 1970—6,300.

[8] Year ending June 30 of that stated.

Table 45.—Chile: Exports of copper, by principal types

(Short tons, copper content)

Destination	1969 Refined Electrolytic	1969 Refined Fire refined	1969 Blister	1969 Total	1970 p Refined Electrolytic	1970 p Refined Fire refined	1970 p Blister	1970 p Total
Argentina	25,700	6,200	-------	31,900	21,900	4,900	-------	26,800
Austria	1,000	-------	-------	1,000	1,200	-------	-------	1,200
Belgium	10,600	1,300	1,000	12,900	14,900	1,300	8,300	24,500
Brazil	11,000	500	-------	11,500	10,500	1,600	-------	12,100
Colombia	100	300	-------	400	-------	400	-------	400
Denmark	1,900	-------	-------	1,900	2,100	-------	-------	2,100
Finland	1,700	-------	-------	1,700	2,300	-------	-------	2,300
France	34,900	21,300	-------	56,200	30,500	24,500	-------	55,000
Germany, West	90,500	15,300	27,700	133,500	119,700	18,400	31,300	169,400
Greece	-------	-------	-------	-------	600	-------	-------	600
Italy	48,900	21,100	2,000	72,000	51,400	20,000	2,100	73,500
Japan	24,500	-------	28,600	53,100	19,600	-------	34,100	53,700
Netherlands	1,000	-------	-------	1,000	6,400	-------	-------	6,400
Norway	5,100	-------	-------	5,100	2,500	-------	-------	2,500
Spain	6,600	1,400	4,300	12,300	6,200	1,300	2,900	10,400
Sweden	18,800	9,200	7,800	35,800	17,800	8,500	3,600	29,900
Switzerland	1,900	1,500	-------	3,400	2,100	1,300	-------	3,400
United Kingdom	64,800	18,900	39,900	123,600	59,400	18,100	31,200	108,700
United States	25,900	-------	95,900	121,800	14,400	1,200	96,100	111,700
Other	-------	100	-------	100	-------	-------	-------	-------
Total	374,900	97,100	207,200	679,200	383,500	101,500	209,600	694,600

p Preliminary.
Source: Corporación del Cobre de Chile.

Table 46.—Peru: Copper production

(Short tons)

	Blister	Refined	Other	Total
1968	r 162,727	42,439	r 29,116	234,282
1969	147,628	37,991	33,524	219,143
1970 p	154,526	39,879	39,346	233,751

r Revised. p Preliminary.

Table 47.—Canada: Copper production (all sources) by Provinces [1]

(Short tons)

Province	1969	1970 p
British Columbia	83,708	109,647
Manitoba	37,097	51,446
New Brunswick	6,791	7,933
Newfoundland	20,464	15,411
Northwest Territories	626	543
Nova Scotia	19	27
Ontario	238,810	291,909
Quebec	160,068	173,534
Saskatchewan	18,230	15,548
Yukon Territories	7,433	7,750
Total	573,246	673,748

p Preliminary.
[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. 1970.

Diatomite

By Benjamin Petkof [1]

Domestic production of diatomite continued strong in 1970 with output only slightly under that of the previous year. The United States retained its position as a major world producer with all production from the Western States. A significant portion of domestic output was exported to nations throughout the world.

DOMESTIC PRODUCTION

Production of diatomite increased in all the Western producing States except California, where a slight decline was noted. However, California remained the largest producing State, followed by Nevada, Washington, Arizona and Oregon.

During the year, nine companies operating 11 plants produced and prepared diatomite for various end uses. This was a decline of three producing companies from the number reported in 1969. Johns-Manville Corp., with facilities near Lompoc, Calif.; GREFCO, Inc., with operations in Esmeralda County, Nev. and Santa Barbara County, Calif.; and Eagle-Picher, Industries, Inc., with operations in Pershing and Storey Counties, Nev. supplied the bulk of the diatomite produced during the year.

The Kenite Corp., Scarsdale, N.Y., which has large reserves of diatomite in Grant County, Wash, and a modern processing plant at Quincy, Wash., was sold to Whitco Chemical Corp., N.Y., during the first half of the year. The Kenite Corp. will continue operations as a wholly owned subsidiary of Whitco Chemical Corp.

Table 1.—Diatomite sold or used by producers in the United States

	1960–62 [1]	1963–65 [1]	1966–68 [1]	1969	1970
Domestic production (sales) short tons	1,446,625	1,740,833	1,881,877	598,482	597,636
Average value per ton	$50.08	$50.40	$54.18	$60.96	$54.63

[1] Annual figures before 1969 are confidential.

CONSUMPTION AND USES

The percentage of total consumption for various end uses changed only slightly from 1969. Filtration continued to be the major use and required almost three-fifths of the total material sold or used by producers in 1970. The quantity used for this purpose increased only slightly from that of 1969. Almost one-fifth of total production was used as industrial filler by the chemical industry. The quantity used for this purpose declined slightly from that of 1969. The remainder was used for insulation, lightweight aggregates, pozzolans, soil conditioner, and other miscellaneous uses.

Table 2.—Domestic consumption of diatomite, by principal uses

(Percent of total consumption)

Use	1966	1967	1968	1969	1970
Filtration	46	48	55	58	58
Fillers	20	18	21	20	19
Insulation	5	4	4	4	4
Miscellaneous	29	30	20	18	19

[1] Physical scientist, Division of Nonmetallic Minerals.

PRICES

Prices of diatomite in 1970 varied significantly from those of 1969. Price declines in excess of 10 percent were noted for uses such as filtration, fillers, and abrasives. Uses such as lightweight aggregate and insulation showed small increases in price. These price variations may be indicative of changing end-use patterns and possible use of substitute materials.

Table 3.—Average annual value per ton of diatomite, by uses

Use	1969	1970
Filtration	$70.14	$61.67
Insulation	46.12	47.84
Abrasives	134.19	119.19
Fillers	61.26	53.26
Lightweight aggregate	39.30	42.08
Miscellaneous	33.16	33.58
Weighted average	60.96	54.63

FOREIGN TRADE

Exports of prepared diatomite in 1970 declined almost 13 percent in quantity and 8 percent in value from those of 1969. Canada received about one-fifth of U.S. exports. The remainder was exported to many other industrial and nonindustrial countries. The average value of exported material was $80.28 per ton. Imports of crude or processed diatomite totaled 484 tons valued at $6,082. Canada and West Germany were the major sources of these imports. The imported material was probably used to evaluate foreign sources of diatomite.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1968	164	$11,993
1969	176	13,510
1970	154	12,363

WORLD REVIEW

World diatomite production remained strong in 1970, and varied only slightly from the production of previous years. The United States, the U.S.S.R., France, Italy, and West Germany continued as major world producers.

Canada.—Since 1955, all Canadian production has come from the Quesnel area in central British Columbia. Fairey and Co., Ltd., mines diatomite north of Quesnel and ships the material to a processing plant in Vancouver, where it is used in the manufacture of insulating brick. Crownite Industrial Minerals, Ltd., a subsidiary of Dome Petroleum, Ltd., mines and processes diatomite and pozzolanic shales from deposits west of Quesnel and produces a burnt shale pozzolan that is used as a construction material.

Iceland.—Kisilidjan H.F., a firm formed by the Government of Iceland and Johns-Manville to mine and process diatomite from the bottom of Lake Myvatin, increased its production capacity from an initial 13,000 tons per year to 22,000 tons per year in 1970. Because of the country's climate, material is dredged only during the summer season. Volcanic ash and organic matter are removed before further processing. The processed diatomite is then transported to Europe for sale and consumption.

Table 5.—Diatomite: World production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada	521	487	[e] 480
Costa Rica	[r] 11,000	[e] 17,000	21,000
Mexico	10,961	12,318	[e] 12,000
United States	[2] 627,292	598,482	597,636
South America:			
Argentina	7,217	11,397	[e] 11,000
Peru	[r] 3,331	23,432	[e] 23,000
Europe:			
Austria	3,284	1,946	4,158
Denmark:			
Diatomite [e]	22,000	22,000	22,000
Moler [e]	240,000	240,000	240,000
Finland	2,183	2,006	734
France	[r] 188,109	[e] 187,000	[e] 190,000
Germany, West (marketable)	[r] 101,249	[e] 125,302	100,924
Iceland	3,031	8,378	14,593
Italy	[r] 63,426	65,848	[e] 66,000
Portugal	3,871	3,124	3,394
Spain [e]	20,000	20,000	20,000
Sweden	[r] 3,803	[e] 3,850	[e] 3,850
U.S.S.R. [e]	400,000	400,000	410,000
United Kingdom	[r] 16,465	[e] 17,000	[e] 17,000
Africa:			
Algeria	23,553	11,624	[e] 12,000
Kenya	2,265	2,538	1,765
South Africa, Republic of	[r] 687	567	935
United Arab Republic	1,346	992	[e] 1,000
Asia: Korea, Republic of	2,441	3,214	2,848
Oceania:			
Australia	[r] 7,532	3,752	[e] 4,000
New Zealand	2,277	2,384	[e] 2,400
Total	[r] 1,767,844	1,784,641	1,782,717

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Brazil, Bulgaria, Colombia, Hungary, Japan, Mozambique, Romania, and Yugoslavia produce diatomite, but available information is insufficient to make reliable estimates of output levels.

[2] Average of production for three years (1966–68).

TECHNOLOGY

Experimental laboratory work has shown that coarse grades of diatomite can be coated with absorptive material, such as alum or polyelectrolytes, to filter fine particulate matter which would normally require much finer and more expensive grades of diatomite. Material from many low-grade domestic deposits might be made usable by the application of a suitable absorptive coating. No cost information was furnished.[2]

[2] Burns, D. E., E. R. Baumann, and C. S. Oulmam. Particulate Removal on Coated Filter Media. J. Am. Water Works Assoc., v. 62, No. 2, February 1970, pp. 121–126.

Feldspar, Nepheline Syenite, and Aplite

By J. Robert Wells [1]

FELDSPAR

The year 1970 was notable for the number and variety of activities instituted by citizens' groups, private corporations, and Government agencies to correct the environmental deterioration being engendered by waste products. As the manufacture of container glass has become solidly established as the leading end use for feldspathic materials in the United States, the evolution of practical and publicly acceptable measures for coping with the waste glass problem is of vital concern to the feldspar industry. Research programs by the Bureau of Mines, the Glass Container Manufacturers Institute, Inc., and the Glass Container Division of Owens-Illinois, Inc., endeavored to devise effective and economic procedures for collection and reuse, recycling, or alternate utilization of discarded glass containers. Some of the proposed remedies would channel the bottles into end uses that would not threaten the advantages to the consuming public of the single-trip container, specifically the superior convenience and the hygienic integrity.

DOMESTIC PRODUCTION

Crude Feldspar.—In 1970, feldspar was mined in 11 States, among which North Carolina, California, Connecticut, South Carolina, and Georgia (ranked according to tonnage reported) jointly provided 94 percent of the total domestic output. The 1970 production figure represents a 4-percent decline in tonnage but a 9-percent increase in total value, compared with 1969. The notably higher total value was attributed to marked unit-value increases in three producing States that, aided by lesser gains in several others, more than cancelled two moderate declines.

Ground Feldspar.—Feldspar was ground for market in 1970 in 15 mills located in eight States, among which North Carolina, the leading producer, was followed in order by Connecticut, California, and South Carolina. Taken together, these four States contributed about 88 percent of the national total. The ground product was distributed to about 30 States and four foreign countries.

The year 1970 was marked by a number of noteworthy changes in the feldspar industry. The Feldspar Corp., the largest domestic producer, completed and placed in operation a $1 million addition to an existing plant at Spruce Pine, N.C. Construction progressed on a new mill at a different location that will increase substantially the feldspar production capacity of International Minerals and Chemical Corp. in that district. Another major feldspar supplier—also in North Carolina—the Kings Mountain Silica Co., Inc., announced the completion of a new grinding plant and storage facilities for its flotation concentrate product at Kings Mountain. In addition to the production of high-potash spar for manufacturing TV-tube glass, the Kings Mountain operations were extended to include the ultrafine grinding of feldspar-silica mixtures for ceramic and filler applications. Discovery of an extensive deposit of good-quality feldspar near Shoshoni, Wyo., established production in that State. A modern grinding mill was built to process the ore, which is said to be abundant and of exceptional purity.

[1] Physical scientist, Division of Nonmetallic Minerals.

Large-scale feldspar production and processing were interrupted in Maine when the Oxford County properties and facilities of Bell Minerals Co.—for many years the State's principal feldspar producer and only grinder—were purchased in September 1970 by the Aldrich Realty Co. of West Paris. Plans were announced for an early resumption of operations by the new management. The West Paris mill of Bell Minerals Co. has long been the processing point also for feldspar from mines in New Hampshire. Presumably as a further consequence of the events in Maine, no feldspar production in New Hampshire was reported in 1970, the first such blank in half a century. In South Dakota, diminishing availability of feldspar for convenient upgrading by hand cobbing led International Minerals and Chemical Corp. to devote greater effort to the production of 140–, 200–, and 325-mesh high-potash spar for ceramic purposes instead of the 20-mesh glass-grade material formerly shipped. The company also began a study to determine the feasibility of installing flotation facilities for processing the feldspar ores in the near future.

Table 1.—Salient feldspar statistics

	1966	1967	1968	1969	1970
United States:					
Crude:					
Sold or used by producers____long tons__	655,452	615,397	667,679	673,985	648,276
Value____thousands__	$7,020	$7,086	$8,265	$8,869	$9,638
Average value per long ton____	$10.71	$11.51	$12.38	$13.16	$14.87
Imports for consumption____long tons__	_______	280	_______	46	225
Value____thousands__	_______	$8	_______	$7	$23
Average value per long ton____	_______	$28.04	_______	$158.36	$102.22
Consumption, apparent [1]____long tons__	655,452	615,677	667,679	674,031	648,501
Ground:					
Sold by merchant mills____short tons__	703,587	663,220	730,737	793,052	647,995
Value____thousands__	$8,944	$8,843	$9,242	$10,465	$9,458
Average value per short ton____	$12.71	$13.33	$12.65	$13.20	$14.60
Imports for consumption____long tons__	3,243	2,783	3,377	4,644	3,247
Value____thousands__	$86	$72	$91	$128	$93
Average value per long ton____	$26.52	$26.00	$26.86	$27.72	$28.64
World: Production____thousand long tons__	2,116	2,005	2,208	2,345	2,298

[1] Measured by quantity sold or used by producers plus imports.

Table 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar [1]							
	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures [2]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1966____	116,936	$997	407,450	$4,803	131,066	$1,220	655,452	$7,020
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

[1] Partly estimated.
[2] Feldspar content.

Table 3.—Ground feldspar sold by merchant mills [1] in the United States

Year	Mills	Domestic feldspar	
		Short tons	Value (thousands)
1966____	19	703,587	$8,944
1967____	19	663,220	8,843
1968____	17	730,737	9,242
1969____	17	793,052	10,465
1970____	15	647,995	9,458

[1] Excludes potters and others who grind for consumption in their own plants.

Table 4.—Ground feldspar sold by merchant mills in the United States, by derivation [1] and uses

(Short tons)

Year	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
	Hand-cobbed					Flotation concentrate				
1966	W	54,678	W	61,090	115,768	281,595	W	W	203,819	485,414
1967	W	38,539	W	61,473	100,012	282,861	W	------	178,754	461,615
1968	W	25,300	W	59,543	84,843	286,895	W	------	223,412	510,307
1969	W	26,538	W	49,592	76,130	312,045	W	W	212,597	524,642
1970	W	18,488	W	27,967	46,455	304,279	W	------	200,858	505,137
	Feldspar-silica mixtures [2]					Grand total [3]				
1966	W	W	------	102,405	102,405	378,464	207,209	36,151	81,763	703,587
1967	W	W	------	101,593	101,593	379,660	208,626	15,304	59,630	663,220
1968	W	W	------	135,587	135,587	396,758	240,251	20,759	72,969	730,737
1969	W	W	------	192,280	192,280	445,548	241,800	26,005	79,699	793,052
1970	W	W	------	96,403	96,403	357,196	232,921	10,432	47,446	647,995

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Partly estimated.
[2] Feldspar content.
[3] "Other" includes soaps, abrasives, and other ceramic and miscellaneous uses.

CONSUMPTION AND USES

Crude Feldspar.—There is practically no commercial consumption of crude feldspar directly in the condition in which it emerges from the mine. Virtually all the mined material is subjected to some degree of processing to prepare it for the needs of industry. A limited number of users, however, continued in 1970 their accustomed practice of acquiring minor quantities of unground mine-run feldspar to be ground separately in their own mills to specifications dictated by their particular purposes.

Ground Feldspar.—Apparent consumption of ground feldspar in the United States in 1970, as reckoned by the quantity sold by domestic merchant mills plus the quantity imported for consumption, was at the lowest level in 7 years and amounted to 18 percent less than in 1969. Of the total quantity sold in 1970 by U.S. grinders, 55 percent was consumed in the manufacture of glass, 36 percent for pottery, 2 percent as an ingredient in enamels, and 7 percent for miscellaneous minor uses. Detailed information is not available concerning the end-use distribution of the imported mineral, but glassmaking is also known to be the chief outlet for Canadian nepheline syenite.

Table 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1966	1967	1968	1969	1970
California	109,126	100,235	W	W	W
Illinois	63,038	59,837	64,628	51,899	44,801
Indiana	W	W	25,897	21,944	23,853
Kentucky	7,052	15,433	10,180	9,077	15,004
Maryland	W	W	W	5,057	W
Massachusetts	3,980	3,539	3,896	4,072	W
Michigan	W	W	W	1,438	W
Mississippi	------	7,845	8,685	8,931	15,187
New Jersey	71,057	W	W	W	W
New York	W	W	20,311	19,668	W
Ohio	70,294	72,701	87,202	120,756	94,010
Oklahoma	W	W	18,385	31,203	14,200
Pennsylvania	30,628	26,188	27,333	23,566	21,884
Tennessee	36,002	32,998	26,898	29,153	W
Texas	26,183	23,269	24,449	21,776	32,365
West Virginia	W	W	34,720	29,465	30,339
Other destinations [1]	286,227	321,175	378,153	415,047	356,352
Total	703,587	663,220	730,737	793,052	647,995

W Withheld to avoid disclosing individual company confidential data; included with "Other destinations."
[1] Includes Arkansas; Colorado; Kansas (1966); Louisiana; Minnesota; Missouri (1967–68, 1970); Rhode Island; Washington (1967–70); Wisconsin (1967–70); shipments that cannot be separated by States and shipments indicated by symbol W. Also includes exports to Africa (1966–67); Canada (1967–70); Mexico and Philippines (1966–70); Panama (1966–67); Venezuela (1968, 1970); and small quantities to other countries.

The making of container glass is easily the largest single end use for feldspathic materials. Production figures for glass containers show, more than do the tonnages consumed, the magnitude of this utilization. In 1970 domestic production of all types of glass containers reached a total of over 267 million gross, of which at least 250 million gross were in the throw-away category—nonreturnable containers for food products, medicines, toiletries, reagent chemicals, etc., or disposable beer, wine, liquor, and no-deposit no-return soft-drink bottles.

PRICES

Major domestic feldspar producers reported sharply higher unit values for their product in 1970. The national average was 13 percent above that for 1969, the sixth consecutive annual increase. Engineering and Mining Journal, December 1970, quoted feldspar prices as follows:

Feldspar, f.o.b. mine or mill, carload lots, per short ton, depending on grade:

North Carolina:	
20 mesh, flotation	$11.00
40 mesh, dry ground	21.00
200 mesh, dry ground	$20.50–21.50
200 mesh, flotation	20.50–26.00
Georgia:	
40 mesh, granular	20.00
200 mesh	23.50
325 mesh	24.50
Connecticut:	
20 mesh, granular	13.50
30 mesh, granular	13.50
200 mesh	20.50
325 mesh	21.50
Maine:	
200–325 mesh	24.00

Although these quotations were indicative of price ranges, actual sales were concluded, as customarily, at negotiated prices not on public record.

FOREIGN TRADE

Imports for consumption of feldspar, crude and ground, during 1970 did not differ markedly in terms of tonnage from the average of the previous 5-years, although the 1970 total value was the second-highest (after 1969) on record. Exports in 1970 in the U.S. Commerce Department's collective classification of feldspar, leucite, nepheline, and nepheline syenite amounted to about 5,000 long tons valued at $195,000, compared with 5,600 long tons and $358,000 in 1969. In spite of these declines in tonnage and value of exports and of the high value of the imports, the United States remained, by a margin of about 1,500 tons and $80,000, in its customary position as a net exporter of feldspathic materials.

Tariff regulations in force during 1970 provided for an import duty of $0.05 per long ton for crude feldspar and of 5 percent ad valorem for ground feldspar. These rates were lower by $0.02 and 1 percent, respectively, than those applicable during 1969 and were further reduced by $0.03 and 1 percent, respectively at the start of 1971. Nepheline syenite of foreign origin, domestic feldspar's most effective competitor, is imported duty-free.

Table 6.—U.S. imports for consumption of feldspar

Country	1969 Long tons	1969 Value (thousands)	1970 Long tons	1970 Value (thousands)
Crude:				
Canada	46	$7	223	$22
South Africa, Republic of	-----	-----	2	1
Total	46	7	225	23
Ground, crushed or pulverized:				
Canada	4,544	124	3,087	86
Sweden	100	4	160	7
Total	4,644	128	3,247	93

WORLD REVIEW

Canada.—Two companies, Indusmin, Ltd., and International Minerals and Chemical Corp. (Canada), Ltd., the only producers in North America of ceramic- and glass-grade nepheline syenite, both operated their mining and processing facilities in the Peterborough area of Ontario at full capacity throughout 1969, increasing their joint output to 18 percent above the corresponding figure for 1968. Each firm, with the assurance of adequate reserves for many years of operation at or above the 1969 level, reported an excellent outlook for 1970. Indusmin, currently the larger supplier of nepheline syenite, expanded the range of its already diversified operations by initiating in 1970 the marketing of another glassmaking raw material, high-grade quartzite, from a 20-million-ton deposit on Lake Huron's Badgeley Island.

Ceylon.—Feldspar production and processing, hitherto limited to a small-scale hand-cobbing exploitation of pegmatite deposits, may soon acquire increased importance. The state-owned Ceylon Ceramics Corp. announced plans to build a plant to supply ground feldspar for its Negambo and Pilivandala ceramics works and possibly to provide significant quantities of the material for export.

Norway.—Norsk Nefelin Division of Christiania Spigerverk, which shares only with two Canadian firms the distinction of being a western-world supplier of nepheline syenite in the grades suitable for the manufacture of glass and ceramics, increased its output of the mineral from 69,000 long tons in 1968 and 148,000 tons in 1969 to an estimated 197,000 tons in 1970. Norsk Nefelin operates an open-pit mine practically at wharfside near Hammerfest, the northernmost city in Europe.

United Kingdom.—Exploratory drilling was recommended to delineate the extent and commercial possibilities of a large body of feldspar recently found at Durness, near Cape Wrath, in Sutherlandshire on the extreme north coast of Scotland. Mining of a rock product, known as "Cornish stone" and usable as a feldspathic material in some applications, is a long-established industry in Cornwall, but the United Kingdom's current requirements of glass- and ceramics-grade feldspar mostly have to be supplied by flotation-processed mineral

Table 7.—Feldspar: World production, by countries
(Long tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada (shipments)	[r] 9,482	11,058	9,800
Mexico	[r] 78,989	82,174	81,515
United States (sold or used)	667,679	673,985	648,321
South America:			
Argentina	20,179	21,491	[e] 22,000
Chile	960	974	3,543
Colombia	[r] 21,406	21,702	22,786
Peru	1,859	1,019	[e] 1,000
Uruguay	434	1,218	1,088
Europe:			
Austria	2,140	1,777	1,187
Finland	53,567	52,555	61,145
France [2]	[r] 174,680	[e] 175,000	[e] 185,000
Germany, West	[r] 283,257	355,573	[e] 364,000
Italy	[r] 165,723	207,844	174,160
Norway [3]	[r] 130,590	126,033	[e] 128,000
Poland [e]	28,000	29,000	30,000
Portugal	[r] 20,339	23,699	29,188
Spain [2]	46,522	43,044	[e] 45,000
Sweden	[r] 26,869	32,774	31,400
U.S.S.R. [e]	235,000	245,000	245,000
Yugoslavia	43,342	44,272	[e] 44,000
Africa:			
Ethiopia	7,017	11,459	------
Kenya	527	1,535	881
Malagasy	(4)	NA	1
Mozambique	98	80	[e] 100
South Africa, Republic of	19,574	21,688	18,598
United Arab Republic	1,691	2,953	[e] 3,000
Asia:			
Ceylon	577	594	1,273
Hong Kong	1,582	1,909	1,595
India	32,964	31,712	28,793
Japan [5]	[r] 65,365	60,029	63,267
Korea, Republic of	20,661	23,065	27,578
Philippines	[r] 41,656	34,832	19,916
Oceania: Australia	[r] 4,838	4,685	[e] 4,700
Total	[r] 2,207,567	2,344,733	2,297,835

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] In addition to the countries listed, Brazil, Czechoslovakia, Romania, and South-West Africa also 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: 1968, [r] 81,712; 1969, [r] [e] 128,000; 1970, [e] 143,000.
[4] Less than ½ unit.
[5] In addition, the following quantities of aplite and saba were produced: 1968, [r] 350,069; 1969, 429,578; 1970, 481,076.

from Scandinavia, and the potential trade-balance advantages of the new Durness deposit are obvious.

U.S.S.R.—Construction was completed of a large installation at Achinsk in Krasnoyarsk Territory, western Siberia, for the purpose of extracting alumina of potline quality for the Soviet Union's aluminum smelters. The new plant, served by the Trans-Siberian Railway and expected to yield 800,000 tons yearly of the desired metallurgical intermediate, is notably out of the ordinary in that its primary input mineral will be the feldspathic rock, nepheline syenite, instead of the more customary bauxite that serves as the starting material for alumina production almost everywhere else. The ore to be processed at Achinsk will be mined 100 miles away at the new town of Belogorsk and has an average content of 25 percent Al_2O_3. Full-scale operation of the new facility will entail, therefore, the mining and transportation of more than 3 million tons per year of this unconventional plant feed, undoubtedly the largest undertaking of its kind in the world.

Yugoslavia.—Yugoslavia feldspar production, which amounts to approximately 45,000 tons per year, will increase considerably with the opening of a new plant, sometime in 1971. The decision to build the new facility, designed to recover about 45,000 tons of marketable feldspar from the flotation processing of about 100,000 tons of pegmatite per year, followed a new appraisal of the recently discovered ore body near Prokuplje in Serbia. The latest assessment of this deposit indicates that proved reserves of minable material that contain 60 percent or more of high-potash feldspar now amount to at least 4.5 million tons, instead of the 3.0 million tons previously estimated. Important quantities of high-grade silica and mica will also be recovered as coproducts in this first feldspar flotation mill in Yugoslavia. Europe has only 2 other such plants located in Finland and Norway.

TECHNOLOGY

The Spruce Pine district of North Carolina undoubtedly has already yielded more high-grade marketable feldspar than any other area of equal extent on earth, and production there thus far has scarcely more than dusted off the top layers of these massive deposits. On the other hand, however, the winning of about a quarter of a million tons of salable feldspar each year inevitably brought with it the accumulation of an at least equal quantity of seemingly worthless waste material. A far-sighted program of research supported by progressive private organizations in collaboration with Federal and State governmental agencies is rapidly turning this profit-swallowing disposal problem around to reveal a potential source of important revenue. A published report delineated the principal goals of the investigation and detailed the more significant conclusions that were reached.[2]

Producers in North Carolina's second feldspar region, the Kings Mountain area, are independently pursuing research toward similar ends. This subject of feldspar tailings management was the principal topic discussed in a paper presented at the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers at Denver, Colo., February 15–19, 1970.[3] An industrial journal and a popular magazine both published articles on the technology and some of the more visible results of the enlightened and hearteningly successful efforts of one organization to minimize environmental disruption without forfeiting the position of No. 1 feldspar producer in the United States.[4]

In a related but not parallel activity, the Bureau of Mines continued to obtain favorable results in a quest for procedures making possible a more profitable utilization of the finely divided material, hitherto of little or no commercial value, that is generated in great quantities in Georgia and South Carolina during the quarrying and processing of granite for use as crushed stone. Experiments in 1970 at the Bureau's Tuscaloosa Metallurgy Research Laboratory in Alabama were directed espe-

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[2] School of Engineering, North Carolina State University. Feldspar Tailings Utilization, Final Report—Research sponsored by U.S. Bureau of Mines, The Feldspar Corp., International Minerals and Chemical Corp., Lawson-United Feldspar and Mineral Co., and North Carolina State University. Raleigh, N.C., September 1969, 68 pp.

[3] Redeker, Immo H. North Carolina Feldspar Flotation and Solutions to Waste Disposal Problems. 17 pp.

[4] Pit and Quarry. Feldspar Corp. Utilizes Latest Equipment to Maintain Pollution-Free Operation. V. 63, No. 4, October 1970, p. 58.

Siler, Leon M. What Can You do With "Tailings"? The State (Raleigh, N.C.), v. 38, No. 3, July 1, 1970, pp. 10–11, 36.

cially toward developing improved flotation schemes capable of treating the waste fines to yield either feldspar or feldspar-silica concentrate acceptably low in iron-mineral content to serve in the manufacture of glass and ceramics.

Prominent among technological developments in 1970 with substantial bearing upon the feldspar commodity situation were those affecting the mineral's largest-scale outlet, the container-glass industry. Throughout the year an industrial journal printed a number of articles that, taken together, provided a synoptic view of the sophisticated technology that is enabling the glassmakers to comply with today's apparently insatiable demand for ever greater quantities of glass containers.[5] Another article in the same journal furnished a graphic rationale for the container manufacturers' urgent need for time-saving technology.[6]

Feldspar is an important constituent in most porcelain enamel formulations. New techniques and some theoretical considerations of interest to enamel makers and users were dealt with in two journal articles.[7]

A patent was granted to Bureau of Mines research workers for a fusion-quench-leach process, by the use of which alumina (or an alumina antecedent) can be produced from a number of silicate mineral materials, including the feldspathic rock anorthosite.[8] A recent foreign patent described an innovative electrostatic process for the beneficiation of a number of minerals, among which feldspar was specifically mentioned.[9]

NEPHELINE SYENITE

Nepheline syenite is a coarsely crystalline rock that bears a superficial resemblance to granite but consists essentially of the feldspathoid minerals—sodium-potassium feldspars and nephelite—with little or no associated free quartz. In its chief commercial application, nepheline syenite serves as a raw material for the manufacture of glass and ceramics. Other end uses, such as a filler in paint, paper, latex products, and plastics, are increasing in number and importance. Since the United States has no domestic production of nepheline syenite in the grades suitable for these purposes, its entire consumption of the mineral depends upon shipments from Ontario. According to the most recent data published in Canadian Minerals Yearbook, mine production of nepheline syenite there totaled about 503,000 short tons (449,000 long tons) in 1969, of which approximately three-quarters was exported to the United States. The average unit values reported for Canadian production and U.S. imports of nepheline syenite fall approximately midway within the range of prices quoted by Ceramic Industry Magazine, January 1971—$8 per ton, low, to $21 per ton, high.

Two welcome additions to the rather scanty literature dealing with nepheline syenite and related minerals have been published. These items, one an extensive monograph and the other a journal article, provide so much authoritative and hard-to-find information on the subject that they are deserving of special mention, albeit in one case somewhat belated.[10]

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[5] Allen, Alfred C. Underwood Boosts Glass Melting 126%. Ceram. Ind., v. 94, No. 3, March 1970, pp. 28–30.
Ceramic Industry Glenshaw Expansion Features Automation. V. 94, No. 6, June 1970, pp. 51–53.
Ceramic Industry. Precision, the Key to Volume Production. V. 95, No. 5, November 1970, pp. 24–27.
Richards, Robert C. Modernization Spells Profits for UG. Ceram. Ind., v. 95, No. 6, December 1970, pp. 33–35.
Svec, J. J. Brockway Pomona Plant Works at Capacity. Ceram. Ind., v. 95, No. 4, October 1970, pp. 42–44.

[6] Ceramic Industry. Triple Speed Line Fills 2000 Bottles Per Minute. V. 94, No. 2, February 1970, pp. 38–39.

[7] Hubbell, Dean S. Anatomy of Colored Archtectural Coatings. Ceram. Ind., v. 95, No. 2, August 1970, pp. 32–35.
Svec, J. J., and Alfred C. Allen. Faster Firing Spells Dollars to Enamelers. Ceram. Ind., v. 94, No. 6, June 1970, pp. 57–58.

[8] Iverson, H. G., and H. Leitch (assigned to U.S. Secretary of the Interior). Extraction of Aluminum Values From Albite, Anorthosite, Kyanite, Bauxite, or Other Low-Grade Siliceous Ores or Rocks. U.S. Pat. 3,507,629, Apr. 21, 1970.

[9] Robert, D. (assigned to Ste. de Produits Chimiques d'Auby). Canadian Pat. 857,700, Dec. 8, 1970.

[10] Allen, J. B., and T. J. Charsley, Nepheline-Syenite and Phonolite. Inst. Geol. Sci. (London), 1968, 169 pp.
Roy, S. B., and S. K. Som. Use of Nepheline Syenite in Ceramic Industry. Bull., Central Glass and Ceram. Res. Inst. (Calcutta), v. 17, No. 1, January-March 1970, pp. 31–37.

Table 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1968	15	(1)	271,966	$3,558
1969	166	$2	346,513	4,449
1970	538	9	352,937	4,634

1 Less than ½ unit.

APLITE

Aplite, a granitic rock of indefinite composition that contains a high proportion of albite or plagioclase feldspar, is mined and processed for the removal of iron-bearing minerals to serve mainly as a raw material for the manufacture of container glass. Aplite of glassmaking quality was produced domestically in 1970 only from two mines in Virginia. The Feldspar Corp. mined and treated ore from Hanover County by an electrostatic process, and ore mined in Nelson County was beneficiated by International Minerals & Chemical Corp. using a method of high-intensity magnetic separation. Mine production of aplite in 1970, responding to the vigorous upward tendency in container-glass demand, reached the highest tonnage level in more than a decade and the highest total value on record. Prices quoted for aplite in Ceramic Industry Magazine, January 1971, were $8.30 per ton (high) and $5.30 per ton (low), substantially below the average unit value indicated by a canvass of producers. No specific annual data on aplite production, sales, or value have been released for publication since 1962.

Ferroalloys

By Horace T. Reno [1]

The domestic ferroalloy industry experienced its best year ever in international trade as exports reached a value of $56 million, $32 million more than the record established in 1969. However, domestic use of the ferroalloys following the trend of activity in the steel industry was 10 percent less than in 1969. Most ferroalloy prices were increased in 1970. The structure of the industry did not change in 1970, but all producers were hard-pressed to meet air pollution standards and some captive power plants were shutdown because of harmful stack gas emissions.

Detailed information concerning the more significant ferroalloys may be found in the chapters for individual alloying elements.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Government inventory of ferroalloys (stockpile grade), December 31, 1970

(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

	1969				1970			
	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]	852,019	77.3	836,717	$119,308	835,463	78.5	807,368	$134,456
Silicomanganese	222,877	66.0	217,543	35,152	193,219	66.0	172,988	32,024
Ferrosilicon	715,172	57.8	675,381	112,293	709,287	59.2	659,216	136,238
Silvery iron	204,027	16.7	203,641	15,891	196,369	18.2	207,664	16,853
Chromium alloys:								
Ferrochromium [2]	296,305	69.8	293,367	81,343	309,613	69.0	289,395	100,667
Other chromium alloys [3]	122,733	43.8	94,388	26,067	96,163	45.0	81,552	25,606
Total	419,038	62.2	387,755	107,410	405,776	63.2	370,947	126,273
Ferrotitanium	4,441	26.9	4,222	3,937	3,360	29.0	3,291	3,503
Ferrophosphorus	130,582	24.7	164,360	4,784	164,107	24.0	176,065	6,539
Ferrocolumbium	2,301	55.5	2,202	9,298	1,260	56.7	1,421	9,385
Other [4]	78,046	36.3	102,182	79,171	86,347	38.0	90,689	82,807
Grand total	2,628,503	60.0	2,594,003	487,244	2,595,188	60.5	2,489,649	548,078

[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 structure of the domestic ferroalloy producing industry did not change significantly in 1970. The 29 producers listed in table 3, two fewer than in 1969, reported production about the same as in 1969. However, some ferromanganese producers changed from blast furnace to electric furnace smelting, forcing consolidation of the figures to prevent disclosure of individual company data. Total shipments of ferroalloys were 4 percent less than in 1969, but the value of shipments was up 12 percent. Shipments rather than production are the measure of activity in the industry, as production in the high-volume ferroalloys is irregular and intermittent.

Table 3.—Producers of ferroalloys in the United States in 1970

Producer	Plant location	Product [1]	Type of furnace
Agrico Chemical Co	Pierce, Fla	FeP	Electric.
Airco Alloys & Carbide	Calvert City, Ky Charleston, S.C Niagara Falls, N.Y	FeCr, FeMn, FeSi, SiMn, Silvery iron.	Do.
Bethlehem Steel Co	Johnstown, Pa	FeMn	Blast.
Chromium Mining & Smelting Co	Woodstock, Tenn	FeMn, SiMn, FeCr, FeSi	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, FeMn, FeSi, SiMn, 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, FeSi, SiMn	Do.
Kawecki Chemical Co	Easton, Pa	FeCb	Aluminothermic.
Mobil Chemical Co	Mt. Pleasant, Tenn 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.
National Lead Co	Niagara Falls, N.Y	FeCTi, FeTi, other [2]	Do.
New Jersey Zinc	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, FeMo	Aluminothermic.
Shieldalloy Corp	Newfield, N.J	FeV, FeTi, FeB, FeMo, FeCb, other.[2]	Do.
Stauffer Chemical Co	Mt. Pleasant, Tenn Silver Bow, Mont Tarpon Springs, Fla	FeP	Electric.
Tennessee Alloys Corp	Bridgeport, Ala	FeSi	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.
Tenn-Tex Alloy Corp of Houston	Houston, Tex	FeMn, SiMn	Do.
Union Carbide Corp	Alloy, W. Va Ashtabula, Ohio Marietta, Ohio Niagara Falls, N.Y Portland, Oreg Sheffield, Ala Birmingham, Ala	FeB, FeCr, FeCb, FeSi, FeMn, FeTi, FeW, FeV, SiMn, other.[2]	Do.
United States Steel Corp	Clairton, Pa Duquesne, Pa	FeMn	Blast.
Universal Oil Products Co	Selma, Ala	FeSi	Electric.
Woodward Iron Co	Woodward, Ala Rockwood, Tenn	FeSi, FeMn, SiMn	Do.

[1] 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

Consumption of ferroalloys in 1970 followed the downward trend in steel production. The total quantity of ferroalloys consumed as additives and alloying elements for all end-uses was 10 percent below the level of consumption in 1969. Although total steel production was down only 7 percent, production of alloy and stainless steels, the big uses for ferroalloys, was down 14 and 18 percent, respectively. These data are only indicative of activity in the steel and ferroalloys industries, owing to the wide variety of secondary materials consumed and the large number of end-use products produced.

In contrast to their consumption in steels, reported consumption of the ferroalloys as alloying elements to produce superalloys and alloys other than steel alloys, increased compared with 1969. However, the comparison may not be valid because the format and instructions for reporting materials used in superalloys, first used in 1969, have not yet proved completely satisfactory.

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1970

(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]	9,310	129,958	809,937	W	17,105	1,172	12,753	35,875	1,016,110
Silicomanganese	8,371	26,645	87,845	W	7,154	W	1,838	6,647	138,500
Silicon alloys [3]	23,218	92,045	157,809	2,722	338,300	423	46,274	48,164	708,955
Ferrotitanium [4]	428	581	958	W	252	556	1,024	1,735	5,534
Ferrophosphorus [5]	9	1,968	11,064	W	927	-----	90	440	14,498
Ferroboron	8	97	W	-----	5	W	W	241	351
Total	41,344	251,294	1,067,613	2,722	363,743	2,151	61,979	93,102	1,883,948

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 1970

(Short tons of contained elements)

	Stainless steels	Other alloy steels	Carbon steels	Tool steels	Cast irons	Superalloys	Alloys (excludes alloy steels and superalloys)	Other uses [1]	Total
Ferrochromium [2]	155,164	37,867	6,123	1,856	5,490	10,779	3,765	5,887	226,931
Ferromolybdenum [3]	882	1,068	202	439	1,372	178	333	340	4,814
Ferrotungsten [4]	64	93	------	300	(5)	25	23	20	525
Ferrovanadium [6]	45	2,405	938	420	49	36	97	335	4,325
Ferrocolumbium	229	414	347	------	------	193	14	5	1,202
Ferrotantalum-columbium	W	W	W	------	------	------	------	40	40
Total	156,384	41,847	7,610	3,015	6,911	11,211	4,232	6,627	237,837

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] Less than ½ unit.
[6] Includes other vanadium-carbon-iron ferroalloys.

STOCKS

Producers' stocks of ferroalloys at the end of 1970 were 10 percent more than at yearend, and consumers' stocks were 4 percent less. The percentage balance does not have special significance, because large-volume alloys are produced intermittently. Consumer stocks of all the ferroalloys at yearend were normal, considering the level of production of carbon and alloy steels in 1970.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States, December 31, 1970

(Short tons)

	Producer		Consumer	
	1969, gross weight	1970, gross weight	1969, gross weight	1970, gross weight
Manganese ferroalloys [1]	194,144	198,378	r 150,950	144,850
Silicon alloys [2]	94,994	134,880	64,638	66,055
Ferrochromium [3]	46,977	52,550	39,687	33,875
Ferrotitanium [4]	1,283	1,351	871	775
Ferrophosphorus [5]	57,586	45,628	2,327	2,553
Ferroboron	228	703	62	48
Total	395,212	433,490	258,535	248,156
	1969, contained element	1970, contained element	1969, contained element	1970, contained element
Ferromolybdenum [6]	W	W	796	677
Ferrotungsten	W	W	147	181
Ferrovanadium	r 363	577	1,272	903
Ferrocolumbium	r 329	426	425	410
Ferrotantalum-columbium	----	----	8	8
Total	692	1,003	2,648	2,179

r Revised. 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 and molybdenum silicide.

PRICES

Domestically produced standard high-carbon ferromanganese, lump, bulk material in carload lots was priced at $164.50 per long ton to October 1 and at $159.50 per ton from then until the end of the year. The price of high-carbon ferrochromium, lump, bulk, in carload lots ranged from 21.7 cents per pound in January to 36.5 cents per pound in December. Low-carbon ferrochromium was priced at 28.6 cents per pound in the first three quarters of the year and 36.5 cents per pound in the last quarter.

The price of 50 percent grade ferrosilicon, lump, bulk, in carload lots, f.o.b. shipping point, freight equalized to the nearest main producer, was 14.1 cents per pound January through June and 15.3 cents per pound July 1 to the end of the year.

Ferrovanadium prices in a split market, per pound of contained vanadium, f.o.b. were $2.90 and $3.12 January through June and $3.48 and $4.12 July to the end of the year. The price of ferronickel per pound of contained nickel in wholesale lots, f.o.b. shipping point from January 1 to November 1 was $1.28 per pound and was increased to $1.305 per pound on November 1 to conform with a price increase of Canadian nickel producers.

The quoted price for low-carbon ferrotitanium was unchanged in 1970 at $1.35 per pound of contained titanium, delivered. Low-alloy, standard ferrocolumbium was priced at $2.65 to $3.52 per pound of contained columbium in ton lots delivered January through June and $2.85 to $4.12 per pound July 1 to the end of the year. Ferrotungsten was quoted at $3.75 per pound of contained tungsten, delivered throughout the year.

FOREIGN TRADE

The slight increase in free world steel production did not have noticeable effect on international trade in the ferroalloys. The value of U.S. imports of ferroalloys and ferroalloy metals for consumption in 1970 was $5 million less than in 1969. However, the $56 million value of exports was $32 million more than the 1969 record. The large increase was due to the total quantity increase of almost 40 percent and the increased unit value of ferromanganese, ferrosilicon, ferrovanadium, and unclassified ferroalloys. The average value of the unclassified ferroalloys exported increased from $285 per ton in 1969 to $735 per ton in 1970.

As in past years, there was no definitive pattern to U.S. trade in ferroalloys. As was to be expected, Canada, the United Kingdom, West Germany, and Japan were the principal recipients of the ferrochromium exports. Mexico, Sweden, India, Japan, Australia, and the Republic of South Africa were the principal recipients of the ferromolybdenum. Canada, West Germany, and Belgium were the principal recipients of ferrophosphorus. Most of the ferrosilicon exported went to the developed countries, United Kingdom, West Germany, Japan, Australia, and Canada; and Canada, Mexico, the Netherlands, France, East and West Germany, and Japan were the principal recipients of ferrovanadium exports.

Table 7.—U.S. exports of ferroalloys

Alloys	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ferrocerium and alloys	45	$303	52	$351	39	$275
Ferrochromium	27,127	5,735	24,573	5,679	28,373	8,259
Ferromanganese	3,710	645	1,759	483	21,747	4,356
Ferromolybdenum	432	1,194	728	2,381	1,007	3,088
Ferrophosphorus	36,708	930	37,351	912	33,106	1,199
Ferrosilicon	18,372	4,481	6,487	1,666	44,694	11,887
Ferrovanadium	278	1,052	644	2,834	2,154	12,127
Ferroalloys, n.e.c.	11,288	7,814	34,057	9,720	19,964	14,486
Total	97,960	22,154	105,651	24,026	151,084	55,677

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1969			1970		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Chromium metal	1,491	(1)	$2,072	1,892	(1)	$3,052
Ferrocerium and other cerium alloys	9	(1)	91	9	(1)	54
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	r 18,240	r 10,848	r 2,327	12,333	7,592	1,874
Containing less than 3 percent carbon	r 39,189	r 26,058	r 10,067	28,972	18,353	7,746
Ferromanganese—						
Containing not over 1 percent carbon	2,955	2,531	929	3,148	2,554	1,036
Containing over 1 and less than 4 percent carbon	35,474	29,030	6,727	20,127	16,524	4,247
Containing not less than 4 percent carbon	r 269,423	r 207,584	r 24,625	267,671	207,901	26,280
Ferromolybdenum, molybdenum metal, compounds, alloys, and scrap (molybdenum content)	70	12	413	122	12	779
Ferronickel	15,696	(1)	9,507	14,237	(1)	9,652
Ferrosilicon	33,614	16,944	4,577	22,404	10,060	4,117
Ferrosilicon-chromium	795	(1)	49	-------	-------	-------
Ferrosilicon-manganese (manganese content)	32,040	21,337	3,532	14,539	9,624	1,774
Ferrotitanium and ferrosilicon-titanium	552	(1)	259	73	(1)	48
Ferrovanadium	382	(1)	1,185	24	18	114
Ferrozirconium	440	(1)	167	660	(1)	260
Ferrophosphorus	28	(1)	2	288	(1)	16
Manganese metal	1,371	(1)	513	1,277	(1)	518
Tungsten metal (lump, grains, or powder) and tungsten carbide (tungsten content)	(1)	10	138	90	74	1,010
Tungsten alloys (unwrought) and scrap (tungsten content)	(2)	(2)	7	2	1	29
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)	54	37	417	549	43	1,141
Ferroalloys not elsewhere classified	1,228	(1)	3,095	917	(1)	2,287

r Revised.
1 Not recorded.
2 Less than ½ unit.

WORLD REVIEW

Japan.—The Japanese ferroalloy industry followed the Japanese steel industry in becoming a major factor in worldwide industry. The Japanese supplied ferroalloy furnaces and equipment to producers in South America and Europe. Measured by the total quantity of the principal ferroalloys produced, the Japanese produced 31 percent more ferroalloys in 1970 than in 1969. Production in 1969 and 1970 was as follows:

	1969 (metric tons)	1970 (metric tons)
Ferrochromium	258,583	361,524
Ferromanganese	382,151	444,498
Ferromolybdenum	2,493	3,152
Ferronickel	180,413	264,661
Ferrosilicon	225,414	302,298
Ferrotungsten	1,154	1,278
Ferrovanadium	2,137	2,570

New Caledonia.—New Caledonia Nickel Company, a joint venture of Société Le Nickel of France and Kaiser Aluminum & Chemical Corp. of the United States, tapped the first of three 33,000 kw furnaces planned for its new Noumea facility. The Noumea facility is a significant part of planned expansion of nickel producing facilities of New Caledonia.

TECHNOLOGY

Technical developments dealing with ferroalloy metals are discussed in the individual commodity chapters. However, control of air pollution was a problem common to all. In 1970, the problem demanded the attention of ferroalloy producers, consumers, and researchers in all parts of the world.

Most authorities agreed that the technology and equipment needed to take care of particulate emissions from ferroalloy furnaces were now available but that the know-how to take care of gaseous emissions was not yet at hand. Most pollution trouble in the ferroalloy industry in 1970 was at its coal-fired powerplants inasmuch as modern smelting furnaces with proper raw materials and proper emission control equipment cause little air pollution and the ferroalloy industries in most countries of the world were actively engaged in alleviating that part of the problem.

The cost of installing suitable equipment to control particulate emissions was estimated by some authorities to increase ferroalloy production costs from 6 to 12 percent. Therefore, much of the research in 1970 was directed towards lowering these costs. The Japanese ferroalloy equipment producer, Tanabe Kokoki, claimed advantages for its shaft-kiln collector for controlling pollution, but at the same time pointed out that economizing in heat and transportation costs would provide negligible savings because the dominant cost factor in the ferroalloy industry is the price of electric power.[2] However, the Kokoki shaft-kiln may offer some capital cost advantage because it traps particulates for reuse. Among other works which may contribute to lower capital costs, the American Wheelabrator Corp. working for the last 5 years with the ferroalloys division of Union Carbide Corp. devised a collector of modular design. The collector was said to have efficiency greater than 99 percent. Considering the public pressure in 1970 for immediate end to pollution, the modular system was probably the most significant of all ferroalloy cost-reduction elements because of the time saved in installation.[3]

[2] American Metal Market. Japan Becoming Major Exporter of Ferroalloy Furnace Equipment. V. 78, No. 35, Feb. 22, 1971, pp. 1 and 3.

[3] American Metal Market. Wheelabrator Aids Pollution Control at Ferroalloys Plant. V. 77, No. 240, Dec. 17, 1970, p. 13.

Fluorspar and Cryolite

By H. B. Wood [1]

FLUORSPAR

During 1970, fluorspar exploration activity increased in the United States and throughout the world. Production increased over 8 percent and consumption increased about 10 percent, reflecting a strong industry.

U.S. production in 1970 increased 47 percent over that of 1969, but was only 7 percent over the 1968 production and 9 percent less than the 1967 production. Work stoppages during 1969 caused a decrease in production that continued into 1970. The United States produced 6 percent of the world fluorspar output and consumed 30 percent.

The total U.S. consumption of fluorspar rose from 1,357,000 short tons in 1969, to 1,372,000 tons in 1970 an increase of 1.1 percent. Most of the increase was in the consumption of acid-grade fluorspar (acid-spar) to make hydrofluoric acid. Acid-spar consumption increased about 4 percent from 721,000 tons in 1969, to 751,000 tons in 1970. There was a 13-percent decrease in the use of metallurgical-grade fluorspar (met-spar) in the open-hearth furnace, from 109,000 tons in 1969, to 95,000 tons in 1970.

Imports for consumption of all grades totaled about 1,092,000 tons, about 5 percent less than in 1969. The imports still constituted about 80 percent of the Nation's total requirements for the year. Mexico continued to be the largest supplier, providing 76 percent of the imports, and 61 percent of the U.S. consumption.

Legislation and Government Programs.—No contracts for fluorspar exploration were made by the Office of Minerals Exploration during 1970. The percentage depletion allowance rates eatablished in 1969 remained the same, domestic 22 percent, and foreign 14 percent. In compliance with instructions from the Office of Emergency Preparedness, and subsequent Public Law 91-320 dated July 10, 1970, the General Services Administration (GSA) disposed of 100,000 short dry tons of acid-spar from government stockpiles for $5,999,000. Bid prices ranged from $48 to $76 per ton. Government inventories as of December 31, 1970, included 1,070,000 tons of acid-spar and 412,000 tons of met-spar in GSA stockpiles. GSA sales of excess fluorspar were expected to continue into 1971 until disposal of the excess 112,000 tons of acid-spar is completed.

The duty on imported fluorspar has remained unchanged since January 1, 1963. Fluorspar that contains not more than 97 percent calcium fluoride (CaF_2) is subject to a duty of $1.875 per short ton; material that contains not more than 97 percent CaF_2 is subject to a duty of $7.50 per short ton.

The National Research Council report on fluorspar supply and demand was completed in December 1970.[2]

DOMESTIC PRODUCTION

The Illinois-Kentucky fluorspar mining districts, consisting of Hardin and Pope Counties in southern Illinois, and Crittenden, Livingston, and Caldwell Counties in Kentucky, continued as the major sources of domestic fluorspar in 1970 and provided over 55 percent of the total shipments for the year. The lead and zinc byproducts of fluorspar mines were also important to the operations of the area. The mines in Colorado, Montana, Nevada, New Mexico, and Utah provided the remainder of the total fluorspar shipments but no significant byproducts. Production from Colorado in-

[1] Commodity specialist, Division of Nonmetallic Minerals.

[2] National Research Council. Trends in the Usage of Fluorspar. NMAB–269, December 1970, 55 pp.

Table 1.—Salient fluorspar statistics

	1966	1967	1968	1969	1970
United States:					
Production:					
Crude:					
Mine production ____ short tons __	737,411	838,631	749,219	533,030	627,212
Material beneficiated _____ do ____	796,418	914,616	765,531	520,084	698,232
Material recovered _______ do ____	250,200	284,300	237,000	160,000	252,128
Finished (shipments) _________ do ____	253,068	295,643	252,411	182,567	269,221
Value ______________ thousands __	$10,841	$13,164	$11,656	$8,411	$13,923
Exports ___________________ short tons __	5,732	10,345	12,614	3,605	14,952
Value _________________ thousands __	$301	$517	$496	$213	$1,145
Imports for consumption _____ short tons __	878,546	911,870	1,050,107	1,149,546	1,092,318
Value _________________ thousands __	$21,968	$24,485	$28,699	$32,818	$32,758
Consumption _______________ short tons __	1,065,124	1,091,158	1,243,414	1,356,624	1,372,404
Stocks Dec. 31:					
Domestic mines:					
Crude __________________ do ____	207,338	126,716	97,522	82,177	51,471
Finished _________________ do ____	26,589	22,522	12,557	9,751	12,370
Consumer plants _____________ do ____	254,726	303,718	323,121	290,470	419,746
World: Production __________________ do ____	3,131,203	3,498,755	4,006,971	4,228,583	4,600,327

creased 54 percent and thereby substantiated Colorado's position as the second largest fluorspar-producing State in the United States.

The mines, concentrating plants, and pelletizing plants of the Minerva Mining Division of Minerval Oil Co. and the Ozark-Mahoning Co. operated at 90 to 95 percent capacity during 1970. Increasing demand for briquets and pellets led to expansion of existing pellet plants and construction of additional facilities. At least six pellet or agglomeration plants were reported to be either in operation or under construction. These plants produce high-quality agglomerates for the iron and steel industry.

Altogether, there were 25 mines reported to be actively producing and shipping fluorspar in seven States. Ten mines stopped shipping; seven other mines resumed shipping or were new producers during 1970.

Exploration activity in search of new commercial fluorspar deposits was accelerated during the year.[3]

New exploration ventures were announced by a consortium of Frontier Resources, Cerro Corp., and Five Resources Inc., and by U.S. Borax and Chemical Corp. Additional exploration work was carried out by Lost River Mining Corp., Ltd., at its complex fluorspar, tin, tungsten, and beryllium deposit on Seward Peninsula, Alaska. Preliminary estimates are favorable, indicating a reserve of 26 million tons that may prove to be economically minable.[4]

New areas were being explored in Idaho, Utah, Nevada, Colorado, New Mexico, and Kentucky.

The Fort Meade, Fla., plant of Aluminum Co. of America (Alcoa), which was built to make cryolite and aluminum fluoride from waste fluosilicic acid (H_2SiF_6), salvaged from a phosphate rock processing plant, went on stream in December 1970. U.S.S. Agri-Chemicals supplies the fluosilicic acid for the Alcoa plant and also markets fluosilicic acid for domestic water systems. Farmland Industries, from its plant near Lakeland, Fla., supplies fluosilicic acid to Kaiser Aluminum & Chemical Corp. to

[3] Industrial Minerals (London). Fluorspar: A World Review. V. 35, September 1971, p. 14.
Skillings Mining Review. Oct. 10, 1970, p. 11.

[4] Alaska, Division Geological Survey, Bureau of Mines. Lost River Reports Progress. Bull. 18, No. 10, November 1970, p. 2.
Lost River Mining Corp., Ltd. Annual Report, 1970.

Table 2.—Shipments of finished fluorspar, by States

State	1969 Short tons	1969 Value Total (thousands)	1969 Value Average per ton	1970 Short tons	1970 Value Total (thousands)	1970 Value Average per ton
Illinois	88,480	$4,676	$52.85	148,208	$8,637	$58.27
Utah	6,667	207	31.05	19,214	595	30.97
Other States [1]	87,420	3,528	40.36	101,799	4,691	46.08
Total	182,567	8,411	46.07	269,221	13,923	51.71

[1] Includes Colorado, Kentucky, Montana, New Mexico, and Nevada.

make cryolite. Kaiser has a plant at Mulberry, Fla., for processing fluosilicic acid into sodium fluorosilicate, which it ships to Chalmette, La., to make aluminum fluoride.[5] At least four other superphosphate-producing companies are known to be salvaging and marketing fluosilicic acid.

CONSUMPTION AND USES

Total domestic consumption rose from 1,357,000 short tons in 1969, to 1,372,000 tons in 1970, an increase of 1.1 percent. As shown in table 3, consumption in the four major iron and steel industry uses was 576,000 tons in 1970, which was 42 percent of the total consumption. This was a slight decrease from the 1969 consumption in the iron and steel industry.

Met-spar, which was consumed at the rate of about 8½ pounds per ton of iron and steel, totaled 379,000 tons in 1969, and 371,000 tons in 1970, indicating a 2-percent tonnage decrease. More met-spar pellets or briquets are being consumed each year in the steel industry. This results in more efficient use of some met-spar fines that had been wasted in the past.

In table 3 the quantity of acid-spar shown as used in the production of aluminum and magnesium is not representative of the total consumption by this industry, because a large proportion of the acid-spar reportedly consumed as hydrofluoric acid is actually converted to aluminum fluoride and synthetic cryolite and used as the electrolyte in making aluminum metal. The quantity of acid-spar consumed in this manner is not reported to the Bureau of Mines. It is estimated that 20 percent, or 270,000 tons, of the total 1970 consumption of fluorspar was consumed by the aluminum industry.[6]

The reported consumption of acid-spar used to make hydrofluoric acid increased from 721,000 tons in 1969, to 751,000 in 1970, an increase of 4 percent. Although the actual tonnage of acid-spar that is made into hydrofluoric acid for industrial chemicals is not reported, by subtracting the amounts known to be consumed in the other industries from the total consumption, it can be estimated that approximately 493,000 tons of acid-spar were consumed for this purpose. This represents about 36 percent of the total consumption in the United States.

[5] Chemical and Engineering News. Apr. 19, 1971, p. 20.
[6] Work cited in footnote 2.

Table 3.—Consumption, by end use and stocks, by grade of fluorspar (domestic and foreign) in the United States in 1970

(Short tons)

End use or product	Containing more than 97 percent calcium fluoride	Containing not more than 97 percent calcium fluoride	Total
Hydrofluoric acid	750,731	(1)	750,731
Glass	8,346	10,413	18,759
Enamel	305	2,312	2,617
Welding rod coatings	2,577	(2)	2,577
Primary aluminum	1,253	-------	1,253
Primary magnesium } Other nonferrous metal }	430	11,113	11,543
Iron and steel castings	422	22,723	23,145
Open-hearth furnaces	-------	95,124	95,124
Basic oxygen furnaces	-------	371,172	371,172
Electric furnaces	3,314	83,154	86,468
Other uses or products [3]	-------	9,015	9,015
Total	767,378	605,026	1,372,404
Stocks Dec. 31	145,475	274,271	419,746

[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	1969				1970			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total (thousands)	Average per ton r	Short tons	Percent of total	Total (thousands)	Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	71,225	51.0	$3,586	$50.34	105,839	53.1	$5,912	$55.86
Glass	18,415	13.2	990	53.76	21,637	10.9	1,302	60.17
Ceramic and enamel	7,289	5.2	250	34.29	9,912	5.0	365	36.82
Nonferrous	2,146	1.6	115	53.58	3,326	1.7	203	61.03
Ferrous [1]	37,964	27.2	1,961	51.65	54,916	27.6	3,278	59.69
Miscellaneous [1]	2,517	1.8	136	54.03	3,495	1.7	206	58.94
Total	139,556	100.0	[2] 7,037	50.42	199,125	100.0	11,266	56.58
Fluxing gravel and foundry lumps:								
Ferrous	42,869	100.0	1,372	32.00	67,956	97.0	2,528	37.20
Miscellaneous	142	------	2	14.08	2,140	3.0	129	60.28
Total	43,011	100.0	1,374	31.94	70,096	100.0	2,657	37.91

r Revised.
[1] Includes exports.
[2] Data may not add to total shown because of independent rounding.

Table 5.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1970
Alabama, Kentucky, Tennessee	73,695
Arizona, Colorado, Utah	20,904
Arkansas, Kansas, Louisiana, Missouri	258,582
California	52,372
Connecticut, Massachusetts, New York, Rhode Island, Vermont	38,663
Illinois	89,065
Indiana	60,784
Iowa, Minnesota, Nebraska, Wisconsin	2,416
Michigan	72,412
New Jersey	72,082
Ohio	155,599
Oklahoma	1,216
Oregon and Washington	2,059
Pennsylvania	154,669
Texas	229,891
West Virginia	55,147
Other States [1]	32,848
Total	1,372,404

[1] Includes Florida, Georgia, Maryland, North Carolina, Virginia, Delaware, and Mississippi.

Table 6.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1969		1970	
	Crude	Finished	Crude	Finished
Illinois	r 39,660	2,558	17,328	3,841
Utah	400	400	1,100	------
Other States [1]	42,117	6,793	33,043	8,529
Total	82,177	9,751	51,471	12,370

r Revised.
[1] Includes Colorado, Kentucky, Montana, and New Mexico.

PRICES

Some quoted acid-spar prices increased 30 percent over prices quoted in 1969. Price variations depend on grades and origin. The average price of imported acidspar rose $3 to $4 per ton, a significantly smaller increase than the price increases reported for domestic fluorspar. No appreciable price changes were indicated for metspar of 70 to 97 percent CaF_2 on the domestic or foreign market. The December 1970 issue of Engineering and Mining Journal quoted the following prices per short ton for the principal commercial grades of fluorspar:

	1969	1970
Domestic f.o.b. Illinois-Kentucky:		
Metallurgical-grade 72½ percent effective CaF_2	$47.50–48.50	$47.50–48.50
Pellets, 70 percent effective CaF_2	50.00–57.00	52.00
Acid-grade concentrates, dry basis, 97 percent CaF_2:		
Carloads	57.50	62.00–75.00
Less than carloads	59.50	62.50–77.00
Bags, extra	5.00	6.00
Pellets, 90 percent effective CaF_2	56.00–60.00	56.00–60.00
Ceramic-grade, 95 to 96 percent CaF_2	55.00	60.00–70.00
European:		
Acid-grade, duty paid, dry basis	47.50–50.00	53.00
Mexican:		
Metallurgical-grade, 70 percent effective CaF_2-border, all rail, f.o.b. cars	30.15	30.15
Tampico, Mexico, f.o.b. vessel	30.15	31.15
Acid-grade, 97+ percent, Eagle Pass, Tex., bulk	47.00–51.00	52.00

Source: Engineering and Mining Journal, December, 1969 and 1970.

FOREIGN TRADE

The United States exported 15,000 tons of both grades of fluorspar in 1970, an increase over the 1968 and 1969 totals. The largest shipments went to Japan and Canada. Japan purchased acid-spar and Canada, mostly met-spar.

U.S. imports of all grades of fluorspar totaled 1,092,000 tons in 1970, a decrease of about 5 percent from that of the previous year. A decrease of 8 percent in the met-spar imports was the cause of most of the decline. Imports accounted for 80 percent of domestic consumption. Mexico provided 76 percent of the total fluorspar imported into the United States, Spain supplied 13 percent, and Italy supplied 8 percent. Other suppliers were the United Kingdom, Brazil, West Germany, and the Republic of South Africa.

Imports from Mexico decreased 3½ percent. This decrease was due to an 8-percent decline in imports of met-spar. Imports of acid-spar from Mexico increased slightly. Imports of acid-spar from Spain decreased 15 percent from the peak year of 1969. Imports of acid-spar from Italy showed a 5-percent decline.

Table 7.—U.S exports of fluorspar and customs district

	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	6,975	$252,887	1,627	$84,339	2,670	$137,533
Germany, West	783	28,232	450	16,189	279	13,046
India	4,143	181,939	1,429	93,242	55	7,426
Japan	10	400	-------	-------	11,720	960,896
Switzerland	421	15,144	-------	-------	28	2,410
United Kingdom	18	2,646	24	1,090	50	1,792
Other countries	263	15,036	75	18,441	150	21,758
Total	[1] 12,614	496,284	3,605	213,301	14,952	1,144,861

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

Table 8.—U.S. imports for consumption of fluorspar, by countries and customs district

Country and customs district	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
CONTAINING MORE THAN 97 PERCENT CALCIUM FLUORIDE				
France: New York City	110	$8	-------	-------
Germany, West: Philadelphia, Pa	-------	-------	4,152	$220
Italy:				
Cleveland, Ohio	13,635	507	-------	-------
Detroit, Mich	-------	-------	8,496	340
Galveston, Tex	31,875	1,023	33,133	1,168
New Orleans, La	37,880	1,326	38,136	1,373
Philadelphia, Pa	5,952	251	4,910	198
Total	89,342	3,107	84,675	3,079
Mexico:				
El Paso, Tex	69,957	2,073	67,718	1,754
Houston, Tex	796	24	1,045	36
Laredo, Tex	304,364	9,152	292,159	9,139
New Orleans, La	43,884	1,615	38,438	1,582
Nogales, Ariz	-------	-------	18,742	669
Philadelphia, Pa	12,795	444	15,314	535
San Diego, Calif	-------	-------	1,987	64
Total	431,796	13,308	435,403	13,779
Spain:				
Cleveland, Ohio	30,268	1,131	14,005	603
Detroit, Mich	29,270	885	27,788	1,154
New Orleans, La	11,210	387	-------	-------
Philadelphia, Pa	95,417	3,798	98,773	4,200
Total	166,165	6,201	140,566	5,957
South Africa, Republic of: Galveston, Tex	5,606	187	-------	-------

See footnote at end of table.

Table 8.—U.S. imports for consumption of fluorspar, by countries and customs district—Continued

Country and customs district	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
CONTAINING MORE THAN 97 PERCENT CALCIUM FLOURIDE—Continued				
United Kingdom:				
Buffalo, N.Y.	17	1	-------	-------
Cleveland, Ohio	-------	-------	7,006	$278
Detroit, Mich	1,441	58	3,967	63
Ogdensburg, N.Y.	50	4	-------	-------
San Juan, Puerto Rico	151	10	-------	-------
Total	1,659	73	10,973	341
Grand total	694,678	22,884	675,769	23,376
CONTAINING NOT MORE THAN 97 PERCENT CALCIUM FLUORIDE				
Brazil: New Orleans, La	11,346	319	10,587	298
Canada:				
Buffalo, N.Y.	67	3	-------	-------
Cleveland, Ohio	2,238	69	-------	-------
Total	2,305	72	-------	-------
Italy: Houston, Tex	-------	-------	662	48
Mexico:				
Baltimore, Md	28,762	743	37,349	1,300
Buffalo, N.Y.	38,949	1,041	7,238	283
Chicago, Ill	1,295	34	8,478	317
Cleveland, Ohio	32,870	1,034	19,787	795
Detroit, Mich	23,790	752	11,683	409
El Paso, Tex	65,387	1,312	42,815	826
Laredo, Tex	189,138	2,989	231,827	3,638
New Orleans, La	36,509	959	15,222	394
Philadelphia, Pa	17,431	501	24,432	886
San Francisco, Calif	66	1	1,455	34
Total	434,197	9,366	400,286	8,882
South Africa, Republic of:				
Baltimore, Md	-------	-------	101	3
New Orleans, La	6,944	172	-------	-------
Philadelphia, Pa	-------	-------	4,913	151
Total	6,944	172	5,014	154
Spain: Philadelphia, Pa	6	(1)	-------	-------
United Kingdom:				
Buffalo, N.Y.	20	1	-------	-------
San Juan, Puerto Rico	50	4	-------	-------
Total	70	5	-------	-------
Grand total	454,868	9,934	416,549	9,382

1 Less than ½ unit.

WORLD REVIEW

Canada.—The bulk of Canada's fluorspar continues to come from the Burin Peninsula of Newfoundland. Canada's production increased 4 percent, continuing the steady increase started in 1967. Canada remains a net importer of fluorspar, mostly from Mexico.

France.—France produced about 320,000 tons of fluorspar and recorded a 5.6 percent increase. About 130,000 tons was reported to be consumed domestically. Most of its exported fluorspar went to European countries.

Germany, West.—West Germany produced 96,000 tons, which reflects no appreciable change since 1967. Although it exports small quantities, mostly to European countries, it reportedly imports about 270,000 tons of met-spar. Farbenfabriken Bayer, A.G. purchased controlling interest in the second of four froth flotation plants in West Germany.[7]

Italy.—Italy increased production 12 percent to about 319,000 tons, continuing its steady increase started in the early sixties.

7 Industrial Minerals (London). Bayers New Fluorspar Mining Subsidiary. V. 30, March 1970, p. 34.

Italy exports mostly to the United States and European countries. The fluorspar-mining industry is dominated by two companies which are Montecatini Edison, S.p.A. and Mineraria-Silius of the C. E. Giulini group.

Mexico.—Mexico remains the largest producer of fluorspar in the world and has the largest reported reserves. Mexico produced 1,079,000 tons in 1970, a decrease of 1 percent from the 1969 production. About 55 percent of its production is 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. At Parral, Chihuahua, the mill tailings, derived from two base-metal concentrating plants assay 15 to 25 percent CaF_2 and are being processed by froth-flotation to produce acid-spar. In 1970, construction was underway at these two plants, to double their production. At Bolanos, Jalisco, near Zacatecas, a similar flotation plant to extract fluorspar from tailings was announced for construction in 1971. In June 1970, Fluoruros de Hidalgo announced that it was in the process of constructing a fluorspar-flotation mill of 20,000 to 25,000-ton-per-year capacity, near Ixmiquilpan in the State of Hidalgo. Fluoresqueda, S.A., resumed production of 3,000 tons per month of acid-spar at its Esqueda, Sonara, flotation plant.[8]

Several new acid-spar-producing flotation plants or enlargements of currently producing plants including those previously mentioned were under construction in 1970, and when completed in 1971 should increase the production capacity by about 100,000 tons per year.

During 1970 operations continued at a 5,000-ton-per-year hydrofluoric acid plant at San Luis Potosi and a 3,000-ton-per-year plant at Monterrey.

In August 1970, the Mexican Department of Industry and Commerce resolved that raw materials mined in Mexico should be converted into finished or semifinished products of higher value than the run-of-the-mine or normally exported, thereby promoting more employment in

[8] Industrial Minerals (London). Fluorspar Mill for Hidalgo. V. 33, June 1970, p. 46.

Table 9.—Fluorspar: World production by countries
(Short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada [2]	100,600	131,600	136,800
Mexico	r 1,020,740	1,089,420	1,078,594
United States (shipments)	252,411	182,567	269,221
South America:			
Argentina	r 23,708	32,383	e 33,000
Brazil	NA	NA	e 40,000
Europe:			
Czechoslovakia e	55,000	65,000	90,000
France (marketable)	r 287,212	303,000	320,000
Germany, East e	r 90,000	r 90,000	90,000
Germany, West (marketable)	r 96,721	93,438	96,173
Italy	r 248,484	284,161	318,861
Spain (marketable)	r 340,938	336,771	373,413
United Kingdom [3]	r 216,161	209,767	e 235,000
U.S.S.R. e	420,000	440,000	450,000
Africa:			
Kenya	212	2,051	4,303
Rhodesia, Southern e	165	165	165
South Africa, Republic of	119,667	165,651	190,693
Tunisia	6,008	13,665	33,841
Asia:			
China, mainland e	r 280,000	r 280,000	300,000
India	1,305	2,385	5,122
Japan	r 14,180	14,067	8,853
Korea, North e	33,000	33,000	33,000
Korea, Republic of	51,372	43,181	52,668
Mongolia e	r 77,000	r 86,000	88,000
Thailand	r 270,184	328,003	350,785
Turkey	r 1,903	2,308	1,835
Total	r 4,006,971	r 4,228,583	4,600,327

e Estimate. p Preliminary. r Revised. NA Not available.
[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] Output of Newfoundland Fluorspar Works of Aluminum Co. of Canada.
[3] Includes material recovered from lead-zinc mine dumps.

Table 10.—World trade in fluorspar [1] in 1969

(Short tons)

Sources	Destinations: Australia [2]	Austria	Belgium-Luxembourg	Canada	Germany, West	India	Italy	Japan	Netherlands	Poland	Sweden	U.S.S.R.	United States	Other [3]	Total receipts by listed destinations	Total recorded exports
Argentina	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	550
Brazil	----	----	----	----	----	----	----	----	----	----	----	----	11,346	----	11,346	11,395
Canada	----	----	----	XX	----	272	----	----	----	----	----	----	2,305	----	2,577	NA
China, mainland	814	----	408	----	----	----	----	134,420	----	19,315	4,836	19,400	----	2,191	181,384	NA
France	258	683	10,607	----	----	----	11,367	----	2,746	----	5,290	----	110	1,668	32,729	112,684
Germany, East	----	----	1,877	----	----	117	504	----	----	11,018	1,597	----	----	2,751	17,864	NA
Germany, West	----	3,873	2,092	----	XX	2,196	173	----	338	----	888	----	----	1,447	11,007	10,974
Italy	----	2,280	----	----	8,354	3,978	XX	----	----	----	----	----	89,342	606	104,560	155,539
Japan	----	----	----	----	----	----	----	----	----	----	----	[4] 38,100	----	----	38,100	[5] 5,359
Korea, North	----	----	----	----	----	----	----	4,742	----	----	----	----	----	----	4,742	NA
Korea, Republic of	----	----	----	----	----	----	----	39,756	----	----	----	----	----	----	39,756	40,958
Mexico	----	----	----	85,135	19,813	----	10,834	18,392	----	----	----	----	865,993	----	1,000,167	1,075,133
Mongolia	----	----	----	----	----	----	----	----	----	----	----	83,600	----	----	83,600	NA
Mozambique [6]	----	----	----	----	----	----	----	2,400	----	----	223	----	----	----	2,623	----
South Africa, Republic of	13,683	----	----	----	6,846	----	8,978	75,769	----	----	6,482	----	12,550	7,758	132,066	124,897
Spain	----	----	----	----	30,664	----	----	----	----	----	----	----	166,171	2,205	199,040	222,610
Thailand	----	----	----	----	----	3,186	----	280,669	----	----	----	----	----	----	283,855	174,123
Tunisia	----	----	----	----	----	----	551	----	----	----	----	----	----	----	551	NA
U.S.S.R.	----	----	----	----	----	----	----	10,512	----	----	----	----	----	----	10,512	NA
United Kingdom	7,248	----	----	16,010	----	987	----	8,595	----	----	578	----	1,729	2,142	37,289	NA
United States	----	----	----	3,237	----	3,230	2	4	----	----	----	----	XX	----	6,473	3,605
Other and unspecified	245	2,320	553	----	114,024	1,646	----	----	27,776	----	56	6,700	----	4,735	158,055	NA
Total	22,248	9,156	15,537	104,382	179,701	15,612	32,409	575,259	30,860	30,333	19,950	147,800	1,149,546	25,503	2,358,296	NA

NA Not available. XX Not applicable.

[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, 1969.

[3] Countries included and total imports by each in short tons are Denmark, 1,905; Finland, 7,264; France, 7,417; Israel, 190; Norway, 2,530; Turkey, 2,813; Venezuela, 63; Yugoslavia, 3,321. Totals for Denmark, Finland, France, Norway, and Yugoslavia are distributed by source country. Details on source countries for imports of Israel, Turkey, and Venezuela 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.

Mexico. The Department stated further: "National producers of acid-grade fluoride are obligated to supply, on a preferred basis, the Mexican industry producing 'acid fluorhydroxide' (HF) or any other product processed from acid-grade fluoride," before exportation of any acid-grade fluoride. Historically, exported acid-spar has sold for 30 to 50 percent more than exported met-spar, and the Mexican Government desires to sell more of the higher priced raw materials, including hydrofluoric acid. The Mexican domestic market is small. In 1970 Mexico consumed less than 40,000 tons of fluor-spar.

The Mexicanization of foreign-owned or foreign-controlled fluorspar mining companies, in which Mexican companies obtain ownership of 51 percent or more of the company, has progressed to where most of the major producing companies are said to be Mexicanized. Industrias Peñoles, S.A., in buying control of two Mexican subsidiaries of U.S. companies, will probably become the largest fluorspar producer in Mexico.

South Africa, Republic of.—The Republic of South Africa continued to be the largest producer of fluorspar in Africa, increasing its production 15 percent to 190,000 tons. New fluorspar deposits have been discovered and are being developed. About 80 percent of South Africa's production is exported, and it ships both acid-spar and met-spar all over the world.

Spain.—Spain increased its production by 11 percent to 373,000 tons, thereby continuing its strong growth trend. Its largest export market was the United States; the next largest market was West Germany.

Thailand.—Thailand is the largest fluorspar producer in Asia. It increased production 7 percent, to 351,000 tons in 1970, continuing its strong growth trend. Although production increase was not as great as it was between 1966 and 1969, it proved its capability to expand with the demand. Most of the production has gone to Japan as met-spar. Thailand is encouraging foreign companies to construct froth-flotation plants in Thailand so it can export the higher priced acid-spar and utilize all of its currently wasted, hand-separated, low-grade fluorspar. Construction in 1971 of a froth-flotation plant in Thailand was announced by Thai Fluorite Processing Co. Ltd., a subsidiary of Kaiser Cement Co., and in 1972 it expects to export acid-spar.[9]

TECHNOLOGY

A new industry is rapidly developing in which fluorine compounds are produced from fluosilicic acid, a normally wasted byproduct derived from processing phosphate rock to produce phosphoric acid and superphosphate. The results of this salvaging process are being watched closely by the fluorspar industry, because if it is proven to be economically successful, the process will contribute additional fluorine supplies, reduce polluting fluorine emissions, and subsequently reduce U.S. dependence on foreign supplies of fluorspar. Results of U.S. Bureau of Mines laboratory tests on recovery of HF from fluosilicic acid have been published.[10]

A major fluorspar producer is making silver fluorides in increasing quantities. The argentic fluoride is a powerful fluorinating agent, whereas the argentous fluoride is only moderately active. Its special use is in the preparation of fluorosteroids.[11]

CRYOLITE

The production of synthetic cryolite from byproduct fluosilicic acid, which is a waste product of the phosphate fertilizer industry, may have a major effect on the supply of cryolite. More installations of this type and those for reclaiming cryolite from aluminum pot linings are anticipated. In table 11 it may be noted that U.S. imports of cryolite for 1969–70 averaged 20,891 tons, and for 1967–68 averaged 35,045 tons, a 40 percent decrease in imports. The increase in manufacturing synthetic cryolite in the United States probably accounts for some of the decrease in imports, but the closing down of the natural croylite mine at Ivigtut, Greenland in 1969, probably accounts for the largest import reduction.

[9] Engineering and Mining Journal. Fluorite Industry Booming in Thailand. June 1971, p. 30.

[10] Blake, Jr., H. E., W. S. Thomas, K. W. Moser, J. L. Reuss, and H. Dolezal. Utilization of Waste Fluosilicic Acid. BuMines Rept. Inv. 7502, April 1971, 60 pp.

[11] European Chemical News. New Products. V. 18, No. 448, Sept. 4, 1970, p. 46.

PRICES

Prices quoted in the Oil, Paint and Drug Reporter, December 28, 1970, for cryolite were as follows: Natural, industrial, in bags, at works, carlots, $15 per 100 pounds; less than carlots, $16.75 per 100 pounds; synthetic, bult, at works, carlots, $240 per short ton; synthetic, in bags, same basis, $255 per short ton.

Table 11.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value (thousands)
1967	36,319	$4,118
1968	33,772	5,455
1969:		
Canada	2,535	476
Denmark	11	3
France	3,144	648
Germany, West	987	220
Italy	13,317	2,824
Japan	110	21
Spain	280	56
Switzerland	22	3
Total	20,406	4,251
1970:		
Canada	1,328	294
Czechoslovakia	77	18
Denmark	606	233
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.	329	115
Total	21,377	4,666

1 Less than ½ unit.

Gem Stones

By Robert G. Clarke [1]

Domestic gem stone production was estimated at $2.4 million in 1970, unchanged from that of 1969. Gem stone collection continued to be principally a recreational activity of individual collectors and hobbyists at free or fee sites. Only 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 by the deposit operators.

DOMESTIC PRODUCTION

Gem stone production was reported from 38 States. The following States led in production and accounted for 78 percent of the total: Oregon, $750,000; California, $200,000; Arizona, $155,000; Texas, $150,000; Washington, $150,000; Wyoming, $130,000; Colorado, $120,000; Montana, $109,000; and Nevada, $100,000.

Many States publish brochures describing their major occurrences of gem stones and minerals, including maps and instructions on how to reach the deposits. The brochures are free and usually may be obtained from the individual State Department of Economic Development, or from the State Geologist.

Reports of activities in gem collecting included all varieties of precious and semiprecious stones. In Louisiana, an 18.20 carat diamond was found in Princeton, in a yard, by a little girl at play.[2] It was named the LaMounce diamond for Louisiana (La), and Mr. Mounce, the jeweler who purchased it. It has since been cut into three fine gems by Lazare Kaplan and Sons of New York City; an oval, a marquise, and a heart shape.

In South Dakota, the Cheyenne River Agency of the South Dakota Sioux operated a quarry near Rapid City for alabaster which was handcrafted at the Sioux Stone Craft Co.[3] Third year sales exceeded the total of the first 2 years combined. Many accounts of interesting field trips resulting in mineral and gem stone finds were related in journals for enthusiasts.[4] [5] Many clubs and societies reported on the activities of their members.

CONSUMPTION

The output of domestic gem stones 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) declined to $292 million, compared with $343 million in 1969 because of greater exports and reexports of diamonds.

PRICES

During the year, price ranges for cut and polished, unmounted gem diamond were as follows: 0.25 carat, $100 to $425; 0.50 carat, $275 to $900; 1 carat, $700 to $2,800; 2 carats, $2,000 to $9,500; and 3 carats, $4,000 to $20,000. The median price for each range was 0.25 carat, $200; 0.5 carat, $500; 1 carat, $1,550; 2 carats, $4,100; and 3 carats, $8,500.

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[1] Physical scientist, Division of Nonmetallic Minerals.

[2] Lapidary Journal. Diamond Found in Louisiana. V. 24, No. 8, November 1970, p. 1122.

[3] Lapidary Journal. Stone Age Provides New Business for Sioux. V. 24, No. 7, October 1970, p. 925.

[4] Gems and Minerals. News Notes of Collecting Areas. No. 388, January 1970–No. 399, December 1970.

[5] Rocks and Minerals. Mineral Localities Information Department. V. 45, No. 1, January 1970–V. 45, No. 12, December 1970.

FOREIGN TRADE

United States exports of diamond in 1970, on which some work was done prior to reexport, amounted to 391,599 carats valued at $116.6 million. Of this total, diamonds, cut but unset, suitable for gem stones, not classified by weight, were 93,937 carats valued at $5.3 million; cut but unset, suitable for gem stones, not over ½ carat, were 49,297 carats valued at $5.4 million; and, cut but unset, suitable for gem stones, over ½ carat, were 248,365 carats valued at $105.9 million.

Reexports of diamond in 1970, on which no work was done, amounted to 1,258,146 carats valued at $67.8 million in the following categories: Cut but unset, suitable for gem stones, not classified by weight, 1,213,958 carats valued at $58.5 million; cut but unset, suitable for gem stones, not over ½ carat, 28,704 carats valued at $4.4 million; cut but unset, suitable for gem stones, over ½ carat, 15,484 carats valued at $4,920,588.

Exports and reexports of all other gem materials amounted to $12.4 million. Of this total, natural precious and semiprecious stones, worked or unworked, not set or strung, were valued at $11.1 million. Exports and reexports of pearls, natural and cultured, not set or strung, were valued at $0.9 million. Synthetic or reconstructed precious or semiprecious stones, not set or strung, exports and reexports, were valued at $0.4 million.

Imports of gem material decreased 14 percent in value compared with that of 1969. Gem diamonds accounted for 87 percent of the total value of imports.

Imports of emeralds decreased 16 percent in value, but increased 6 percent in quantity. Of 24 countries supplying emeralds to the United States, India furnished 215,664 carats valued at $2.8 million; Brazil, 33,565 carats valued at $0.6 million; and Colombia, 17,419 carats valued at $1.5 million. These three countries furnished 82 percent of the quantity (in carats) and 64 percent of the value of emeralds. Imports of emeralds from Switzerland amounted to 14,224 carats valued at $1.2 million, but the actual country of origin is unknown.

Imports of rubies and sapphires decreased 37 percent in value from 29 countries. Four countries accounted for 76 percent of the value of rubies and sapphires as follows: Thailand, $2.3 million; India, $0.9 million; Ceylon, $0.7 million; and Hong Kong, $0.5 million. The value of imported natural and cultured pearls decreased 22 and 17 percent, respectively; the value of imported imitation pearls increased 122 percent.

Table 1.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1969		1970	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut ... carats	2,932	$287,566	2,633	$234,164
Cut but unset ... do	1,758	217,081	1,642	190,733
Emeralds: Cut but unset ... do	309	9,175	326	7,715
Rubies and sapphires: Cut but unset	NA	9,201	NA	5,769
Marcasites	NA	6	NA	4
Pearls:				
Natural	NA	475	NA	371
Cultured	NA	12,238	NA	10,184
Imitation	NA	672	NA	1,493
Other precious and semiprecious stones:				
Rough and uncut	NA	4,847	NA	10,001
Cut but unset	NA	12,799	NA	12,034
Other, n.s.p.f	NA	559	NA	590
Synthetic:				
Cut but unset ... number	4,886	2,793	7,333	4,363
Other	NA	282	NA	526
Imitation gem stones	NA	8,999	NA	8,096
Total	NA	566,693	NA	486,043

NA Not available.

Table 2.–U.S. imports for consumption of diamond (exclusive of industrial diamond), by countries

(Thousand carats and thousand dollars)

Country	1968				1969				1970			
	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	46	$7,455	954	$119,396	59	$6,729	916	$113,114	64	$6,572	863	$103,705
Brazil	10	594	(1)	8	29	1,033	1	58	31	1,184	1	80
Canada	9	1,256	5	205	8	1,307	(1)	54	2	462	1	60
Central African Republic	218	11,818	1	61	232	9,806	---	---	165	5,826	---	---
France	22	1,004	22	2,514	10	379	20	2,484	4	195	27	2,550
Germany, West	(1)	2	5	556	1	13	5	507	2	117	4	516
Guyana	14	830	(1)	5	20	1,020	---	---	26	1,074	(1)	19
India	---	---	30	2,714	---	---	30	2,663	---	---	40	3,475
Israel	50	5,245	666	70,217	36	4,155	658	73,777	52	6,723	604	61,753
Japan	(1)	52	1	100	(1)	5	1	71	(1)	20	(1)	18
Liberia	7	1,898	---	---	13	2,976	---	---	6	1,893	---	---
Netherlands	46	9,953	19	3,073	48	12,810	27	3,561	23	7,886	13	1,899
Sierra Leone	61	1,892	9	1,310	224	8,331	10	1,447	---	---	6	814
South Africa, Republic of	434	46,380	35	9,076	361	41,585	28	8,713	593	54,571	26	6,868
Switzerland	20	2,039	4	785	6	1,043	3	919	4	354	1	262
U.S.S.R.	---	---	63	9,588	---	---	43	6,629	---	---	44	6,826
United Kingdom	1,439	152,881	17	2,239	1,697	185,278	9	1,496	1,432	140,243	6	970
Venezuela	95	3,468	---	---	157	5,439	---	---	223	6,333	---	---
Western Africa, n.e.c.	36	5,614	(1)	5	27	5,210	---	---	1	366	---	---
Other countries	7	272	3	626	4	447	7	1,588	5	345	6	918
Total	2,514	252,653	1,834	222,478	2,932	287,566	1,758	217,081	2,633	234,164	1,642	190,733

[1] Less than ½ unit.

WORLD REVIEW

Angola.—Diamond exports amounted to 2,239,912 carats, compared with 1,980,394 carats in 1969. The number of exploration projects increased tremendously because most of the area previously held exclusively for Companhia de Diamantes de Angola (DIAMANG) has been released, particularly at sites near Luanda and Gabela.

Australia.—A large kimberlite intrusion was located by a team working for Stellar Mining Co. in the Kimberley district of Western Australia, where gems have been discovered in prior years.[6]

Botswana.—Work at the Orapa pipe, covering 276 acres, claimed to be the world's second largest, proceeded on schedule.[7] The indicated recovery ratio of industrial diamond to gem diamond was 90 to 10. First stage development was forecast for July 1971 at 7,250 metric tons per day to yield 2 million carats per year.

Brazil.—Dredging activity for diamond in the Rio Jequitinhonha was increased 50 percent by the transfer of a dredge formerly used for gold recovery in the Rio das Belhas by Mineração Tejucana S.A., of Minas Gerais. Geologists reportedly found diamond pipe or kimberley-like deposits of diamonds in Piauí State.[8] Opals in large quantities were also reported from Piauí State. Exact weight and value of gem production were unavailable, but the Federal Government of Brazil has set up a Gem Bank in Minas Gerais State to control the gem industry.

Central African Republic.—Diamond production fell 18 percent in value and 10 percent in volume from 1969. Most of the decrease was due to disagreements between mining companies and the Government. Also, in 1970 the Government passed a law forbidding anyone but native-born citizens from prospecting for diamonds or other precious stones.

Congo, Kinshasa.—In 1970 the total output of diamonds, both gem and industrial, was almost equal to that of 1969. However, the amount of gem diamonds (in carats) increased 256 percent. The increase in gem diamonds reflected a decrease in industrial diamonds, which alleviated slightly the Government's distress in light of the planned sales of U.S. surplus industrial diamond holdings. The Congo retained its world rank of number one for total natural diamonds produced.

India.—The National Mineral Development Corp. operated the nationalized diamond industry in the Panna district more vigorously, and also conducted prospecting operations at Angore, in the Chhatarpur district, and at Andhra Pradesh, in the Anantpur district.[9] India aimed to satisfy domestic diamond demand through domestic production. India imported rough diamonds purchased through the Central Selling Organization (CSO) and reexported finished gems.

Israel.—The decrease in general business activity in the United States in 1970 affected the two countries that import the greatest amount of rough diamonds and export the greatest amount of polished diamonds. Belgium ranked first and Israel ranked second, and both countries procured most of their rough diamonds through the CSO. At Tel Aviv, in the world's largest diamond exchange, daily transactions in 1970 were estimated at $60 million.[10]

Ivory Coast.—Diamond production in 1970 increased 5 percent over that of 1969. A new plant at Tortiya (south of Korogho) was started to treat low-grade ore. Improvements were also made at older plants at Seguela. The increase in production from all plants was estimated at 30 percent, and will be reflected in future reports. Output of diamonds from Ivory Coast is estimated to be 40 percent gem stones.

Kenya.—Gem stone production included amethyst, sapphire, ruby, garnet, tourmaline, aquamarine, and zircon. Indicated quantities and value were greater than in 1969.

Liberia.—Exports of rough diamonds were reported as 775,500 carats valued at $5.5 million. No distinction was made between gem diamonds and industrial diamonds, but according to a report by the Director of the Bureau of Natural Resources and Surveys of Liberia, most of the diamond output was not high quality.

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6 Mining & Mineral Engineering (London). V. 6, No. 12, December 1970, p. 53.

7 Mining Magazine. Botswana Diamonds. V. 123, No. 6, December 1970, p. 473.

8 Rolff, Almeida. Gem News From Brazil. Lapidary J., v. 24, No. 3, June 1970, pp. 514–516.

9 Singh, D. V. A Review on Diamond and Its Beneficiation. J. Mines, Metals and Fuels, v. 18, No. 11, November 1970, pp. 399–406.

10 Time. Israel, the Kindest Cut of All. V. 96, No. 7, Aug. 17, 1970, p. 62.

Table 3.—Diamond: World production, by countries [1]

(Thousand carats)

Country [2]	1968 Gem	1968 Industrial	1968 Total	1969 Gem	1969 Industrial	1969 Total	1970 [p] Gem	1970 [p] Industrial	1970 [p] Total
Africa:									
Angola	1,316	351	1,667	1,617	404	2,021	1,917	479	2,396
Central African Republic	305	304	609	268	267	535	241	241	482
Congo (Kinshasa)	551	11,353	11,904	491	13,625	14,116	1,750	12,336	14,086
Ghana	245	2,202	2,447	239	2,152	2,391	252	2,271	2,523
Guinea [e]	21	49	70	22	50	72	22	52	[3] 74
Ivory Coast	77	110	187	81	121	202	85	128	213
Lesotho	2	10	12	5	24	29	4	13	17
Liberia [4]	537	212	749	562	184	746	[5] 620	[5] 206	[5] 826
Sierra Leone	560	962	1,522	736	1,253	1,989	[5] 723	[5] 1,232	[5] 1,955
South Africa, Republic of:									
Premier mine	[r] 608	1,824	2,432	631	1,891	2,522	669	2,008	[6] 2,677
Other De Beers Company [7]	[r] 2,313	1,892	4,205	2,457	2,010	4,467	[e] 2,511	[e] 2,054	[e] 4,565
Other	[r] 478	318	796	524	350	874	[e] 522	[e] 348	[e] 870
Total, South Africa, Republic of	[r] 3,399	4,034	7,433	3,612	4,251	7,863	3,702	4,410	8,112
South-West Africa, Territory of	1,636	86	1,722	1,923	101	2,024	[e] 2,100	[e] 100	[e] 2,200
Tanzania	356	346	702	394	383	777	359	349	708
Other areas:									
Brazil [e]	160	160	320	160	160	320	160	160	320
Guyana	28	38	66	21	31	52	24	37	61
India	7	2	9	10	2	12	[e] 10	[e] 2	[e] 12
Indonesia [e]	14	6	20	14	6	20	14	6	20
U.S.S.R. [e]	1,400	5,600	7,000	1,500	6,000	7,500	1,600	6,250	7,850
Venezuela	60	54	114	118	76	194	129	371	500
World total	[r] 10,674	25,879	36,553	11,773	29,090	40,863	13,712	28,643	42,355

[e] Estimate. [p] Preliminary. [r] Revised.

[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 the case of all countries except Angola, Congo (Kinshasa), Lesotho (1969 only), Liberia, and Venezuela, where sources list both total output and the detail. The estimated distribution of the total in the case of several countries is conjectural, based on unofficial sources of varying reliability.

[2] In addition to the countries listed, Botswana also produces diamond, but output statistics are regarded as confidential by the producer, and there is insufficient general information to prepare reliable estimates.

[3] Government of Guinea estimate.

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

[5] Exports.

[6] Officially reported production of nonalluvial stones from Transvaal; the Premier mine is the only major source of such stones in the Transvaal.

[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.

Sierra Leone.—Diamonds are the country's most important mineral resource. To derive maximum benefit from its diamond resources, the Government acquired majority control (51 percent) of Sierra Leone Selection Trust Ltd. (SLST), which had the concession to about 450 square miles of the best diamond area. A new company, the National Diamond Mining Co., Ltd. (DIMINCO) was formed. Diamond exports dropped owing to the depressed world diamond market.[11]

South Africa, Republica of.—From the best information available, South Africa ranked second in total diamond production and first in gem diamonds in 1970. The Department of Mines also reported production of 7,500,000 carats of emerald, of which 4,975,000 carats was exported; and 1,150 short tons of Tiger's-Eye, of which 139 short tons was exported. In the annual report of De Beers Consolidated Mines Ltd., sales by the CSO were 23 percent less than sales in 1969, and the book value of diamonds-on-hand increased 92 percent.[12]

Southern Rhodesia.—A large emerald crystal, 2 inches high by 3 inches across, weighing 1,160 carats, was found at the Chikwanda mine of Rhodesia Star mines, Fort Victoria, Rhodesia, in late December 1969. If a cut gem stone was produced from it, one appraiser estimated the gem could be worth $2 million. The collector, who has acquired it, intends to keep it uncut.[13]

Tanzania.—Diamonds were the principal mineral mined and almost the entire output came from Williamson Diamonds Ltd., which is 50 percent Government owned. Prospecting for colored gem stones attracted numerous small miners in the northern sections for minerals such as tanzanite.[14]

U.S.S.R.—Diamond production increased in 1970 and was claimed by the U.S.S.R. to rank second in the world. However, most of the output was industrial diamond, and was from the pipes in Yakutia near Mirny. Gem deposits were reported to have been discovered in the Turkestan mountain range in Uzbekistan and included turquoise, amethyst, chalcedony, jasper, and selenite.[15]

TECHNOLOGY

The practical aspects of the diamond cutter's art, from cleaving and sawing to the final facetting operations were described; and the assistance of science was explained as an aid to the cutter in understanding the structure and properties of the diamond crystal.[16]

Pigmented synthetic quartz crystals of large size (up to 2 pounds) in citrine, peridine, and cobalt blue colors, developed by Soviet scientists, and believed to be intended for less expensive jewelry items, were displayed at gem shows as crystals and in cut form in jewelry.[17]

On May 28, 1970, General Electric Corp. made public its progress in developing man-made, gem-quality diamonds up to 1 carat in size, but the cost of their production exceeded that of natural stones.[18]

The defects of the crystalline structure of a natural emerald from Muzo, Colombia, and of an artificial emerald synthesized by Gilson, were studied by X-ray. The study revealed zoning of strong misorientations in the natural crystals and a high number of irregularities of curved grains in the synthetic.[19]

Polarized absorption spectra of natural yellow, green, and blue sapphires, and of synthetic blue sapphires grown by the Verneuil process were studied and interpreted for the roles of titanium and iron in the resulting colors.[20]

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[11] Bureau of Mines. Mineral Trade Notes. Diamonds. V. 68, No. 2, pp. 8, 9.

[12] Mining Journal. De Beers Consolidated Mines Ltd. Annual Report. V. 276, No. 7082, May 14, 1971, pp. 389–395.

[13] Lapidary Journal. Giant Emerald Crystal Found at Ft. Victoria, Rhodesia. V. 24, No. 4, July 1970, p. 646.

[14] Skilling's Mining Review. Diamonds and Gold Are Leading Exports of Tanzania. V. 59, No. 48, Nov. 28, 1970, pp. 14, 15.

[15] Mining Journal. V. 276, No. 7082, May 14, 1971, p. 391.

[16] Rainier, D. M. How Gem Diamonds are Fashioned. Ind. Diamond Rev., v. 30, No. 358, September 1970, pp. 350–357.

[17] Pough, F. H. Colored Synthetic Quartz From Russia. Lapidary J., v. 24, No. 3, June 1970, pp. 444–446.

[18] Lapidary Journal. G. E. Announces First Man–Made Gem–Quality Diamonds. V. 24, No. 4, July 1970, pp. 540–548.

[19] Schubnel, H. J., and A. Zarka. Topographie Aux Rayons X D'une Émeraude Naturelle et D'une Émeraude Artificielle. Association Francoise de Gemmologie. Bull. No. 25, December 1970, pp. 7–10.

[20] Lehmann, G. and H. Harder. Optical Spectra of Di- and Trivalent Iron in Corundum. The Am. Miner., v. 55, Nos. 1 and 2, January–February 1970, pp. 98–105.

Gold

By Charles D. Hoyt [1]

In contrast to 1968–69, 1970 was a year of calm for the gold industry. Prices remained near the monetary level of $35 per ounce until October, when they surged to over $39 per ounce. The two most important events of 1970 concerning gold were the South African-International Monetary Fund (IMF) agreement,[2] which essentially placed a $35 floor on free-market gold prices, and the introduction and use by the IMF of special drawing rights (SDR) as a new international reserve asset. Both of these developments contributed to the price stability of gold in 1970.

World gold output reached a new high in 1970 of 47 million ounces. South Africa provided over two-thirds of the production. The U.S.S.R., with an estimated output of 6.5 million ounces, was by far the second largest producer. Canada and the United States ranked third and fourth, respectively.

Domestic gold output increased modestly to about 1.74 million ounces. Reduced economic activity in the United States in 1970 caused a sharp drop in industrial consumption of gold, which in turn also lowered gold imports for industrial use by about one-sixth.

The estimated total world gold reserves of non-Communist central banks and governments at the end of December 1970 was almost $41.3 billion, a slight increase over that of 1969. The U.S. gold reserves at the end of 1970 were $11,072 million, which included both Treasury gold ($10,732 million) and Exchange Stabilization Fund gold deposits.

Legislative and Government Programs.— On January 1, 1970, IMF made the first allocation of $3,414 million in SDR to 104 participants. The United States, the United Kingdom, West Germany, and France had the largest allocations which were issued at a rate equal to 16.8 percent of IMF quotas. In the first year of operation for the SDR, or "paper gold" as they are often called, 37 IMF members exchanged $472 million in SDR. At yearend, plans were made to distribute the second allotment of almost $3 billion in SDR, which were to be issued on January 1, 1971. The first year of operation for the SDR must be judged successful since there were no major monetary crises and gold prices remained stable most of the year.

On July 1, 1970, the Heavy Metals Program of the Department of the Interior, which was started in mid-1966, was terminated. Conducted jointly by the Geological Survey and the Bureau of Mines, this comprehensive program to stimulate domestic gold production examined in considerable depth most aspects of the gold cycle, ranging from exploration through recycling of scrap material. The first commercial benefits resulting from the program's exploration and research activities were achieved with the opening of the Nevada Cortez gold mine (1969) and the early 1971 startup of the Carlin mill addition. The latter addition is using a Bureau of Mines process to treat carbonaceous gold ores.

Effective April 21, 1970 the Treasury Department amended the Gold Regulations [3] to allow holders of Treasury Gold Licenses to export gold bullion for sale in foreign countries.

[1] Physical scientist, Division of Nonferrous Metals.

[2] International Monetary Fund. 1970 Annual Report. Pp. 184–189.

[3] U.S. Department of the Treasury. Exports of Gold. 35 FR 4815, Apr. 21, 1970.

Table 1.—Salient gold statistics

	1966	1967	1968	1969	1970
United States:					
Mine production..thousand troy ounces..	1,803	1,584	1,478	1,733	1,743
Value..thousands..	$63,119	$55,447	$58,038	$71,944	$63,439
Ore (dry and siliceous) produced:					
Gold ore......thousand short tons..	3,447	3,076	2,780	3,393	3,692
Gold-silver ore..do....	248	157	199	208	W
Silver ore..do....	669	617	655	r 655	673
Percentage derived from—					
Dry and siliceous ores..	58	69	63	59	60
Base-metal ores..	37	27	34	40	38
Placers..	5	4	3	1	2
Refinery production [1] thousand troy ounces..	1,802	1,526	1,539	1,717	NA
Exports [2]..do....	13,067	28,720	23,962	338	1,074
Imports, general [2]..do....	1,200	930	5,944	5,861	6,652
Stocks Dec. 31:					
Monetary [3]..millions..	$13,235	$12,065	$10,892	$11,859	$11,072
Industrial....thousand troy ounces..	2,734	3,086	3,617	4,158	3,984
Consumption in industry and the arts thousand troy ounces..	6,062	6,294	6,604	7,109	5,973
Price: [4] Average per troy ounce..	$35.00	$35.00	$39.26	$41.51	$36.41
World:					
Production.......thousand troy ounces..	46,580	45,737	46,165	46,526	47,356
Official reserves [5]..millions..	$43,185	$41,600	$40,905	r $41,010	$41,280

r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data; included in gold ore, silver ore, and lead-zinc 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 1970.
[5] Held by free-world central banks and governments.

DOMESTIC PRODUCTION

In 1970 domestic mine production of gold increased slightly to 1.74 million ounces. Increased output in Alaska, Colorado, and Nevada more than compensated for modest declines in South Dakota and Utah. Gold output by the Homestake Mining Co. declined slightly to 578,644 ounces valued at over $21 million for an average selling price of $36.39 per ounce. Homestake, the country's largest gold mine, processed 1.95 million tons of ore in 1970. In addition to the gold, 117,000 ounces of byproduct silver were recovered. Measured ore reserves at yearend were slightly over 9 million tons, and indicated ore reserves were 1.4 million tons.

In late 1970, Homestake announced plans for a 5-year, $8 million, deep-level development program. The program will exploit richer ore bodies between the 4,850 and 6,800-foot level. At present, this is the deepest mining level. A six-compartment shaft will be sunk from the 4,850-foot level to the 7,400-foot level.

Gold output at the Carlin, Nev. open pit operation declined slightly, and the newer Cortez mine increased its output by one-fourth. The Carlin operation stripped about 5 million tons of waste and mined 1.2 million tons of ore. The mill processed about 860,000 tons of ore and recovered slightly over 201,000 ounces of gold. In its first complete year of operation, Cortez Gold Mines, stripped 3.3 million tons of waste and recovered 209,000 ounces of gold by milling about 744,000 tons of ore. The proven ore reserves at Cortez are about 3 million tons averaging 0.275 ounce of gold per ton. The Cortez gold production is refined by Engelhard Industries.

The second largest domestic gold producer was the Utah Mines Division of Kennecott Copper Corp. at Bingham Canyon, near Salt Lake City. In 1970 the processing of over 40 million tons of copper ore yielded over 355,000 ounces of byproduct gold.

Combined output from the country's four largest gold producers—Homestake, Utah Mines, Cortez, and Carlin—represented three-quarters of the total domestic production in 1970.

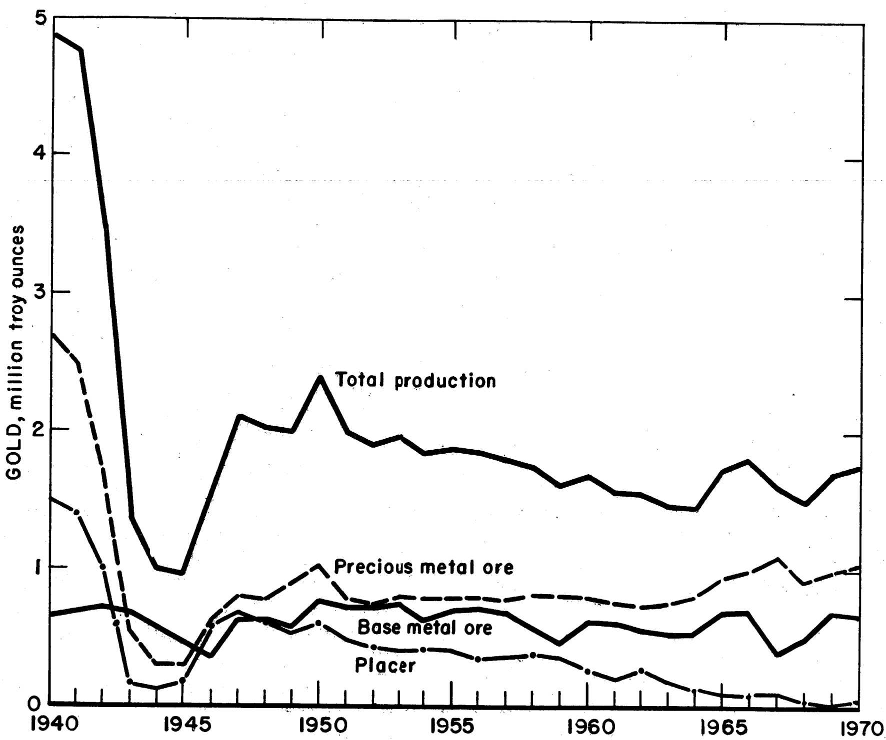

Figure 1.—Gold production in the United States.

In addition to Homestake, Carlin, and Cortez, the only other primary domestic gold producer was the Mayflower mine in the Park City district, Utah. This mine, operated by Hecla Mining Co., mined and milled 116,000 tons of ore and recovered 50,798[4] ounces of gold, along with silver, lead, zinc, and copper. Ore reserves at yearend were estimated at 240,000 tons.

In late 1970, the Carlin Gold Mining Co. completed construction of a new 600-ton-per-day milling unit to treat carbonaceous ores which had previously been stockpiled. The new unit was to go on stream in January 1971. Heap-leaching experiments were being conducted at both the Carlin and Cortez mines.

In recent years, secondary gold (scrap) recovery has become increasingly important as a source of commercial supply. Over the past decade secondary gold output has increased more than 2½ times. Secondary output for 1970 declined, but still will supply a very significant portion of total commercial demand, probably about 35 to 40 percent.

Because of the high intrinsic value of gold, and the precious metals in general, the scrap cycle is quite sophisticated. Elaborate precautions are usually taken to recover all forms of gold scrap. Industrial scrap undoubtedly has a lower degree of total recovery because of its low gold content, which may only be 2 to 4 cents per square inch of plated surface. The introduction of selective gold plating (plating only the area that needs the gold) in recent years has probably further reduced the unit value per square inch plated. The economics of such recovery are dependent on the value of the associated metals.

[4] Hecla Mining Co. Annual Report, 1969. Pp. 8, 13.

CONSUMPTION AND USES

Domestic consumption of gold, as indicated by sales to fabricators of industrial and artistic products, declined sharply in 1970 owing to reduced economic activity in the United States. The Office of Domestic Gold and Silver Operations, U.S. Treasury Department, estimated the net domestic industrial use of gold for 1970 to be 56 percent for jewelry and the arts, 33 percent for industrial uses, and the remaining 11 percent for dentistry.

Historically, the dominant domestic use for gold was in jewelry and the arts, which in 1960 consumed nearly 70 percent of total commercial demand. By 1970 these uses had dropped to slightly over half of total demand. Industrial, space, and defense uses of gold through the past decade have approximately doubled. Even in 1970, with the reduced overall consumption, industrial uses increased their share of the total demand.

Much of the gold used in industry is in the form of metal or metal alloys. Gold in high-quality jewelry is in the form of Karat gold, an alloy of gold (58.3 percent for 14 Karat) and copper (about 25 to 32 percent for 14 Karat), further alloyed with other metals (silver, zinc, platinum, etc.) depending on the type of jewelry to be manufactured. In addition, substantial amounts of gold are consumed in the electroplating of jewelry and decorative articles, and also as rolled gold plate and gold fill. Gold-containing brazing alloys also are used in jewelry. In dentistry, gold alloys containing 20 to 70 percent gold are used in wire form for orthodontic applications, and alloys (with 60 to 92.5 percent gold) are used in cast form for inlays, crowns, bridges, etc. Gold alloys are also used as solders. The ease of preparation of gold alloy castings by the dentist is an important positive factor in their extensive use.

The major industrial use of gold is in the electrical and electronics industry, because it has outstanding characteristics of high electrical conductivity, high heat and light reflectivity, superior malleability, and corrosion resistance. One of the major uses is in forming separable connectors and sockets to provide low-resistance connections in all types of applications. Gold is also used widely in printed circuitry because it provides the low-cost, long-term, low-resistance, and low-pressure contact needed for insertion and removal of the circuits. No other metal can compete in application with this combination of desirable characteristics. Other important applications for industrial gold are in semiconductor parts, electron tubes, microwave guide coatings, and various types of relay and switch contacts. There are also numerous special uses for gold in space and defense applications where high quality over long periods of time is mandatory. The largest single application for brazing alloys is in jet-engine seals and manifolds which require 20 to 30 ounces per engine. The aircraft and space industry also consume small, but significant amounts of gold in numerous exotic uses, such as space heater reflectors, face masks, coatings for engine shrouds, and duct work on fighter aircraft.

STOCKS

Monetary.—Compared with December 1969, the December 1970 total U.S. gold stock, including gold in the Exchange Stabilization Fund, declined $787 million to $11,072 million. This loss compares with a gain during 1969 of $967 million. The 1970 decline was largely accounted for by two transactions with the IMF. The first was a resale of $400 million in gold out of $800 million sold to the United States by the IMF in the 1956–60 period. The second was a U.S. quota payment in December 1970 to the IMF of $385 million.

The U.S. balance of payments, measured on a liquidity basis, showed a deficit of over $4.5 billion (excluding the SDR allocation). This compares with the 1969 liquidity deficit of $7.0 billion. The 1970 estimate for the balance of payments deficit on the official reserve transactions basis indicates a deficit of about $9.5 billion including the SDR, as compared with a surplus of $2.7 billion in 1969.

Interpretation of these figures is particularly complicated because of Eurodollar transactions. The President's Council of Economic Advisers characterized 1970 as "a year of general calm in the foreign exchange markets. It was free of any crises like those that had occured intermittently in preceding years." [5]

At yearend the gold reserves of non-Communist central banks and governments, and international banking institutions were estimated at $41,280 million compared with $41,010 million at the end of 1969. Gold reserves of principal non-Communist countries in millions of dollars at the end of 1970 were as follows: West Germany, $3,980; France, $3,532; Italy, $2,887; Switzerland, $2,732; the Netherlands, $1,787; and the United Kingdom, $1,349. IMF had gold reserves of $4,339 million at the end of 1970.

Industrial.—Gold held in inventories by domestic refiners and fabricators declined 4 percent below yearend 1969 stocks to 3,984,000 ounces according to the Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury. Industry stocks had increased steadily from 1.66 million ounces in 1960 to 4.2 million in 1969. The decline in 1970 was the first in 11 years.

[5] Economic Report of the President. February 1971, p. 143.

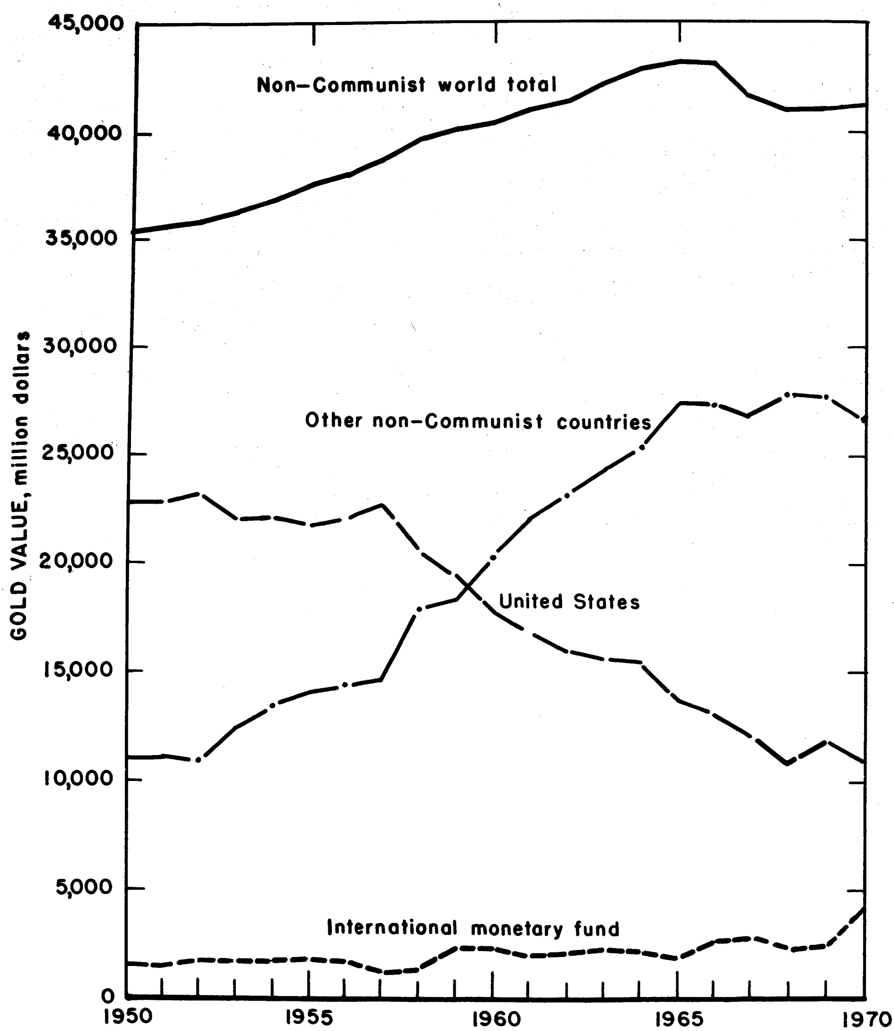

Figure 2.—Gold reserves of free world central banks and governments.

PRICES

During much of 1970 gold prices remained near the monetary level within a range of $35 to $37 per ounce. The average selling price for gold as quoted by Engelhard Industries in 1970 was $36.41 per ounce. Monthly averages and price ranges are compiled in table 2. U.S. gold prices surged to a 1970 high of $39.45 per ounce in late October, possibly as a cumulative reaction to the 10 months of low prices. The demand subsided and the year closed at about $38 per ounce.

The general London gold pricing parallelled U.S. prices, but were about $0.45 per ounce lower.

Factors depressing gold prices included unloading of earlier speculative gold purchases, South African free market sales, the success of the SDR, change in the Eurodollar situation, and reduced U.S. economic activity with lessened commercial gold demand.

Table 2.—U.S. monthly gold selling price
(Engelhard Industries)

Month	1970		
	Average	Low	High
January	$35.39	$35.20	$35.60
February	35.45	35.40	35.50
March	35.55	35.40	35.75
April	36.07	35.75	36.30
May	36.44	36.15	36.65
June	35.93	35.65	36.15
July	35.82	35.75	36.00
August	35.90	35.75	36.30
September	36.64	36.35	36.85
October	37.96	36.75	39.45
November	37.89	37.20	38.10
December	37.88	37.55	38.10
Average	36.41	36.08	36.73

The greatest stimuli to increased gold prices and a positive long-term upward price trend for gold were two comprehensive studies on existing world demand patterns that were compiled by two major London-based mining groups. These studies were made by Consolidated Gold Fields Ltd.[6] and Charter Consolidated Ltd.[7] Both studies concluded that private demand in 1968 and 1969 for fabricated gold already exceeded the free world output of 41 million ounces. This leads to the conclusion that with a relatively fixed supply and rising commercial demand, the long-term price trend can only be upward. Earlier estimates of world commercial demand for gold have traditionally stated that it was about half of world output.

The Gold Fields study showed that about three-fourths of world commercial gold demand goes to jewelry manufacturing. The balance was consumed in electronics, dentistry, decorative, additional industrial uses, and in coin and metal markets. These markets were distributed among Europe, 41 percent; the United States, 16 percent; other industrialized countries, 6½ percent; India and Pakistan, 14 percent; and the remainder, 22½ percent among all other nations.

The Gold Fields study carefully defines and categorizes various types of speculation, hoarding, and consumption. Both the Gold Fields and the Charter Consolidated studies[8] reached similar conclusions. One of the major complicating factors in a study of private gold demand was illustrated in the Charter findings, which observed that in 1968 about 40 percent of the world's nonmonetary absorption of gold passed at some stage through unofficial hands (it was smuggled) before reaching its market. The main conclusion of this study of the nonmonetary market is that "the outlook for gold is much more resilient than many people have supposed . . . and that . . . gold is . . . already in a position to stand independently as an industrial commodity."

It is interesting to note that the 1970 Annual Report of the IMF, released September 7, 1970, estimates 1969 industrial and artistic use of gold to be $930 million, based on the $35 monetary price. Theoretically this would be increased to $1.1 billion in gold since the average 1969 U.S. free market gold price was $41.51.

FOREIGN TRADE

In 1970 total U.S. gold imports were about 6.7 million ounces and exports were about 1.1 million ounces. Most of this trade was in refined bullion form. Canada provided 64 percent of the imports and Switzerland provided 13 percent. South Af-

[6] Lloyd-Jacob, D. O., and P. D. Fells. Gold 1969 (Private study). 49 Moorgate, London, E.C.2. September 1969, 18 pp.

[7] Smets, L. Gold: Dodo or Phoenix? Optima, v. 2, No. 2, June 1970, pp. 51–55.

[8] Work cited in footnote 6 and 7.

rica and India received nearly all the exports. Nearly 90 percent of the exports were monetary transactions, and an estimated 40 percent of the imports were monetary movements; the balance were imports for commercial uses.

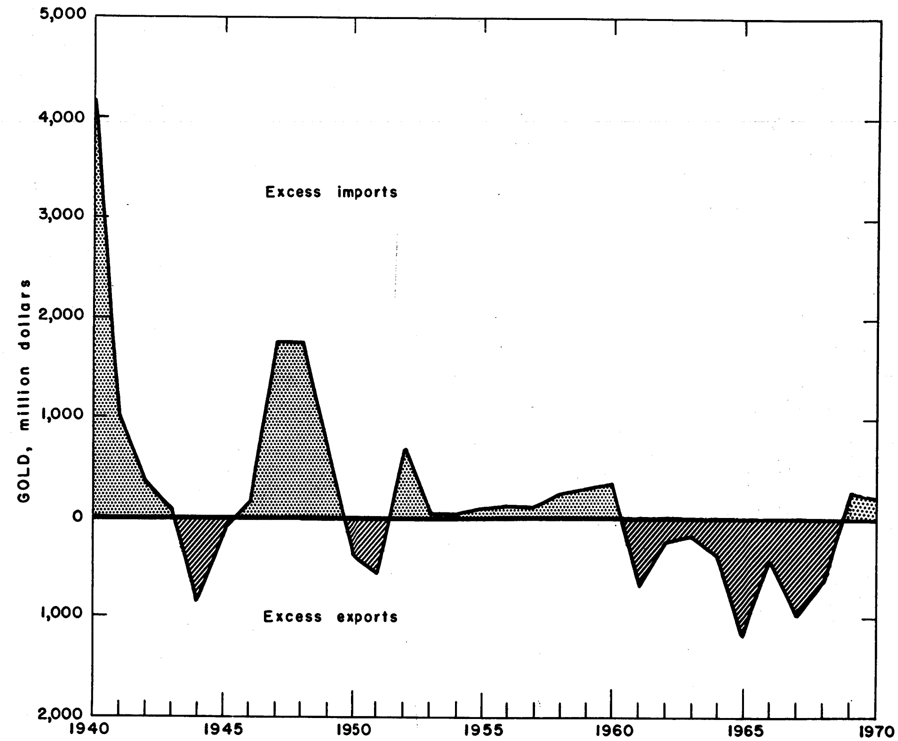

Figure 3.—Net exports or imports of gold.

WORLD REVIEW

Total world gold output in 1970 reached a record level of 47.36 million ounces, compared with the 1969 level of 46.53 million ounces. The major factor in this increase was the Republic of South Africa's record high production of 32.16 million ounces, supported by estimates of continued increases in gold output of the U.S.S.R.

Canada.—Output of gold in Canada in 1970 dropped for the 10th consecutive year. It declined 8 percent below the 1969 level to 2.34 million ounces. The most important development for Canadian gold mines was the Government's decision to extend the Emergency Gold Mining Assistance Act (EGMA) to June 30, 1973. It was to expire on December 31, 1970. EGMA was first applied in 1948–50. Until September 1970, this subsidy program paid $281 million to gold mine operators.

In the first half of this century, gold mining was of unusual importance to Canada's northern development, and to its economy in general. From about 1920 to the 1950's, gold was Canada's most valuable mineral commodity. Even today there are six Canadian communities which are primarily dependent on gold mining for most of their economic support. A recent study by Cyril G. Delbridge, of the Canadian Government's Economic Research Section, Mineral Resources Branch of the Department of Energy, Mines, and Resources, Ottawa, projects a continual decline in

Canadian gold output throughout the 1970's.

In the latest EGMA annual report [9] for the fiscal year ending March 31, 1970, it reports that 33 gold mines received assistance, and that three gold mines shut down in 1969. EGMA assistance payments for this fiscal year were $14.4 million. The Campbell Red Lake mine in Ontario, because of low production costs, was the only operating lode gold mine ineligible for assistance.

Output by Giant Yellowknife Mines Ltd. in the Northwest Territories dropped slightly in 1970 to almost 229,000 ounces recovered from processing 425,000 tons of ore. This was sold at an average price of $36.47 per ounce.

Ghana.—In early 1969, Lonrho Ltd., a London-based investment firm with worldwide interests, acquired Ashanti Goldfields Corp., Ltd., the major gold producer in Ghana. Lonrho received from the Government of Ghana a royalty-free, 50-year lease, dating from 1969, in exchange for 20 percent of the Ashanti equity. The Ghana Government also has the option to purchase an additional 20 percent. In 1969 a new shaft was sunk to 5,200 feet, and the mill capacity was expanded to 80,000 tons per month. Despite a strike in June and July, in the fiscal year ending September 30, 1970, gold recovery was 480,000 ounces from milling 620,000 tons of ore. This was a slight increase over 1969 output. Capital expenditures at Ashanti are almost $3 million per year. It is expected that output in 1971 will be 516,000 ounces, and that an-

[9] Department of Energy, Mines and Resources (Ontario, Canada). Report on the Administration of the Emergency Gold Mining Assistance Act for the fiscal year ended Mar. 31, 1970. July 1970, pp. 7–8.

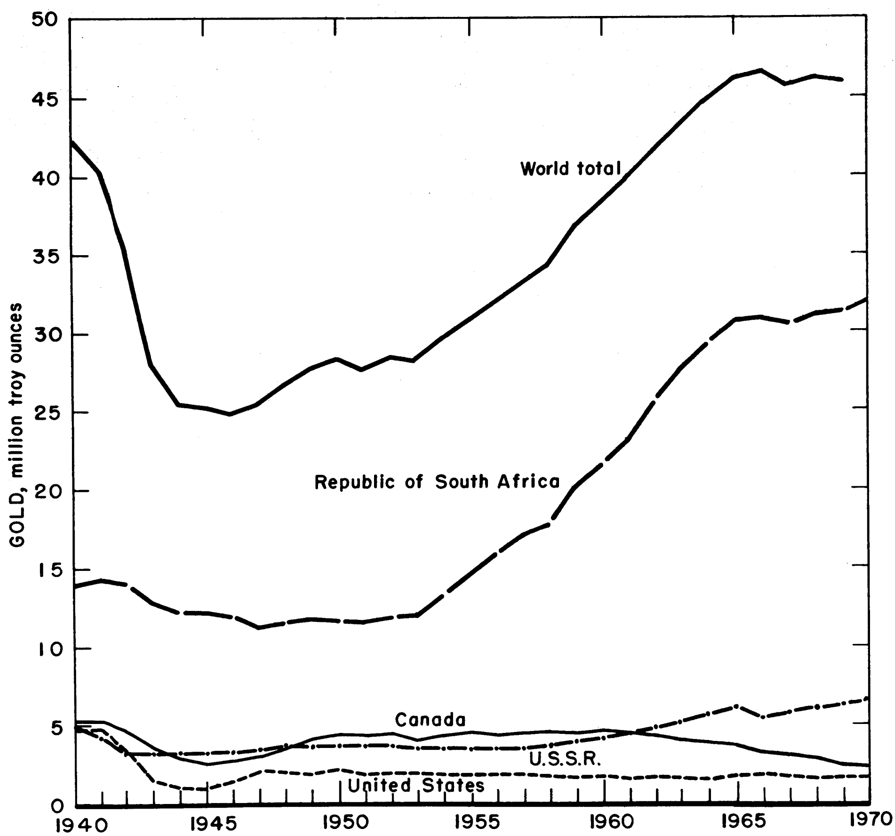

Figure 4.—World production of gold.

nual production "will continue to increase substantially in coming years." [10]

Philippines.—Gold output in 1970 compared with 1969 increased about 6 percent to nearly 603,000 ounces. The major gold producer, Benguet Consolidated, Inc., produced about 40 percent of the total output. The second largest producer, Lepanto Consolidated Mining Co., increased its output in 1970 and was responsible for nearly 23 percent of the year's total. Output at Lepanto should expand further in 1971 when a new 200-ton-per-day mill begins operation. Mill construction began in August 1970, and completion is scheduled for mid-1971.

The Philippine gold mines operate under a Government subsidy program in which the mines must sell their output to the Government at $35 per ounce to be eligible for the subsidy. Small mines are paid at a maximum subsidy rate of $40.82 per troy ounce, and the larger mines have a maximum subsidy of $36.11 per ounce. The mines may sell their gold on the free market if they choose to forego the subsidy. It appears as though this may be likely in 1971 if the free market prices continue their upward trend.

Coproduct gold is mined primarily by Philex Mining Corp. and Atlas Consolidated Mining and Development Corp., which annually produce about 50,000 ounces and 28,000 ounces, respectively. It is expected that coproduct output will increase in the future as copper production expands.

South Africa, Republic of.—Output from South African gold mines in 1970 reached a record level of 32.16 million ounces valued at $1.097 billion from the mining and milling of 74.47 million tons of ore. Nearly all of this production came from 47 deep underground mines that are members of the Chamber of Mines of South Africa. One mine, the Luipaard Vlei operation, shut down on March 31, 1970. Among the other 46 mines, the West Rand Consolidated produces both gold and uranium as primary products. Nine of the remaining 45 mines produce uranium as a byproduct of gold mining. Nearly all of the 47 mines are owned by the following seven large mining investment houses:

Company	Mines
Anglo-America Corp. of South Africa, Ltd	12
Gold Fields of South Africa, Ltd	8
Union Corporation, Ltd	8
Anglo-Transvaal Consolidated Inv., Co., Ltd	5
Rand Mines, Ltd	4
General Mining & Finance Corp. Ltd	4
Johannesburg Consolidated Inv. Co., Ltd	2

Because of the importance of gold mining to the economy, the South African Government began subsidizing marginal gold mines on April 1, 1968, under the Gold Mines Assistance Act. Mines are eligible if, without the benefit of assistance, they would be forced to close within 8 years. A fixed formula determines the rate of assistance. During 1970, 19 mines received assistance under the new program.

The importance of increased gold prices to South Africa was indicated by the estimate of the Chamber of Mines' president that for each $1.00 increase in gold price, almost 8 million ounces of gold could be mined that would not otherwise be economically feasible to mine.

In 1970 the South African Government agreed to provide a loan of $10 million to open a new gold mine in the West Rand, near Johannesburg. Shaft sinking is scheduled to begin in 1971, and the mine is expected to begin production in 1974 and to reach full production of 100,000 tons per month in 1975.

Although the mining industry is diversifying rapidly, gold mining is still very important to the South African economy and is its major source of foreign exchange. Therefore, the question of the long-range future of gold mining is of major concern to South Africans and to the world's industrial users of gold. It now appears that the current level of output can be sustained for most of the 1970's. Beyond this, it appears likely that output will decline. Factors contributing to the decline will be as follows: lower ore grades, inflation, skilled labor shortages, the need for deeper mining with associated temperature and rock pressure problems, increased capital expenditures, and lower world prices for uranium, which is associated as a byproduct from about one-sixth of the existing gold mines. On the sustaining side, output levels would be assisted by higher gold

[10] Lonrho Limited Report and Accounts. Annual Report, 1970.

prices, increased mining productivity through introduction of selective mining techniques, long-term uranium contracts at higher price levels, and increased South African assistance in financing new mines or subsidizing existing operations.

TECHNOLOGY

The Department of the Interior's Heavy Metals Program was formally terminated in mid-1970, but some elements of the research have been continued. In late 1970 the Carlin Gold Mining Co. completed the construction of its new 500-ton-per-day mill which is using the Bureau of Mines' process to treat carbonaceous gold ores. This plant was scheduled to begin operation in January 1971. Research on the development of heap-leaching techniques was continued by the Bureau of Mines in cooperation with both the Carlin and the Cortez gold mining operations. At the Carlin operation, a commercial size unit using cyanide leaching has been operating. This four-pad unit can leach about 16,000 tons of crushed ore per month. The ore feed reportedly averages 0.06 ounce of gold per ton of ore.

In 1970 the Bureau of Mines Salt Lake City Metallurgy Research Center conducted field and laboratory research on the application of activated carbon to the recovery of gold from dilute cyanide solutions and ore pulps. An unsuccessful research attempt was made to leach gold-bearing mill tailings from the Mercur, Utah, tailings dump. This work was described in a Bureau report.[11]

Bureau research continued on the recovery of precious metals from electronic scrap. The dual objectives of the project are to develop methods of determining the type and amount of precious metals in military electronic scrap and to develop an economical process for recovering precious metals from low-value scrap. Pyrometallurgical methods are complicated by large amounts of aluminum which require excessive amounts of fluxes and form difficult-to-handle slags.

In late 1970 the trade press reported extensively[12] on a new highly efficient ion exchange resin discovered and developed by Dr. Gabriella Schmuckler of the Technion-Israel Institute of Technology. The Bureau of Mines investigated the resin and concluded, "The resin was found to quantitatively collect gold from acid solutions over a wide range of acid concentrations. Common metals were not collected by the resin nor did they seriously interfere with the collection of gold."[13]

Research investigation results have also been published on the gold-chlorine system[14] for use in chlorine metallurgy, and on the use of malononitrile $CH_2(CN)_2$ as a gold leachant.[15]

A statistical analysis was made of wagon-drill gold samples from the Nevada Getchell mine. The study concluded that wagon-drill hole cuttings appear to yield satisfactory samples . . . and that in submicron deposits, such as Getchell, fewer samples can provide satisfactory grade estimates than if the deposit were coarse-grained.[16]

Concerning resources, publications were issued on gold placer mining evaluation and dredge selection,[17] gold investigations in Idaho,[18] and a study of the role of carbonaceous materials in gold deposits at Carlin, Nev.[19] The Geological Survey issued reports on the gold content of water,

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11 Nichols, I. L., and L. Peterson. Leaching Gold-Bearing Mill Tailings From Mercur, Utah. BuMines Rept. of Inv. 7395, June 1970, 10 pp.

12 Secondary Raw Materials. New Process To Recover Precious Metals Developed by Israel Technion Researcher. V. 8, No. 12, December 1970, pp. 51–52.

13 Green, T. E., and S. L. Law. Properties of an Ion Exchange Resin With High Selectivity for Gold. BuMines Rept. of Inv. 7358, 1970, p. 9.

14 Landsberg, A., and C. L. Hoatson. The Kinetics and Equilibria of the Gold-Chlorine System. J. of the Less-Common Metals, v. 22, No. 3, November 1970, pp. 327–339.

15 Heinen, H. J., J. A. Eisele, and B. J. Scheiner. Malononitrile Extraction of Gold From Ores. BuMines Rept. of Inv. 7464, December 1970, 11 pp.

16 Koch, George S., Jr., and Richard F. Link. A Statistical Interpretation of Sample Assay Data From the Getchell Mine, Humboldt County, Nevada. BuMines Rept. of Inv. 7383, May 1970, 23 pp.

17 Romanowitz, C. M., H. J. Bennett, and W. L. Dare. Gold Placer Mining. BuMines Inf. Circ. 8462, 1970, 56 pp.

18 Banister, D'Arcy P. Geochemical Investigations for Gold, Antimony, and Silver at Stibnite, Idaho. BuMines Rept. of Inv. 7417, July 1970, 7 pp.

Rice, W. L. Investigation of a Low-Grade Gold Deposit in the Orogrande District, Idaho. BuMines Rept. of Inv. 7425, September 1970, 14 pp.

19 Radtke, A. S., and B. J. Scheiner. Studies of Hydrothermal Gold Deposition, Carlin Gold Deposit, Nevada: The Role of Carbonaceous Materials in Gold Deposition. Econ. Geol., v. 65, No. 2, March–April 1970, pp. 87–102.

plants and animals [20] and the absorption of gold by plants.[21]

One element of the Bureau of Mines' resource investigations is to develop methods for the cost evaluation of mineral deposits. A comprehensive study [22] was made using sensitivity and probabilistic analysis methods to obtain a financial evaluation of mineral deposits. Data used to illustrate the evaluation method were from a large, low-grade, open pit gold deposit. The Geological Survey reported on a portable refraction survey of the Nome, Alaska, gold placers [23] which was conducted in 1967, as part of the heavy metals program.

A technological forecast for the 1970's concluded that the prospects for precious metals are good, since the most dramatic advances are expected to be in the growth of requirements for electronic materials. Greater use is predicted for gold, silver, and platinum in thin film circuits. Gold is expected to be used more in bimetallic substrates, mountings, and frames. Much of the industrial gold used in electronic applications is elecroplated.[24]

A brief review by staff members of Engelhard Minerals & Chemicals Corp. of the rigorous controls and standards for electroplating was presented.[25] Matthey-Bishop announced [26] it was introducing a new line of thick film inks for making hybrid and integrated electronic circuits using combinations of gold with platinum-group metals. The trade press also reported [27] that Englehard had developed a new high-speed process known as E.H.S. for gold-plating strip and wire, which plates at a reported rate of 100 microinches per minute.

Since 1968, the Chamber of Mines of South Africa Research Organization has been publishing on a quarterly basis the Gold Bulletin with selected abstracts from the technical literature on gold.[28] These are prepared on behalf of the Chamber by Johnson Matthey and Co., Ltd., London. This useful bibliographic reference abstracts both periodicals and patent specifications. The four 1970 issues contain about 350 to 400 abstracts.

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20 Jones, R. S. Gold Content of Water, Plants, and Animals, U.S. Geol. Survey Circ. 625, 1970, 15 pp.

21 Shacklette, H. T., H. W. Lakin, A. E. Hubert, and G. C. Curtin. Absorption of Gold by Plants. U.S. Geol. Survey Bull. 1314–B, 1970, 23 pp.

22 Bennett, H. J., Jerrold G. Thompson, H. J. Quiring, and J. E. Toland. Financial Evaulation of Mineral Deposits Using Sensitivity and Probabilistic Analysis Methods. BuMines Inf. Circ. 8495, 1970, 82 pp.

23 Greene, H. G. A Portable Refraction Seismograph Survey of Gold Placer Areas Near Nome, Alaska. U.S. Geol. Survey Bull. 1312–B, 1970, 29 pp.

24 Metal Progress. Surveying the 70's. V. 97, No. 1, January 1970, p. 21.

25 Haley, A., R. Bazzone, and P. Epstein. Specifying and Testing Gold Plating. Electronic Products Magazine, v. 13, No. 8, Jan. 18, 1971, pp. 91–94, 136.

26 American Metal Market. Matthey-Bishop Launches Group To Make Thick Film Inks. V. 77, No. 157, Aug. 17, 1970, p. 19.

27 American Metal Market. Precious Clads Boast of Many Assets. V. 77, No. 151, Aug. 7, 1970, p. 7A-sec. 2.

28 Chamber of Mines of South Africa Research Organization (Johannesburg). Gold Bulletin, Quarterly Publication. 1970 issues, No. 9–12.

Table 3.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

State	1966	1967	1968	1969	1970
Alaska	27,325	22,948	21,262	21,227	34,776
Arizona	142,528	80,844	95,999	110,878	109,853
California	64,764	40,570	15,682	7,904	4,999
Colorado	31,915	21,181	22,638	25,777	37,114
Idaho	5,056	4,838	3,227	3,403	3,128
Montana	25,009	9,786	13,385	24,189	22,456
Nevada	366,903	434,993	317,382	456,294	480,144
New Mexico	9,295	5,188	6,630	8,952	8,719
Oregon	281	186	23	875	256
Pennsylvania [1]	85,000	73,337	54,453	47,020	55,008
South Dakota	606,467	601,785	593,052	593,146	578,716
Tennessee	141	181	140	126	124
Utah	438,736	288,350	334,419	433,385	408,029
Washington	(1)	(1)	(1)	(1)	(1)
Wyoming	----------	----------	----------	(1)	----------
Total	1,803,420	1,584,187	1,478,292	1,733,176	1,743,322

1 Production of Pennsylvania, Washington, and Wyoming (1969) combined to avoid disclosing individual company confidential data.

Table 4.—Mine production of recoverable gold in the United States, by months

(Troy ounces)

Month	1969	1970
January	128,918	146,274
February	129,443	135,329
March	147,158	148,173
April	143,237	138,898
May	144,811	147,338
June	133,257	147,955
July	147,218	139,139
August	151,655	150,685
September	147,700	147,062
October	162,577	143,382
November	153,476	151,698
December	143,726	147,389
Total	1,733,176	1,743,322

Table 5.—Twenty-five leading gold-producing mines in the United States in 1970, 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	Cortez	Lander, Nev	Cortez Gold Mines	Gold ore.
4	Carlin	Eureka, Nev	Carlin Gold Mining Co	Do.
5	Knob Hill and Gold Dollar	Ferry, Wash	Knob Hill Mines, Inc	Do.
6	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
7	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Copper ore.
8	Hogatza River	Yukon River Region, Alaska	United States Smelting Refining and Mining Co	Placer.
9	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper ore.
10	Veteran Pit	White Pine, Nev	Kennecott Copper Corp	Do.
11	Tripp Pit	do	do	Do.
12	Berkeley Pit	Silver Bow, Mont	The Anaconda Co	Do.
13	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
14	Copper Canyon	Lander, Nev	Duval Corp	Copper ore.
15	San Manuel	Pinal, Ariz	Magma Copper Co	Do.
16	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
17	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
18	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
19	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co	Lead, lead-zinc ores.
20	Continental	Grant, N. Mex	do	Copper ore.
21	Belle Creole	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
22	Cache Creek	Yukon River Region, Alaska	L. McGee	Placer.
23	Trixie	Utah, Utah	Kennecott Copper Corp	Gold-silver ore.
24	Christmas	Gila, Ariz	Inspiration Consolidated Copper Co	Copper ore.
25	Big Mike	Pershing, Nev	Ranchers Exploration and Development Corp	Do.

Table 6.–Production of gold in the United States in 1970, by States, types of mines, and classes 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	34,776	---	---	---	---	---	---
Arizona	---	144	65	(1)	(1)	[1] 89,583	[1] 506
California	2,264	990	948	(2)	(2)	---	---
Colorado	1,613	---	---	---	---	(3)	(3)
Idaho	5	240	134	(1)	(1)	[1] 543,849	[1] 974
Montana	14	(4)	(4)	(4)	(4)	[4] 38,801	[4] 2,768
Nevada	3	[5] 1,661,485	[5] 410,705	---	---	(5)	(5)
New Mexico	---	---	---	(1)	(1)	[1] 476	[1] 74
South Dakota	---	1,954,129	578,715	---	---	49	1
Utah	---	---	---	(2)	(2)	533	6
Other States [6]	38	75,135	54,010	300	215	75	1
Total	38,713	3,692,123	1,044,577	300	215	673,366	4,330
Percent of total gold	2	---	60	---	(7)	---	(7)

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	134,968,089	107,292	100	1	---	---
California	62	1	---	---	---	---
Colorado	[8] 306,300	[8] 866	(8)	(8)	(8)	(8)
Idaho	1,601	27	36,054	26	---	---
Montana	[8] 18,726,463	[8] 19,638	(8)	(8)	(8)	(8)
Nevada	14,183,221	69,188	3,697	222	---	---
New Mexico	18,591,648	8,409	---	---	39,773	63
South Dakota	---	---	---	---	---	---
Utah	40,147,764	347,548	32,754	242	---	---
Other States [6]	---	---	---	---	---	---
Total	226,925,148	552,969	72,605	491	39,773	63
Percent of total gold	---	32	---	(7)	---	(7)

State	Lode				Total	
	Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.			
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	---	---	---	---	---	34,776
Arizona	132,963	251	82,546	1,738	135,273,425	109,853
California	[2] 104,125	[2] 1,489	20	[9] 297	105,197	4,999
Colorado	[3] 822,547	[3] 34,628	709	7	1,129,556	37,114
Idaho	911,551	1,962	---	---	1,493,295	3,128
Montana	14	10	3,893	26	18,769,171	22,456
Nevada	1,229	20	2,292	[10] 6	15,851,924	480,144
New Mexico	122,417	172	810	1	18,755,124	8,719
South Dakota	---	---	---	---	1,954,178	578,716
Utah	[2] 682,662	[2] 60,217	1,004	16	40,864,717	408,029
Other States [6]	1,903,799	158	---	[11] 966	1,979,309	55,388
Total	4,681,307	98,907	91,274	3,057	236,175,896	1,743,322
Percent of total gold	---	6	---	(7)	---	100

[1] Gold-silver and silver ores combined to avoid disclosing individual company confidential data.
[2] Gold-silver and lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Silver and lead-zinc ores combined to avoid disclosing individual company confidential data.
[4] Gold, gold-silver, and silver ores combined to avoid disclosing individual company confidential data.
[5] Gold and silver ores combined to avoid disclosing individual company confidential data.
[6] Includes Oregon, Pennsylvania, Tennessee, and Washington.
[7] Less than ½ unit.
[8] Copper, lead, and zinc ores combined to avoid disclosing individual company confidential data.
[9] Includes byproduct gold recovered from tungsten ore.
[10] Includes byproduct gold recovered from uranium ore.
[11] Includes byproduct gold recovered from magnetite-pyrite ore.

Table 7.—Gold produced in the United States from ore, old tailings, etc., in 1970, 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]	
			Recoverable in bullion		Concentrates smelted and recoverable metal			
		Thousand short tons [1] [2]	Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	-----	-----	-----	-----	-----	-----	-----	-----
Arizona	150,549	150,025	-----	-----	3,371,204	103,664	524	6,189
California	105	102	25	-----	13,636	1,688	3	1,022
Colorado	1,133	1,133	3,925	-----	163,211	31,556	(3)	20
Idaho	1,540	1,536	129	-----	177,422	2,852	4	142
Montana	18,780	18,743	-----	-----	435,575	19,776	37	2,666
Nevada	20,134	19,952	16	410,110	372,014	67,061	182	2,954
New Mexico	20,757	20,689	-----	-----	685,682	8,643	68	76
South Dakota	1,954	1,954	349,859	228,856	-----	-----	(3)	1
Utah	40,909	40,736	-----	-----	1,044,771	404,697	173	3,332
Other States [4]	1,979	1,979	3	-----	408,110	55,131	(3)	216
Total	257,840	256,849	353,957	638,966	6,671,625	695,068	991	16,618

[1] Includes some nongold-bearing ores not separable.
[2] Excludes tonnages of magnetite-pyrite, tungsten, and uranium ores from which gold was recovered as a byproduct.
[3] Less than ½ unit.
[4] Includes 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
1966	432,130	519,631	24.0	28.8	42.1	5.1
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

[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 treated (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1968	4	4	3,770	20	$778	$0.206
1969	4	4	814	13	547	.672
1970	1	1	709	29	1,055	1.488
Dragline dredging:						
1968	3	3	[1] 81	[2] 1	54	[3] .499
1969	2	2	[1] 2	([2] [4])	17	[3] .934
1970	1	3	[1] 2	([2] [4])	20	[3] 10.000
Hydraulicking:						
1968	--------	--------	--------	--------	--------	--------
1969	4	--------	3	([4])	3	1.245
1970	8	4	17	1	20	1.176
Nonfloating washing plants:						
1968	26	37	[1] 384	[2] 8	325	[3] .498
1969	30	42	[1] 347	[2] 9	365	[3] .727
1970	19	37	[1] 275	[2] 8	291	[3] 1.058
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1968	50	22	[1] 241	[2] 8	296	[3] 1.227
1969	26	4	112	3	123	1.100
1970	9	2	[1] 4	[2] 1	23	[3] 5.750
Total placers:						
1968	83	66	[1] 4,476	[2] 37	1,457	[3] .292
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

[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	1966	1967	1968	1969	1970
Jewelry and arts	3,758	3,840	3,908	3,839	3,340
Dental	424	566	771	710	658
Industrial, including space and defense	1,880	1,888	1,925	2,560	1,975
Total	6,062	6,294	6,604	7,109	5,973

[e] Estimated by Office of Domestic Gold and Silver Operations, U.S. Treasury Department.

Table 11.—U.S. exports of gold in 1970, by countries

Destination	Ore, base bullion, and scrap		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Belgium-Luxembourg	73,512	$2,733	2,230	$68
Canada	705	26	990	38
Germany, West	12,317	442	131	5
India	----	----	285,717	10,000
Mexico	929	34	4,600	170
Singapore	----	----	673,840	23,585
Sweden	1,200	43	----	----
United Kingdom	17,099	612	----	----
Venezuela	355	13	600	21
Total	106,117	3,903	968,108	33,887

Table 12.—U.S. imports of gold in 1970, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Australia	25,214	$794	300	$11
Austria	----	----	43	2
Belgium-Luxembourg	15	(1)	39,415	1,422
Burma	----	----	598,067	20,932
Canada	79,751	2,792	4,185,546	149,220
Chile	10,332	350	----	----
Colombia	174	6	223,400	7,817
Czechoslovakia	8	(1)		
Ecuador	67	2	----	----
El Salvador	----	----	347	12
France	----	----	32,147	1,164
Germany, West	----	----	44,322	1,579
Honduras	5,227	123	2,594	91
Hong Kong	2,382	83	----	----
Italy	134	5	----	----
Japan	55	2	68,589	2,400
Mexico	4,305	155	----	----
Nicaragua	47,262	1,666	----	----
Norway	455	16	----	----
Panama	66	2	----	----
Peru	18,636	618	----	----
Philippines	89,602	3,255	35,854	1,256
Singapore	925	32	----	----
South Africa, Republic of	1,333	48	----	----
Sweden	----	----	4,436	156
Switzerland	----	----	894,159	32,887
United Kingdom	1,045	43	235,380	8,493
Venezuela	----	----	781	30
Total	286,988	9,992	6,365,380	227,472

1 Less than ½ unit.

Table 13.—Value of gold imported into and exported from the United States

(Thousand dollars)

Year	Imports	Exports
1968	$226,263	$839,159
1969	236,906	12,287
1970	237,464	37,790

Table 14.—Gold: World production, by countries

(Troy ounces)

Country [1]	1968	1969	1970 [p]
North America:			
Canada	2,688,018	2,545,109	2,338,454
Costa Rica [e]	500	500	500
El Salvador	------	------	2,301
Haiti [e]	3,000	3,000	3,000
Honduras	6,150	6,223	3,333
Mexico	176,952	180,599	180,623
Nicaragua	193,008	120,011	115,173
United States [2]	1,478,292	1,733,176	1,743,322
South America:			
Bolivia	[r] 69,031	49,854	30,603
Brazil	176,628	176,938	180,076
Chile	57,743	59,102	50,718
Colombia	239,555	218,872	201,500
Ecuador	8,659	7,287	[e] 7,300
French Guiana	5,099	3,590	[e] 3,600
Guyana	4,088	2,102	4,433
Peru	105,118	131,641	104,258
Surinam	4,702	2,389	1,137
Venezuela	20,600	19,385	21,862
Europe:			
Finland	21,380	18,872	20,319
France	[r] 58,450	54,946	58,000
Germany, West [e]	1,000	1,000	1,000
Portugal (mine output)	17,394	17,758	16,137
Sweden (mine output)	49,737	45,011	44,345
U.S.S.R. [e 3]	5,900,000	6,250,000	6,500,000
Yugoslavia	70,314	84,074	97,384
Africa:			
Cameroon	465	177	154
Congo (Brazzaville)	4,790	3,922	[e] 4,000
Congo (Kinshasa)	169,975	175,804	177,128
Ethiopia	38,828	42,400	27,282
Gabon	16,724	14,243	16,108
Ghana	[r] 739,731	706,621	703,858
Kenya	[r] 31,988	17,903	------
Liberia [4]	3,216	1,136	[e] 1,100
Malagasy Republic	543	646	534
Nigeria	215	298	123
Rhodesia, Southern	499,943	[e] 480,000	[e] 500,000
South Africa, Republic of	31,168,831	31,275,882	32,164,107
Sudan	29	------	------
Tanzania	17,473	16,016	7,859
Zambia [e]	5,000	5,000	5,000
Asia:			
Burma [e]	150	150	150
Cambodia [e]	4,000	4,000	4,000
China, mainland [e]	50,000	50,000	50,000
India	115,357	109,473	104,200
Indonesia	5,968	8,250	7,608
Japan [5]	238,511	246,492	255,759
Korea:			
North [e]	160,000	160,000	160,000
South [2]	62,405	50,734	51,345
Malaysia:			
Malaya	1,454	3,153	[e] 3,912
Sarawak	2,718	2,271	1,265
Philippines	527,355	571,145	602,715
Taiwan	20,994	21,486	22,602
Oceania:			
Australia	[r] 781,782	699,223	617,000
Fiji	106,784	91,572	103,785
New Zealand	8,626	10,717	11,283
Papua and New Guinea	26,144	25,857	[6] 23,798
Total	[r] 46,165,417	46,526,010	47,356,053

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Gold is also produced in Bulgaria, Czechoslovakia, Romania, 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: 1968—614,348 ounces; 1969—677,476 ounces; and 1970—NA.

[6] New Guinea only.

Graphite

By David G. Willard [1]

The graphite industry experienced some minor problems in 1970. The total U.S. supply of natural graphite increased as the result of a sharp rise in imports. Nevertheless, some key foreign grades, particularly Ceylon lump, were difficult to obtain. At the same time, the slowdown in the nation's economy caused industrial demand for graphite to decline, resulting in a sizable increase in industry stock.

Domestic production of synthetic graphite maintained a steady growth with an increase of 22 percent to 274,076 tons during the year.

Legislation and Government Programs.—Defense material inventories showed that the 1970 yearend stockpile of various natural graphites totaled 41,593 tons, a reduction of 1,235 tons from the 42,828 tons at yearend 1969. The change was caused by the release of 388 tons of Ceylon lump, 268 tons of Malagasy flake, and 579 tons of other crystalline types.

The release of Ceylon lump eliminated the stockpile excess of that type of graphite. A total of 14,067 tons of Malagasy flake remained in excess and was authorized for disposal in limited increments over a period of years. A further disposal of the Malagasy flake is under consideration. No other changes occurred during 1970 in any Government programs affecting graphite.

DOMESTIC PRODUCTION

The Southwestern Graphite Co. of Burnet, Tex., a subsidiary of the Joseph Dixon Crucible Co., continued to be the only domestic producer of natural graphite in 1970. Data on output cannot be disclosed, but it showed a considerable decline from the previous year.

Synthetic graphite output increased to 274,076 tons in 1970, 22 percent more than the 225,526 tons produced in 1969. Total value rose to $158.5 million, 15 percent above the 1969 value of $138.2 million. The eight companies producing synthetic graphite during the year and their plant locations are as follows:

Company	*Location*
Air Reduction Co., Inc.:	
Airco Speer Electrode and Anode Division	Niagara Falls, N.Y.
Airco Speer Carbon Products Division	St. Marys, Pa.
Becker Brothers Carbon Co	Cicero, Ill.
Carborundum Co.:	
Kentucky 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, N.Y.
Do	Columbia, Tenn.

There were no new producers of synthetic graphite in 1970. A former source, the Space Age Materials Corp. plant of Charles Pfizer & Co., Inc., in Woodside, N.Y. was closed during the year.

[1] Economist, Division of Nonmetallic Minerals.

Table 1.—Salient natural graphite statistics [1]

	1966	1967	1968	1969	1970
United States:					
Consumption [2] ... short tons	[3] 48,400	38,300	38,500	[r] 39,100	32,900
Value ... thousands	[3] $6,629	$5,700	$5,904	[r] $6,339	$5,866
Exports ... short tons	3,200	3,600	4,200	5,700	5,800
Value ... thousands	$428	$460	$509	$682	$701
Imports for consumption [2] ... short tons	56,700	56,700	67,900	58,500	66,400
Value ... thousands	$2,545	$2,348	$2,495	$2,419	$3,027
World: Production ... short tons	533,816	394,817	481,793	424,320	417,366

[r] Revised.
[1] All short tons rounded to nearest 100.
[2] Includes some artificial graphite.
[3] Includes some estimated data.

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
Excess: Stockpile grade	14,422	------	14,422
Total	25,222	------	25,222
Malagasy crystalline fines: Objective	5,230	[1] 1,910	7,140
Ceylon amorphous lump: Objective	[2] 4,300	1,198	5,498
Other than Ceylon and Malagasy, crystalline:			
Objective	[3] 2,800	------	2,800
Excess: Stockpile grade	933	------	933
Total	3,733	------	3,733

[1] Includes 1 short ton non-stockpile-grade material.
[2] Includes 56 short tons non-stockpile-grade material.
[3] Includes 867 short tons non-stockpile-grade material.

Source: Office of Emergency Preparedness. Stockpile Report to the Congress July–December 1970.

CONSUMPTION AND USES

In 1970 consumption of natural graphite declined about 15 percent from the 1969 level, primarily because of the nationwide slowdown in industrial activity. Other factors included reduced automobile production, particularly the strike against General Motors Corp., (the automobile industry is a major user of graphite), and decreased manufacture of lead additives for gasolines in which graphite serves as a catalyst support.

Technological developments and materials subsitution have also acted to reduce the demand for graphite. Some steel mills have replaced graphite as a carbon raiser with various manufactured compounds containing carbon in another form. The increasing use of electric furnaces in foundries and smelters has lessened the requirements for graphite crucibles and refractories.

Caution is suggested in using the data presented in table 3. They are incomplete regarding total consumption but do indicate trends and relative distribution. The overall analysis described in the preceding paragraphs, however, has been confirmed by industry sources.

Table 3.—Consumption [1] of natural graphite in the United States in 1970, by uses

Use	Crystalline		Amorphous [2]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	796	$204,457	364	$131,208	1,160	$335,665
Bearings	57	24,808	29	17,079	86	41,887
Brake linings	460	168,154	523	200,107	983	368,261
Carbon brushes	135	87,753	363	184,176	498	271,929
Crucibles, retorts, stoppers, sleeves, and nozzles	3,986	698,952	204	45,504	4,190	744,456
Foundry facings	1,817	373,551	4,870	540,184	6,687	913,735
Lubricants	346	112,340	2,306	371,125	2,652	483,465
Packings	189	108,930	148	45,851	337	154,781
Paints and polishes	19	6,830	129	19,655	148	26,485
Pencils	1,287	499,731	676	140,533	1,963	640,264
Refractories	597	70,670	6,076	575,279	6,673	645,949
Rubber	90	41,792	108	23,183	198	64,975
Steelmaking	863	134,706	3,648	353,627	4,511	488,333
Other [3]	1,717	399,764	1,105	285,679	2,822	685,443
Total	12,359	2,932,438	20,549	2,933,190	32,908	5,865,628

[1] Data incomplete. Excludes numerous small consuming firms.
[2] Includes mixtures of natural and manufactured graphite.
[3] Includes adhesives, chemical equipment and processes, electronic products, gray iron castings, powdered metal parts, small packages, and specialties.

PRICES

Prices for most grades of natural graphite rose during 1970 despite lower demand. Reasons for the rise include an apparent increase in foreign demand, a shortage in some foreign supplies, and higher costs of domestic processing.

Quoted prices for natural graphite show the range of prices negotiated between buyer and seller for different specifications of several kinds of graphite.

The Oil, Paint and Drug Reporter reports prices on an ex-warehouse basis. December 1970 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, quoted in the Engineering and Mining Journal, for two major classifications of graphite imported by the United States, were as follows:

	Per short ton	
	1969	1970
Flake and crystalline graphite, bags:		
Ceylon	$80–$179	$91–$172
Germany, West	118–635	123–777
Malagasy Republic	82–281	86–281
Norway	68–109	77–121
Amorphous, nonflake, cryptocrystalline graphite (80 to 85 percent carbon):		
Mexico (bulk)	19–21	19
South Korea (bulk)	24	22
Hong Kong (bags)	24	24

FOREIGN TRADE

Exports (including reexports) of natural graphite increased about 2 percent over the record 1969 level to 5,783 tons. Gains in sales to Latin America, Europe, and Australia offset smaller shipments to Canada, Asia, and Africa. Imports for consumption, including a small quantity of artificial graphite, resumed an upward trend with a 13-percent rise to 66,449 tons, largely as the result of a 16-percent increase in purchases from Mexico. However, imports of high-grade graphite from Ceylon fell 29 percent because of higher prices and increased competition from foreign buyers.

Table 4.—U.S. exports of natural graphite, by countries

Destination	Amorphous, crystalline flake, lump, or chip, and natural, n.e.c. [1]			
	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	18	$2	53	$8
Australia	42	4	211	16
Belgium-Luxembourg	6	1	278	24
Bolivia	11	1	-----	---
Brazil	55	5	76	7
Canada	2,087	235	1,586	179
Chile	41	4	34	4
Colombia	38	6	168	15
Denmark	41	5	22	3
Dominican Republic	55	4	2	(2)
France	376	42	645	95
Germany, West	92	8	234	28
India	-----	---	55	4
Israel	20	1	-----	---
Italy	95	13	300	35
Japan	408	54	309	41
Libya	35	6	-----	---
Mexico	362	46	586	75
Netherlands	343	40	177	15
New Zealand	25	2	4	(2)
Norway	-----	---	27	3
Panama	23	3	35	3
Peru	17	2	68	9
Philippines	168	17	69	5
Spain	10	2	-----	---
Switzerland	9	1	99	13
Taiwan	38	4	40	5
United Kingdom	1,020	138	553	89
Venezuela	159	27	79	15
Other countries	61	9	73	10
Total	5,655	682	5,783	701

[1] Not elsewhere classified.
[2] Less than ½ unit.

WORLD REVIEW

In 1970 world demand for graphite increased over the 1969 level, particularly because of heavy buying by Japan. At the same time, importers in the Western nations encountered difficulty in obtaining supplies of key grades from Ceylon. Orders to producers in other nations therefore rose rapidly, sometimes exceeding productive capacity, and delays in obtaining shipments resulted. Some purchasers placed orders with several producers to insure receiving supplies, thus adding an artificial element to demand.

Ceylon.—The export tax on graphite, first imposed in 1969, was raised from 25 to 50 percent of value during 1970, causing a sharp rise in the cost of Ceylonese graphite. The Ceylon Government's intention concerning public ownership of the industry remained unclear at yearend. Because of the increased competition from Japan and other Asian nations, U.S. importers found it difficult to obtain supplies from Ceylon.

South Africa, Republic of.—Graphitwerk Kropfmuehl AG of West Germany purchased a graphite mine at an undisclosed location in South Africa. It is the company's second investment in graphite mining on the continent; the first was a joint venture with two partners in Southern Rhodesia.[2]

[2] Industrial Minerals. V. 37, October 1970, p. 33.

Table 5.—U.S. imports for consumption of natural and artifical 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)
1968	4,760	$591	246	$64	62,804	$1,802	112	$37	67,922	$2,494
1969:										
Austria	------	------	------	------	20	2	------	------	20	2
Ceylon	------	------	102	9	3,415	393	------	------	3,517	402
France	2	1	------	------	14	8	------	------	16	9
Germany, West	317	59	92	30	1,114	148	12	9	1,535	246
Hong Kong	------	------	------	------	337	8	------	------	337	8
Italy	------	------	16	6	------	------	2	2	18	8
Korea, Republic of	22	2	------	------	596	15	------	------	618	17
Malagasy Republic	r 4,511	457	------	------	511	50	------	------	r 5,022	507
Mexico	------	------	------	------	43,269	876	------	------	43,269	876
Norway	------	------	------	------	4,037	334	------	------	4,037	334
Sweden	------	------	------	------	44	4	------	------	44	4
Switzerland	------	------	------	------	------	------	6	2	6	2
United Kingdom	20	4	------	------	------	------	(1)	(1)	20	4
Total	r 4,872	523	210	45	53,357	1,838	20	13	r 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

r Revised.
1 Less than ½ unit.

Table 6.—World production of natural graphite, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
Argentina	[r] 410	268	[e] 300
Austria	[r] 26,959	28,467	30,570
Brazil	2,491	12,989	NA
Ceylon [2]	11,907	12,586	10,788
China, mainland [e]	33,000	33,000	33,000
Germany, West	14,157	14,369	[e] 14,500
Hong Kong	558	219	-------
Italy	[r] 1,558	1,895	2,302
Japan	1,641	1,903	1,615
Korea, North [e]	83,000	83,000	83,000
Korea, Republic of [3]	143,003	81,939	65,621
Malagasy Republic	[r] 18,110	18,594	20,058
Mexico	58,085	47,311	61,341
Norway	9,117	10,274	[e] 10,500
South Africa, Republic of	797	506	771
U.S.S.R. [e]	77,000	77,000	83,000
United States	W	W	W
Total	[r] 481,793	424,320	417,366

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

[1] In addition to the countries listed, Czechoslovakia, India, Southern Rhodesia, and the Territory of South-West Africa produced graphite, but available information is inadequate to make reliable estimates of output levels.

[2] Exports.

[3] Official South Korean sources give figures in metric tons that convert to the following, in short tons: Crystalline graphite 1968—709; 1969—654; 1970—NA: Amorphous graphite 1968—395,551; 1969—341,510. The amorphous graphite figures so reported, however, include material not marketed for traditional uses of graphite.

Table 7.—Malagasy Republic: Exports of graphite by countries

(Short tons)

Destination	1968	1969
Australia	191	166
Canada	86	44
France	2,063	3,865
Germany, West	2,625	3,135
India	91	124
Italy	752	994
Japan	2,272	1,969
Netherlands	66	44
Poland	165	116
Spain	215	340
United Kingdom	4,629	5,086
United States	4,286	4,375
Other countries	70	150
Total	17,511	20,408

TECHNOLOGY

Research and testing of graphite powders and fibers in various types of composite materials continued. Several companies, including Poco Graphite, Inc.,[3] the Monsanto Co.,[4] and Ultra Carbon Corp.,[5] began marketing new forms and compounds of graphite during the year. However, widespread use of the more advanced materials that incorporate graphite fiber, outside the aerospace industry, still appeared to be well in the future.[6]

A recent experiment indicated the possibility of a solid state separation of the titanium oxide and iron in ilmenite by the reduction of ilmenite in the presence of graphite.[7]

[3] Metallurgia. New Graphite Powder. V. 82, No. 493, November 1970, p. 193.

[4] American Metal Market. Monsanto Marketing Graphite Fiber for Use in High-Strength Composites. V. 77, No. 151, Aug. 7, 1970, p. 15.

[5] Chemical Engineering. Graphite on Graphite. V. 77, No. 26, Nov. 30, 1970, p. 38.

[6] Iron Age. Boron Versus Graphite: No Contest. V. 206, No. 17, Oct. 22, 1970, p. 57.

[7] Metallurgical Transactions. Kinetics and Mechanism of Ilmenite Reduction With Graphite. V. 1, No. 6, June 1970, pp. 1729–1734.

Gypsum

By Richard E. Dawes [1]

The scarcity of mortgage money and increased interest rates discouraged residential building through the first three-quarters of 1970. In the fourth quarter, as mortgage money became more available and interest rates declined, building construction increased and rejuvenated gypsum industry production and sales by yearend. Production of crude gypsum in the United States in 1970 declined by about 5 percent in quantity to 9.4 million short tons, and declined more than 9 percent in value to $35.1 million, the lowest value in more than a decade. Increased imports of crude gypsum offset the lower domestic production, so the total supply of crude was only 1 percent less than in 1969. Imports in 1970 of 6.1 million tons represented a new high, so with lower domestic output, the ratio of domestic crude production to total crude supply was at a record low level. Sales of uncalcined gypsum for use as a retarder in Portland cement declined slightly more than 3 percent from the record 1969 high. The unit value of calcined gypsum rose about 2 percent, which reflected increasing production costs, although total calcined gypsum value was down almost 8 percent from the 1969 record high value.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Active mines and plants [1]	121	113	115	r 114	108
Crude: [2]					
Mined	9,647	9,393	10,018	9,905	9,436
Value	$35,681	$34,383	$36,775	$38,354	$35,132
Imports for consumption	5,479	4,563	5,474	5,858	6,128
Calcined:					
Produced	8,434	7,879	8,844	9,324	8,449
Value	$119,747	$115,467	$133,239	$143,466	$132,047
Products sold (value)	$376,871	$362,268	$404,739	$414,880	$353,474
Exports (value)	$2,674	$2,918	$3,556	$3,446	$3,475
Imports for consumption (value)	$17,281	$11,353	$13,058	$14,602	$16,513
World: Production	53,676	50,879	54,486	56,481	55,581

r Revised.
[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.

DOMESTIC PRODUCTION

Over 9.4 million tons of crude gypsum was produced in 21 States at 69 mines, of which 56 were open pit and 13 were underground, although one site was operated as a combination open pit and underground mine. The leading gypsum-producing States were Michigan, Texas, Iowa, and California, which collectively accounted for over 50 percent of domestic production.

Domestic and imported gypsum was calcined at 76 plants in 30 States. The plants utilized 229 kettles and 71 other pieces of calcining equipment to produce over 8.4 million tons of calcined gypsum. The leading States producing calcined gypsum were New York, Texas, California, Iowa, and Georgia, which collectively represented over 45 percent of the total domestic calcined gypsum output. Gypsum board production was down about 7 per-

[1] Physical scientist, Division of Nonmetallic Minerals.

cent from the record high in 1969. Over 9.5 billion square feet of gypsum board products, with a value of nearly $300 million, were fabricated on 84 board machines.

Kaiser Gypsum Co. phased out its Rosario, N.M., gypsum wallboard plant at the end of 1970 because of current economic conditions. The plant, which employed 37 people, was built in 1960 with an annual production capacity of 125 million square feet. It is the smallest of the company's six domestic wallboard plants. The decision to close down the Rosario plant stemmed from operating losses due to reduced sales and poor wallboard prices in the New Mexico, Colorado, and Texas markets.

National Gypsum Co. created a new Industrialized Housing and Urban Development Department in their Building Products Division. This move gives the company greater opportunity to supply material for in-plant, factory-produced housing. The company modernized and expanded its gypsum wallboard manufacturing plant near Portsmouth, N.H. The 50-percent expansion of production is scheduled for completion in early 1971.

Grand Rapids Gypsum Co., Grand Rapids, Mich., announced plans for an air pollution control program and expansion of its Eagle Mills plant. New calcining facilities and an electrostatic dust collecting system would be installed by early 1971.

G.A.F., Inc., closed its New York gypsum operations early in 1970.

Table 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1969			1970		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arizona	4	83	$424	4	98	$358
California	9	1,210	3,339	7	1,132	3,271
Colorado	5	94	339	4	W	W
Iowa	5	1,169	5,274	5	1,136	4,223
Michigan	5	1,327	5,384	5	1,312	5,061
Nevada	3	521	1,550	3	451	1,457
New Mexico	5	141	526	4	W	W
New York	4	492	2,945	3	425	2,737
Oklahoma	r 8	r 980	r 3,912	7	874	2,616
South Dakota	1	11	46	1	15	61
Texas	8	1,314	4,398	8	1,220	4,252
Wyoming	4	W	W	4	216	868
Other States [1]	14	2,563	10,217	14	2,557	10,228
Total	r 75	r 9,905	r 38,354	69	9,436	35,132

r Revised. 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 (1969), 1 mine each; Arkansas, Indiana, Ohio, and Utah, 2 mines each; Kansas, 3 mines (1970).

Table 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1969					1970				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	7	874	$10,922	16	11	7	822	$10,403	16	4
Florida	3	W	W	9	2	3	438	5,194	9	2
Georgia	3	551	10,577	15	------	3	538	9,432	15	------
Iowa	5	823	12,837	22	4	5	713	12,301	22	4
Michigan	4	373	6,840	10	1	4	325	6,130	9	1
Nevada	3	325	3,506	12	6	3	240	3,425	12	6
New Jersey	4	383	5,022	9	3	4	334	4,785	9	4
New York	8	921	13,891	25	6	7	874	13,551	21	8
Ohio	3	356	5,506	9	1	3	321	4,984	9	1
Texas	7	961	15,102	28	3	7	870	14,273	28	3
Other States [2]	30	3,757	59,263	80	40	30	2,974	47,569	79	38
Total	77	9,324	143,466	235	77	76	8,449	132,047	229	71

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

[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, Pennsylvania, and Washington, 1 plant each; Kansas, Louisiana, Maryland, New Mexico, Oklahoma, Utah, Virginia, and Wyoming, 2 plants each; and Indiana, 3 plants.

CONSUMPTION AND USES

The domestic supply of newly mined crude gypsum totaled 15.6 million tons, 9.4 million tons from domestic mines and 6.1 million tons imported primarily from U.S.-company-affiliated mines in Canada, Mexico, and Jamaica. Approximately 4.3 million tons of the crude was sold uncalcined, of which nearly 3.4 million tons was for use as portland cement retarder, 800,000 tons for agricultural use, and the remainder for filler and other uses. The nearly 27-percent decrease in sales of agricultural gypsum was again attributed to reduced demand by California potato and cotton growers, who are among the principal consumers of agricultural gypsum in the United States.

Consumption of calcined gypsum for prefabricated building products declined and returned to 1968 levels. The decrease of 700,000 tons reflected the generally reduced building construction activity prevalent throughout the nation during 1970, which significantly affected wallboard sales. Total output of wallboard, however, still represented over 90 percent of the square footage of prefabricated products produced. Sales of building plasters, lath, and other specialty prefabricated products declined considerably. Dental and orthopedic was the only use that increased during the year. The popularity of ½-inch wallboard again dominated the prefabricated product lines and represented over 60 percent of the value of prefabricated products.

Table 4.—Gypsum products (made from domestic, imported, and byproduct gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Uncalcined:				
Portland-cement retarder	3,464	$15,850	3,358	$15,933
Agricultural gypsum	1,100	5,333	804	4,238
Other uses [1]	117	865	96	1,123
Total	4,681	22,048	4,258	21,294
Calcined: Industrial:				
Plate glass and terra cotta plasters	21	350	12	128
Pottery plasters	61	1,631	59	1,464
Dental and orthopedic plasters	15	661	16	747
Industrial molding, art, and casting plasters	115	2,761	100	2,637
Other industrial uses [2]	104	3,366	97	4,082
Total	316	8,769	284	9,058
Building:				
Plasters:				
Basecoat	473	9,745	411	8,708
Veneer plaster (basecoat and finishes)	51	2,767	48	2,715
Mill-mixed basecoats (sanded and perlited)	253	7,138	206	6,130
To mixing plants	W	W	W	W
Gaging and molding	74	1,986	64	1,821
Prepared finishes	8	632	7	530
Roof deck	290	5,234	240	4,534
Keene's cement	17	586	W	W
Other [3]	10	547	24	1,032
Total	1,176	28,635	1,000	25,470
Prefabricated products [4]	[5] 9,369	355,428	8,669	297,652
Total	-------	384,063	-------	323,122
Grand total, value	-------	414,880	-------	353,474

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes uncalcined gypsum for use in filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.
[2] Includes dead-burned filler, granite polishing, and miscellaneous uses.
[3] Includes joint filler, patching, painter's, insulating, and unclassified building plasters; and quantity and value indicated by symbol W.
[4] Excludes tile.
[5] Includes weight of paper, metal, or other materials.

Table 5.—Prefabricated products sold or used in the United States, by products

Product	1969 Thousand square feet	1969 Thousand short tons [1]	1969 Value (thousands)	1970 Thousand square feet	1970 Thousand short tons [1]	1970 Value (thousands)
Lath:						
3/8 inch	685,672	496	$17,886	501,684	395	$13,059
1/2 inch	217,695	208	7,807	208,574	198	6,801
Other [2]	13,728	17	606	15,498	18	613
Total	917,095	721	26,299	725,756	611	20,473
Wallboard:						
1/4 inch	110,242	62	2,746	105,164	66	2,344
3/8 inch	1,310,027	940	41,477	1,188,863	914	33,052
1/2 inch	6,369,691	5,839	215,067	6,070,972	5,483	179,416
5/8 inch	1,244,750	1,451	57,833	1,220,309	1,336	51,162
1 inch [3]	55,299	79	2,194	29,555	43	2,844
Total	9,090,009	8,371	319,317	8,614,863	7,842	268,818
Sheathing	228,917	227	7,495	184,784	178	6,059
Laminated board	[4] 9,256	12	687	7,974	8	946
Formboard	37,106	38	1,630	29,578	30	1,356
Grand total [5]	10,282,383	9,369	355,428	[6] 9,562,956	8,669	297,652

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of 1/4-inch and 1-inch lath.
[3] Includes a small amount of 5/16-inch, 3/4-inch, 1 5/8-inch, and 3 3/4-inch wallboard.
[4] Area of component board and not of finished products.
[5] Excludes tile, for which figures were withheld to avoid disclosing individual company confidential data.
[6] Data may not add to total shown because of independent rounding.

PRICES

Efforts by gypsum producers to improve the price situation occurred throughout the year, as some companies announced price increases on gypsum wallboard and lath products. The upward price adjustments reflected feeling within the industry that the products have been underpriced. One producer sought to improve the price situation in the East by initiating a job delivery policy that would reduce the delivered price of wallboard to big customers by eliminating the middle man. Industry opinion as to the effect of the job delivery policy on the cost to the ultimate consumer, indicated that savings up to as much as $8 per thousand square feet delivered might be realized. Prices quoted in the Engineering News-Record, however, were not affected by the new policy because list prices in the past have been adjusted by discounting.

The average prices for gypsum products as published monthly in Engineering News-Record for 20 U.S. cities showed mixed directions of change. Neat plaster averaged $37.83 in January and rose to $40.57 per ton in December; gaging plaster averaged $42.96 per ton in January and rose to $47.53 by December. Tongue and groove sheathing also showed a rising price over the year; in January the average price was $60.75 and by December it was $63.26 per thousand square feet. Average prices for board product, however, were generally somewhat lower. Quotations for 3/8-inch gypsum board went from an average $54.39 per thousand square feet to $54.25. For 1/2-inch gypsum board the price went from $63.46 to $62.84 per thousand square feet; 3/8-inch gypsum lath showed price quotations decreasing from an average $46.58 in January to $46.25 per thousand square feet in December. The averages do not include any discounting allowances that were available in the various cities.

FOREIGN TRADE

Imports of crude gypsum from overseas U.S.-company-affiliated mines increased from 5.8 million tons in 1969 to 6.1 million tons in 1970. Receipts of crude gypsum from Canada through east coast and Pacific Northwest customs districts comprised 77 percent of the total imports; from Mexico through the California, Washington, Texas, and Florida districts, 16 percent; from Jamaica through Gulf coast districts, 4 percent; and from the Dominican Republic, Taiwan, Venezuela, and Italy through the Puerto Rico, New York, and Maryland districts, 3 percent.

An increase in imports from Mexico of 191,000 short tons occurred in 1970. Imports from Canada and the Dominican Republic also increased, but imports from Jamaica were down 37,000 tons from 1969 levels.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined		Other manufactures n.e.c., value	Total value
	Quantity	Value		
1968	39	$1,688	$1,868	$3,556
1969	40	2,003	1,443	3,446
1970	41	1,915	1,560	3,475

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			
1968	5,474	$11,384	2	$89	$932	$653	$13,058
1969	5,858	12,394	2	87	1,242	r 879	r 14,602
1970	6,128	13,723	2	106	1,559	1,125	16,513

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 countries

(Thousand short tons and thousand dollars)

Country	1969		1970	
	Quantity	Value	Quantity	Value
Canada	4,722	$10,277	4,730	$10,859
Taiwan	-----	-------	58	44
Dominican Republic	43	136	90	287
Italy	(1)	2	(1)	3
Jamaica	304	830	267	731
Mexico	789	1,144	980	1,767
Other countries	(1)	5	3	32
Total	5,858	12,394	6,128	13,723

[1] Less than ½ unit.

WORLD REVIEW

Argentina.—Argentina remained the largest producer of gypsum in the South American area. The level of production was basically determined by domestic demand for cement; however, a certain amount of trade did take place, notably between Argentina and Uruguay.

Australia.—Large proportions of gypsum production are controlled by two major plaster manufacturers, Australia Gypsum Industries Ltd. of Melbourne and the Colonial Sugar Refining Co., Ltd., of Sidney. Production in the state of South Australia accounted for over three-fourths of the Australian production. Consumption of gypsum in uses other than agricultural indicated that about two-thirds of the consumption was for plaster of paris production and the remainder was for Portland cement retarder. Exports of gypsum were principally to the countries of New Zealand, the Philippines, and Taiwan. The average export value for the first quarter of 1970 showed a decrease to $5.43 per ton f.o.b. from $5.50 in 1969.

Australian Gypsum Industries, Ltd., announced that it had established a technical link with the United States Gypsum Co. There were no financial ties as yet. However, the arrangement provided for an exchange of information on research and development work carried out by either company on gypsum products, with manufacturing and patent rights included. This allows the Australian company access to an entire new range of products, particularly in the field of metal accessories used in partitioning.

Table 9.—Gypsum: World production, by countries

(Short tons)

Country [1]	1968	1969	1970 p
North America:			
Canada (shipments) [2]	5,926,935	6,373,648	6,442,000
United States	10,018,000	9,905,000	9,436,000
Central America:			
Dominican Republic	r 111,648	e 110,000	e 110,000
Guatemala	8,488	8,514	8,499
Honduras	7,188	8,443	10,146
Jamaica	r 232,960	281,121	e 285,000
Mexico	1,361,620	1,343,818	1,422,927
Nicaragua [2]	r 15,680	33,600	e 33,000
Trinidad and Tobago	4,760	4,480	e 4,500
South America:			
Argentina	r 478,486	590,073	e 595,000
Brazil	r 238,978	e 240,000	e 240,000
Chile	r 113,608	137,821	140,288
Colombia	133,380	166,449	208,405
Paraguay	r 3,808	3,858	6,614
Peru	39,335	49,630	e 50,000
Venezuela e	r 109,100	90,400	110,200
Europe:			
Austria [2]	769,648	745,206	692,065
Belgium	89,735	87,052	e 95,000
Bulgaria	r 213,848	e 187,400	187,400
Czechoslovakia	r 448,600	485,000	e 507,000
France [2]	r 5,858,273	6,568,886	6,711,084
Germany:			
East [3]	r 249,088	262,195	e 264,500
West (marketable)	r 1,677,237	2,013,084	1,623,661
Greece	r 253,855	299,080	330,700
Italy e	r 3,196,700	3,306,900	3,417,200
Luxembourg	r 7,016	10,129	5,580
Poland	870,825	892,871	e 909,400
Portugal	117,171	104,868	e 104,700
Spain	r 4,389,551	4,346,598	e 4,409,200
U.S.S.R.	5,177,550	5,032,045	e 5,180,900
United Kingdom [2]	r 5,063,529	5,065,769	4,712,968
Yugoslavia	216,747	255,547	276,260
Africa:			
Angola	14,316	18,075	e 16,300
Ethiopia	r 397	5,722	5,126
Kenya [2]	r 46,411	68,172	65,058
Libya [4]	r 15,400	e 9,000	3,030
Niger	2,157	e 2,200	e 2,200
South Africa, Republic of	348,385	396,193	452,058
Sudan [2]	11,272	e 5,000	1,804
Tanzania	4,917	12,161	22,838
United Arab Republic	r 628,501	517,975	e 551,200
Asia:			
Burma	e r 3,300	3,858	3,300
China, mainland e	r 551,200	606,300	606,300
Cyprus	22,399	17,953	37,867
India	r 1,456,392	1,531,676	973,048
Iran e [4]	r 1,676,000	1,759,800	1,847,800
Israel e [5]	r 77,200	78,300	77,200
Japan	r 683,555	683,427	640,652
Lebanon	44,092	33,069	38,581
Mongolia e	r 27,600	27,600	27,600
Pakistan	50,706	226,425	184,661
Philippines	22,764	40,800	19,244
Saudi Arabia	44,425	e 38,600	18,994
Syrian Arab Republic e	r 16,500	16,500	16,500
Taiwan	r 6,213	5,647	12,484
Thailand	141,199	101,449	159,008
Turkey e	r 242,500	308,600	352,700
Oceania: Australia	r 944,995	957,468	e 914,900
Total	r 54,486,143	56,481,455	55,580,650

e Estimate. p Preliminary. r Revised.

[1] Gypsum is also produced in Ireland, Romania, Switzerland, and Cuba, 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.

Canada.—Canadian Gypsum Co., Ltd., a subsidiary of the United States Gypsum Co., began construction of a new $3 million gypsum wallboard plant at St. Jerome, Quebec, that was scheduled to begin operation early in 1971.

With the completion of a new gypsum wallboard plant in Edmondton, Alberta, by B.A.C.M. Industries, Ltd. there are now 16 gypsum products plants in Canada, one of which produces only plaster. Preliminary production estimates indicate that output from Nova Scotia again represented about three-fourths of the total Canadian production. Newfoundland and Ontario were the next largest producing provences. The average value of gypsum produced in Canada in 1970 showed a slight decline to $2.32 per short ton.

France.—France continued to be the largest producer and the largest exporter of gypsum in Europe. The principal producing area, in and around Paris, accounted for about 70 percent of the country's total output. Most of the mines and plants in the area belong to the three large integrated manufacturers, Lambert Frères et Cie, Société Poliet & Chausson, and Société G.R.M. Plâtres Mussat. The second important mining and manufacturing area is in the south of France near Marseilles. Operations are carried out by two companies, S.A. des Plâtières de Vaucluse and Gypses & Plâtres de France.

India.—India is self-sufficient in gypsum and has extensive reserves in eight States; however, many of the country's deposits are excessively distant from consuming areas. The result is temporary shortages and high freight rates. India's total annual production, therefore, is consumed in the country and largely within the fertilizer, cement, ceramic, and chemical and pharmaceutical industries. Recently revised data on proved and indicated reserves from the Geological Survey of India indicate that more than 1.1 billion metric tons of gypsum has been located. Gypsum mining in India is confined to open pit operations, and contaminating clays interbedded with the ore necessitate continuous selective mining.[2]

Mauritania.—Late in 1970 it was announced that a substantial deposit of gypsum had been discovered near the capital, Nouakchott. Reserves had been reported in the billions of tons. The deposit extends over many square kilometers and is comprised of two types of gypsum—gypsum in dunes and compact gypsum.

Mexico.—Almost all the crude gypsum output for Mexico is exported to the United States. The vast bulk of the output is shipped from a quarry on San Marcos Island, in the Gulf of California, to the west coast of the United States.

United Kingdom.—The United States Gypsum Co., whose principal European interests are Gyproc-Benelux S.A. in Belgium and Gessi San Salvo S.p.A. of Italy, has disposed of its 15-percent interest in B.P.B. Industries, Ltd. The two companies will, however, maintaiin a close working relationship and continue to exchange expertise in research information.

An article described the gypsum industry of Britain.[3]

TECHNOLOGY

Interest continued to be shown in the use of gypsum as a source of sulfur; however, the reduced price of sulfur has changed the economic situation for the various processes being considered. The increasing seriousness of waste piles of byproduct gypsum resulting from the manufacture of fertilizers is creating interest in obtaining answers from an environmental standpoint.[4] A method for the bacteriological extraction of sulfur values from a subterranean gypsum stratum uses a culture of thiobacillus thioparus, or other sulfide reducing and oxidizing bacteria, inoculated into the gypsum stratum via a cased borehole. Raw sewage is used as a culture medium and the bacteria are permitted a sufficient work period to form hydrogen sulfide gas. The hydrogen sulfide gas is recovered and treated by conventional methods for its sulfur content.[5]

An improved fire-resistant plaster, com-

[2] Bureau of Mines. Mineral Trade Notes. V. 67, No. 11, pp. 23–24.

[3] Industrial Minerals. Gypsum in Britian. V. 37, October 1970, pp. 17–21.

[4] Industrial Minerals Magazine. Gypsum's Sulfur Values. No. 37, October 1970, pp. 22–25.

[5] Johnson, C. J., W. G. Mouat, and A. G. Davidson. Bacteriological Extraction of Sulfur Values From Gypsum. U.S. Pat. 3,542,431, Nov. 24, 1970.

prised of a gypsum plaster base with a sizable percentage of either lime, portland cement, phosphate rock, or phosphatic shale, an adhesive binder and either expanded perlite, or exfoliated vermiculite was patented.[6] Another improved gypsum plaster that dries to a hard, highly stable mass consists of a mixture of accelerated anhydrous gypsum plaster, retarded hemihydrate plaster, and 5 to 7 percent of expanded perlite or exfoliated vermiculite. This mix is shown to be workable over a comparatively long period of time.[7]

A retarder for use in gypsum plaster consists of a methoxy polyethylene glycol, or similar compound.[8] A second gypsum plaster retarder is comprised of certain polycarboxylic compounds obtained by condensation of aliphatic amino acid with formaldehyde.[9]

A plaster for single-coat plastering of concrete blocks or other high-suction backgrounds was patented.[10] The plaster consists of 54 to 74 percent gypsum plaster produced by continuous calcination of powdered gypsum in a vessel of which the contents are fluidized by evolved water, 25 to 35 percent of ground limestone, and minor percentages of lime cellulose ether, ground crude gypsum, and animal glue.

In alpha-type gypsum plaster manufacture, the starting gypsum rock is mixed with lithium hydroxide or similar compound as a retarder before it is calcined.[11] A patent was issued on the manufacture of a hydraulic binding agent for building purposes, in which gypsum plaster is mixed with optimum proportions of fluorspar, copper oxide, and a natural aluminum silicate material such as kaolin.[12]

A method to avoid caking of moist hemihydrate consists of separating the hemihydrate gypsum plaster from water in a continuous decanting centrifuge. The centrifuge casing is heated so that all surfaces are hotter than 100° C.[13]

Granulation of hemihydrate gypsum is accomplished when plaster, the calcium sulfate hemihydrate obtained by conventional means is agitated in the presence of water at a temperature of 80° to 90°. The granules are then dried. Optionally, there is added to the wet plaster either asbestos or expanded perlite or both to make it a reinforced product or lightweight product or both.[14]

A method and apparatus for high-speed drying of gypsum board was patented and consists of a multitiered continuous dryer for gypsum board using high-velocity, high-temperature jets of air.[15]

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[6] Ware, F. Heat and Fire-Resistant Plaster Compositions. U.S. Pat. 3,502,490, Mar. 24, 1970.

[7] Hynes, J. P. Gypsum Plaster. British Pat. 1,184,938, Mar. 18, 1970.

[8] Pratt, R. J., and D. W. Young (assigned to Sinclair Research Inc., New York). Set Retarded Plaster Composition. U.S. Pat. 3,544,344, Dec. 1, 1970.

[9] Kuntze, R. A. (assigned to Dominican Tar & Chemical Co.). Gypsum Retarder. Canadian Pat. 841,074, May 5, 1970.

[10] Pilgram, T. A., and A. W. Thornhill (assigned to British Gypsum Ltd.). Gypsum Plaster. Canadian Pat. 831,069, Dec. 30. 1969.

[11] Chambers, G. P. C., and M. R. Damm. Manfacture of Calcium Sulfate Hemihydrate. U.S. Pat. 3,520,708, July 14, 1970.

[12] Way, T. Hydraulic Binding Agent. British Pat. 1,200,429, July 29, 1970.

[13] Brown, M. G., and E. G. Foster (assigned to Imperial Chemical Industries, Ltd., London). Gypsum Plaster. British Pat. 1,190,014, Apr. 29, 1970.

[14] (Patentee not named, assigned to Rigips Baustoffwerke G.m.b.H.). A Method for Granulating Hemihydrate Gypsum Plaster. British Pat. 1,190,295, Apr. 29, 1970.

[15] Schuette, H. W., and R. N. Hume (assigned to Moore Dry Kiln Co.). Method and Apparatus for High Speed Drying of Gypsum Board. U.S. Pat. 3,529,357, Sept. 22, 1970.

Helium

By Edwin M. Thomasson [1]

Sales of grade A helium in the United States in 1970 were 647.2 million cubic feet (MMcf), a decline of about 112.3 MMcf from 1969 sales. Of the total, 230.7 MMcf was sold by the Bureau of Mines, compared with 360.7 MMcf in 1969. Private plants had a total sales volume of 416.5 MMcf in 1970, compared with 398.8 MMcf in 1969. Helium purchases by the Bureau of Mines under the conservation program totaled 3,490.6 MMcf in 1970.

The price of helium, f.o.b. Bureau of Mines plants, remained $35 per thousand cubic feet. This price was established in 1961. Helium was sold by private producers at various rates, all somewhat lower than the Bureau of Mines price.

PRODUCTION

On January 1, 1970, there were 12 helium extraction plants operating in the United States. On December 31, 1970, 11 of these plants remained in operation. Table 1 shows the plants operating at the beginning of the year and their status at yearend. These plants may be classified in three categories: (1) plants owned by the Federal Government and operated by the Bureau of Mines, (2) privately owned and operated "conservation" plants producing only crude helium (50- to 85-percent purity), almost all of which is purchased by the Bureau of Mines under the national helium conservation program, and (3) privately owned and operated plants producing helium for independent sale to commercial (non-Federal) customers.

Total production of helium (of all grades) from all plants during 1970 was 4,676.8 MMcf. This is a decrease of about 1.6 percent from the 1969 production of 4,752.4 MMcf.

Bureau of Mines Plants.—Three Bureau of Mines plants, at Amarillo and Exell, Tex., and Keyes, Okla., were in operation at the beginning of the year. However, the plant at Amarillo, Tex., which commenced operation in 1929, was closed on April 15, 1970. The loading facility at the Amarillo plant continues in operation with high-purity helium being supplied from the Exell plant by means of a pipeline connecting the two. Production from the three plants was 660.1 MMcf of high-purity (99.997+-percent purity) helium, or about the same as the 1969 production of 666.9 MMcf. Helium produced by the Bureau of Mines and not sold was stored in the Cliffside gasfield near Amarillo, Tex. The Bureau of Mines plants at Exell, Tex., and Keyes, Okla., processed essentially all the helium-bearing natural gas tendered by the natural gas pipeline company serving the plants.

Extensive modernization of the Exell plant and the installation of additional processing facilities continued throughout the year.

Conservation Plants.—Five privately owned and operated helium extraction plants produced helium for sale to the Bureau of Mines under long-term contract for the Government's helium conservation program. These plants produced only crude helium, principally for storage at the Cliffside field, but two of the plants sold small quantities of crude helium produced in excess of conservation contract requirements to private helium plants for purification. Some of this excess helium was stored at the Cliffside field under contract with the private producers. During

[1] Staff engineer, Division of Helium.

Table 1.—Ownership and location of helium extraction plants in the United States

Category and owner or operator [1]	Location	Type of production	Status Dec. 31, 1970
Government owned (1):			
Bureau of Mines	Amarillo, Tex	Grade A helium	Abandoned.
Do	Exell, Tex	do	Operating.
Do	Keyes, Okla	do	Do.
Conservation plants (2):			
Cities Service Helex, Inc	Ulysses, Kans	Crude helium only	Do.
National Helium Corp	Liberal, Kans	do	Do.
Northern Helex Co	Bushton, Kans	do	Do.
Phillips Petroleum Co	Dumas, Tex	do	Do.
Do	Hansford Co., Tex	do	Do.
Privately owned (3):			
Alamo Chemical Co	Elkhart, Kans	Grade A helium	Do.
Cities Service Cryogenics, Inc	Scott City, Kans	Crude helium [2]	Do.
Kansas Refined Helium Co	Otis, Kans	Grade A helium	Do.
Kerr-McGee Corp	Navajo, Ariz	Grade A helium [3]	Do.
Linde Co.[4]	Shiprock, N. Mex	Grade A helium	Not operating.
Western Helium Co	Navajo, Ariz	do	Operating.

[1] See text for full descriptions of plant categories.
[2] Crude helium is shipped by pipeline to Cities Service Helex plant for purification.
[3] Plant equipped to produce liquid helium.
[4] Former Bureau of Mines plant, now owned by the Navajo Indian Tribe and operated under lease as a pilot-plant operation.

Table 2.—Helium production in the United States
(Million cubic feet)

Year	Quantity
1966	4,606.1
1967	4,712.3
1968	4,854.8
1969	4,752.4
1970	4,676.8

Table 3.—Production of grade A helium by Bureau of Mines plants
(Million cubic feet)

Plant location	Quantity	
	1969	1970
Amarillo, Tex.[1]	57.1	10.6
Exell, Tex	256.4	255.9
Keyes, Okla	353.4	393.6
Total	666.9	660.1

[1] Plant ceased operation Apr. 15, 1970.

Table 4.—Helium purchased by the Bureau of Mines for conservation
(Million cubic feet)

Company	Location	Helium delivered				
		1966	1967	1968	1969	1970
Cities Service Helex Inc	Ulysses, Kans	717.4	740.6	771.4	718.3	716.5
National Helium Corp	Liberal, Kans	1,303.7	1,245.6	1,211.6	1,247.4	1,165.8
Northern Helex Co	Bushton, Kans	565.5	654.9	618.1	662.4	612.9
Phillips Petroleum Co	Dumas, Tex	539.8	551.2	569.9	587.9	587.3
Do	Hansford Co., Tex	490.7	426.4	468.8	429.3	408.1
Total		3,617.1	3,618.7	3,639.8	3,645.3	3,490.6

Table 5.—Helium in conservation storage
(Million cubic feet)

Year	Quantity in storage Dec. 31	Amount privately owned [1]
1966	12,720.2	50.2
1967	16,527.0	57.4
1968	20,328.5	69.8
1969	24,224.0	21.0
1970	28,236.1	58.1

[1] Helium stored for private companies under storage contracts and not owned by Bureau of Mines.

1970, the five conservation plants produced a total of 3,600.2 MMcf of helium. The Bureau of Mines purchased 3,490.6 MMcf of this total, compared with 3,645.3 MMcf purchased in 1969.

Private Plants.—Five privately owned helium extraction plants were in operation during the year. These private plants operate independently of the Federal helium program, and sales are made for the most part directly, or through industrial gas distributors, to commercial (non-Federal) customers.

Production from all private helium plants in 1970 was 416.5 MMcf of grade A helium. This compares with the 398.8 MMcf produced by these plants during 1969.

CONSUMPTION

Bureau of Mines sales of grade A helium continued to decline during the year. Bureau sales were 230.7 MMcf in 1970, compared with 360.7 MMcf in 1969. Total sales of grade A helium from both Bureau and private sources also decreased from a total of 759.8 MMcf in 1969 to 647.2 MMcf in 1970. Of the total Bureau of Mines sales of high-purity helium, 177.5 MMcf was delivered to Federal agencies and 53.2 MMcf to commercial customers. However, much of the helium delivered to commercial firms was redistributed to Federal agencies; thus, the amount is not indicative of actual helium use by non-Federal customers.

Table 6.—Shipments of grade A helium from Bureau of Mines plants to various customers

(Million cubic feet)

Recipient	1969		1970	
	Quantity	Percent [1]	Quantity	Percent [1]
Federal agencies:				
Department of Defense	191.6	53.1	119.5	51.8
Atomic Energy Commission	23.3	6.5	17.1	7.4
National Aeronautics and Space Administration	63.8	17.7	37.4	16.2
Weather Bureau (ESSA)	4.5	1.2	3.1	1.3
Other	.8	.2	.4	.2
Subtotal	284.0	78.7	177.5	76.9
Non-Federal customers [2]	76.7	21.3	53.2	23.1
Grand total	360.7	100.0	230.7	100.0

[1] Percentage of all shipments.
[2] A large part of this helium is redistributed by the Bureau's non-Federal customers to Federal agencies and their contractors; hence, the data herein are not indicative of actual helium use by non-Federal customers.

The decline in total helium sales in the United States follows a trend first established in 1967. Peak sales occurred in 1966, when 948 MMcf of helium was sold (used). Most of the decline in helium sales (usage) is believed attributable to the reduced level of activity in the Nation's space and missile programs and the shift in these programs from development to operational status. Also, the overall slowdown in the Nation's economy has undoubtedly contributed to the reduction of helium sales in the past few years.

All Bureau of Mines grade A helium was shipped in gaseous form in cylinders, highway semitrailers, or railway tank cars. Private plants shipped helium in both the gaseous and liquid states.

Helium redistribution continued satisfactorily under contracts between the General Services Administration and private companies. The private companies purchase helium from the Bureau of Mines in bulk, repackage it in smaller containers, and distribute it to the helium-using Federal agencies. These contracts make relatively small quantities of helium readily available to the agencies and reduce freight charges for small purchases.

The largest user of helium in 1970 was again the Nation's space and missile program. Private industry and research organizations also continued to use large quantities of helium.

Table 7.—Grade A helium used in the United States

(Million cubic feet)

Year	Quantity [1]
1966	948
1967	907
1968	867
1969	760
1970	647

[1] Includes helium produced and sold by privately owned helium extraction plants.

RESOURCES

The survey to locate the helium resources of the United States was continued throughout the year. A total of 457 natural gas samples from fields and wells in 20 States and five foreign countries were collected and analyzed for helium.

Judging from the information now available, no significant discoveries of helium were made in 1970; however, the future development of new fields could increase estimates of reserves.

As of December 31, 1970, the helium reserves of the United States were estimated to be 154 billion cubic feet, exclusive of the 28 billion cubic feet of helium in storage at Cliffside Field, Potter County, Tex., near Amarillo. Five major helium-bearing gasfields located in the Texas Panhandle, Oklahoma Panhandle, and southwestern Kansas contain over 80 percent of the helium reserves of the United States. These fields are (1) the Hugoton field in Kansas, Oklahoma, and Texas; (2) the Panhandle field of Texas; (3) the Keyes field in Oklahoma; (4) the Greenwood field in Kansas and Colorado; and (5) the Cliffside field in Texas. All of these fields are within 200 miles of Amarillo, Tex. The remaining helium reserves are contained in 83 gasfields located in Arizona, Colorado, Kansas, Montana, New Mexico, Oklahoma, Texas, Utah, West Virginia, and Wyoming.

FOREIGN TRADE

Export licenses for helium were granted by the Office of Munitions Control, U.S. Department of State.[2] Exports of helium in 1970 are estimated to be about 60 to 65 MMcf. Most exported helium was used in fundamental and applied research, in chromatography, and in various atomic energy applications.

WORLD REVIEW

The only helium extraction plant in operation in the free world besides those in the United States is located near Swift Current in Saskatchewan, Canada. The plant began production in December 1963. It processes nonflammable helium-bearing gas from a small reserve. In 1967, the plant's annual capacity was increased from 12 MMcf to 36 MMcf. While exact production data are not known, it is believed that the plant operates at near capacity. Most of the helium produced is said to be exported to Japan and other Asian countries, although some is used in Canada.

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[2] The authority to grant export licenses for helium was transferred to the Department of Commerce from the Department of State in March 1971.

Iron Ore

By F. L. Klinger [1]

World production of iron ore in 1970 increased about 7 percent compared with that of 1969. Increased output was evident in most of the principal producing countries. Demand was strong in the first half of the year but declined to some extent in the last half as the pace of steelmaking was slowed in the United States, Europe, and Japan. Iron ore prices were generally higher, continuing a trend begun in 1969 after several years of decline. Demand for high iron content ores, beneficiated to increasingly strict physical and chemical specifications, continued to raise the quality of marketable ore as well as the costs of production. This inevitably led to the closing of additional high-cost or low-volume producers such as small underground mines and to the coalition of other producers into larger, more competitive units.

Transportation continued to be a major element in iron ore costs, but it was also an area where important savings were possible. The trend toward increasing the size of individual ore shipments, ore-carrying vessels, and of the capacity of port facilities to service them was evident all over the world. Several ports were completed or under construction to handle vessels in the 250,000-ton range. The capacity of loading and unloading systems installed was as high as 15,000 to 20,000 tons per hour. Slurry transport systems were affording such economies in transport and handling costs that a number of iron ore deposits, previously regarded as marginal or uneconomic, could now be exploited.

Capacity for iron ore pellet production continued to rise. New plants or expansions of existing plants were completed or under construction in the United States and a dozen other countries. The United States produced more than half of the world's pellets; output in 1970 was 55.4 million tons. The number of metallized-pellet plants was also increasing.

Australia became the world's leading exporter of iron ore in 1970 and was the principal recipient of new iron ore investments. Australia's export commitments under long-term contracts totaled more than 1 billion tons of iron ore, about three-fourths of which was destined for Japan. Major expansions of production capacity were announced in Canada and Brazil.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Iron ore (usable;[1] less than 5 percent Mn):					
Production [2]	90,147	84,179	85,865	88,328	89,760
Shipments [3]	90,041	82,415	81,934	89,854	87,176
Value [3]	$854,134	$817,511	$836,433	$929,293	$941,739
Average value at mines per ton	$9.49	$9.92	$10.21	$10.34	$10.80
Exports	7,779	5,906	5,884	5,160	5,492
Value	$92,157	$71,585	$70,835	$62,310	$67,898
Imports for consumption	46,259	44,611	43,941	40,732	44,876
Value	$462,354	$443,918	$453,753	$402,178	$479,380
Consumption	134,047	127,424	131,753	140,235	135,000
Stocks Dec. 31:					
At mines [3]	12,160	12,959	16,041	13,566	15,316
At consuming plants	54,658	55,121	53,232	r 50,935	52,781
At U.S. docks	2,707	2,987	2,797	2,648	3,403
Manganiferous iron ore (5 to 35 percent Mn):					
Shipments	246	289	245	385	329
World: Production	625,799	612,820	668,142	707,183	754,299

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.

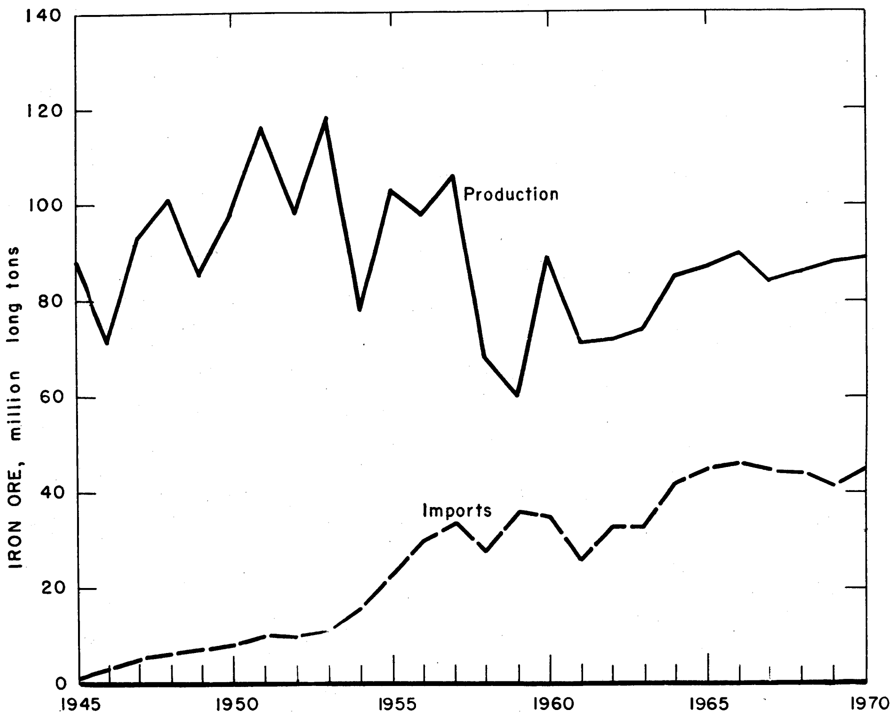

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

Preliminary figures indicated a 1.4-percent increase in total man-hours worked in iron ore mines and beneficiating plants in the United States in 1970. The average number of men employed declined to about 17,000 compared with 18,600 in 1969. The drop in employment occurred principally in Michigan, where three underground mines were closed at the end of 1969. In the Lake Superior district, the average number of men employed was 66 percent of the national total, compared with 67 percent in 1969.

The number of man-shifts worked in the Lake Superior district in 1970 increased 1 percent compared with 1969, as output of crude ore rose 2.7 percent and output of usable ore, 1.4 percent. This reflected increased production from taconite operations. For the rest of the country, the number of man-shifts increased about 2 percent, output of crude ore rose 3 percent, and output of usable ore, about 2 percent. Nationwide, calculated output per man-shift increased 1.3 percent for crude ore; the figure for usable ore appeared to be almost the same as in 1969. A true measurement of productivity was prevented by the usual practice of mining companies to maintain a stable labor force by keeping men employed all year, even if not producing iron ore.

The trend toward reducing the number of relatively small, high-cost mines in favor of more efficient, large-scale operations was continued. There were 18 fewer mines operating at yearend compared with 1969, although several of these were closed because ore reserves were exhausted. Employment figures in 1970 for the iron mining industry in most of the principal producing States were lower than in 1969.

Revised employment data for 1969 showed a total of 42,634,000 man-hours worked and the average number of men employed to be 18,646.

DOMESTIC PRODUCTION

Crude iron ore production in 1970 increased 2.6 percent compared with 1969. The higher output was generated mainly by taconite operations in Minnesota and Wisconsin, which compensated for reduced production from "soft-ore" mines of the Mesabi and Menominee ranges. In Wisconsin, the Black River Falls mine and plant of Inland Steel Co. has its first full year of production in 1970.

Domestic output of crude ore was produced from 10 underground mines and 64 open pits in 1970, compared with 12 underground mines and 80 open pits in 1969. The proportion of crude ore mined from open pits in 1970 was 93.8 percent, slightly higher than in the previous year. The average iron content of all crude ore mined in 1970 was approximately 33 percent.

Mines operated during 1970 but closed by yearend included the Humboldt mine on the Marquette range, Michigan; the West Hill mine on the Mesabi range and the Lauretta Manganiferous mine on the Cuyuna range in Minnesota; and the Pyne underground mine in the Birmingham district. The Pyne mine, operated by the Woodward Co. (Division of the Mead Corp.), was the last of the "red ore" mines operating in Alabama.

Production of usable ore was 1.6 percent more than in 1969, but shipments declined 3 percent. Production and shipments of direct-shipping ores in 1970 were more than 25 percent less than in 1969 because the market continued to favor ores having a higher iron content and/or a more uniform structure. Production of pellets and sinter at domestic mines was about 5 percent more than in 1969, and the proportion of beneficiated ore[2] rose to about 92 percent of the national output compared with 89 percent in 1969. The average iron content of usable ore production and shipments was slightly higher than 59 percent. The Lake Superior district again accounted for 78 percent of the national output.

In Minnesota, United States Steel Corp. began constructing additional processing facilities at the Minntac plant near Mountain Iron. The new facilities, which will include two Allis-Chalmers "Grate Kiln" pelletizing lines with a design capacity of 3 million tons each, will increase nominal production capacity of the plant to 12 million tons of pellets per year. The expansion was scheduled to be completed in 1972. Elsewhere on the Mesabi, United States Steel began production of ore at the Twin City mine near Chisholm, and was preparing to strip surface overburden from the Donora ore body near Aurora. Rhude & Fryberger, Inc. announced that it was developing a new open pit mine near Kinney, at the Rana property. Natural ores will be mined by open pits at these properties. In other developments, Bethlehem Steel Corp. and Pickands Mather & Co. were investigating the economic feasibility of constructing a 4-million-ton-per-year pelletizing facility for iron ore at Hibbing. The two firms announced in September that a contract for the cost study had been awarded to United Engineers & Constructors, Inc., of Philadelphia, Pa.

In Michigan, the Eagle Mills pellet plant was closed at yearend. The plant, located east of Negaunee, pelletized a portion of the concentrates produced at the Republic mine. These concentrates will now be pelletized at the Humboldt plant, which was idled in 1970 when the Humboldt mine was closed.

In California, Standard Slag Co. was reported to be building an iron ore processing plant in the Kingston Peak area of San Bernardino County. The plant was scheduled to begin production in November 1971 to fulfill a 5-year contract for supply of 2.5 million tons of iron ore to the Nippon Steel Corp. of Japan. Source of the ore is expected to be the Kingston (also known as the Beck or Iron Gossan) deposit.

In New York, National Lead Co. continued construction of a $4.5 million plant for regrinding magnetite concentrate. Completion of the facility was expected in May 1971. Although the plant was primarily designed to recover additional ilmenite, the quality of coproduct magnetite will also be improved. The company hopes to expand its sales of magnetite in the heavy-media market, and to the steel industry for use in direct-reduction processes. National Lead is a co-owner of the SL/RN direct-reduction process.

In Alaska, United States Steel acquired a

[2] Beneficiated by further treatment than ordinary crushing and screening.

10-year lease on 563 acres of the Klukwan Indian Reservation, north of Juneau. The Klukwan iron deposits reportedly contain an average of 13 percent iron and 2 percent titanium. No development plans were announced. South of Juneau, the Marcona Corp. was reported to have completed planned field work on the Snettisham deposits by mid-1970. The company had previously announced plans for a $130 million project to exploit the deposits, but no further developments were reported in 1970.

CONSUMPTION AND USES

The method of reporting iron ore consumption adopted in 1963 was continued in 1970. Concentrate used for agglomerate produced at mine sites was not reported as iron ore consumption. Its consumption was reported when the agglomerate produced was shipped to the furnace site and used. However, concentrate and fines used for agglomerate production (mainly sinter) at blast furnaces and steel mills was reported as iron ore consumed. This method of reporting gives a valid balance between reported consumption and iron ore supply (production plus imports less exports, including adjustments for losses due to processing and transporting).

Iron ore consumed in making agglomerates at steel mills includes foreign and domestic direct-shipping ores, fines generated in shipping, and foreign and domestic iron ore concentrate. Other materials such as limestone, flue dust, mill scale, and coke breeze used in making agglomerates were excluded.

Total consumption of iron ore in 1970 was 3.7 percent less than the record consumption reported for 1969. Consumption in steel furnaces continued to decline as more open-hearth furnaces were shut down. Consumption of iron ore in blast furnaces was 4.7 million tons less than in 1969 as production of pig iron fell about 3 percent. The weight ratio of iron ore consumed to hot metal produced remained at approximately 1.6 to 1.

STOCKS

Total stocks of iron ore at U.S. mines, docks, and consuming plants, excluding byproduct ore, totaled 71.5 million tons on December 31, 1970. This represented a 6-percent increace compared with total stocks at yearend 1969 and a return to the levels of 1967–68. The relatively low level of stocks in 1969 was attributed to reduced shipments from Canada owing to strikes at the Canadian mines in that year. Total stocks of iron ore in the United States at yearend were equivalent to about 6 months' supply at the average rate of domestic consumption in 1970. Stocks at U.S. mines increased 11 percent by the end of the year as shipments were down nearly 2.7 million tons from the 1969 level.

PRICES

Base prices for Lake Superior natural iron ores and pellets were higher in 1970. Published prices per long ton, 51.5 percent iron, natural, rail of vessel at Lower Lake ports, were 25 cents higher than in 1969 and were as follows: Mesabi non-Bessemer, $10.80; Mesabi Bessemer, $10.95; Old Range non-Bessemer, $11.05; and Old Range Bessemer, $11.20. Lake Superior pellets were priced at $0.266 per long ton unit, up 1.4 cents from 1969.

Bulk vessel freight rates on iron ore shipments from the head of the lakes to lower lake ports were increased 10 cents per ton, effective August 15, by the Interlake Steamship division of Pickands Mather & Co. An additional charge of 5 cents per ton was made for deliveries to docks not capable of handling vessels having drafts of more than 23 feet.

Further increases in iron ore prices were announced in late 1970 for the 1971 season. Hanna Mining Co. announced increases of 37 cents per long ton for natural ores and 1.4 cents per long ton unit for pellets. The new prices, to be effective January 1, 1971, 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 for pellets would be $0.28 per long ton unit. Any increase in transportation or handling costs during 1971 was to be borne by the buyer.

The average value of usable iron ore shipped from domestic mines in 1970 (excluding byproduct ore) was $10.80 per long ton, f.o.b. mines, compared with $10.34 in 1969 and $10.21 in 1968. These data were taken from producers' statements and approximated the commercial selling price less the cost of mine-to-market transportation.

Published prices of selected foreign ores were as follows: Venezuela, Orinoco No. 1, 58 percent iron, f.o.b. Puerto Ordaz, per long ton, $7.88 (January-August) and $8.55 (September-December); and Brazil, lump ore, 68.5 percent iron, f.o.b. shipping point, $9.10 to $9.60 per long ton. Approximate f.o.b. prices for Australian lump ore, 64 percent iron, were reported to be $10.15 to $10.25 per long ton in late 1970 (see World Review—Australia).

TRANSPORTATION

The trend toward increasing capacity of ore-carrying ships and of loading and handling facilities to service them was continued in 1970. On the Great Lakes, two large self-unloading iron ore carriers were scheduled for service in 1971. One was being built for Bethlehem Steel by Erie Marine division of Litton Industries, Inc.; it has a length of 1,000 feet and a cargo capacity of 51,500 long tons at 25 foot, 6 inch draft. The unloading system can discharge ore at rates up to 20,000 tons per hour. The vessel will increase the transport capacity of Bethlehem's seven-ship fleet by as much as 50 percent. The second vessel, an 858-foot carrier built for United States Steel by The American Ship Building Co., has a cargo capacity of about 45,000 tons and an unloading rate believed to be comparable to the first. The latter company was also building two 630-foot, self-unloading lake carriers designed to transport ore to upriver terminals. These ships, scheduled for service in 1973–74, will be of 19,000 deadweight tons (d.w.t.) and will have unloading rates of 5,000 tons per hour. They are expected to reduce unloading time by 75 percent compared with manual methods.

Abroad, new port facilities were completed in 1970 for accommodating iron ore carriers of up to 250,000 tons at Sept Iles, Quebec, and 200,000 tons at the Europoort terminal in Holland. The port at Tubarão, Brazil was being developed to allow loading 250,000-ton carriers, and plans were announced to develop a second port, at Sepetiba Bay, to accommodate vessels of similar size. Dredging of the port at Point Central, Mauritania, was expected to allow loading of vessels of 147,000 d.w.t. by April 1971. In Western Australia, contracts were let for construction of an iron ore loading facility at East Intercourse Island, near Dampier, designed to accommodate 160,000-ton carriers.

The Grängesberg Co. of Sweden ordered a third 265,000-ton ore/oil carrier for delivery in 1974. All three to these vessels are being built at the Uljanik shipyard in Pula, Yugoslavia. The first two are scheduled for service in 1973 and are already contracted for on a time-charter basis for 3 to 5 years after delivery.

The tonnage of individual iron ore cargoes loaded at foreign ports continued to rise. The largest reported was 138,000 gross tons loaded at Tubarão; others included 122,000 tons at Sept Iles, 111,000 tons at Port Hedland, and 88,000 tons at Port Cartier.

The number of ore carriers operating in world fleets on January 1, 1970, was reported to be 273, averaging 30,800 d.w.t., compared with 131 vessels averaging 18,100 d.w.t. on January 1, 1960. Corresponding figures for ore/oil carriers were 126, averaging 56,000 d.w.t., compared with 55 vessels averaging 24,000 d.w.t. 10 years previously.[3]

A study of bulk-commodity transportation on the Great Lakes was published by the Bureau of Mines. It presents hydrologic data; discusses factors which influence the volume, pattern, and cost of shipping different commodities; and presents estimates of the composition, characteristics, and operating costs of the U.S. lake vessel fleet in 1995.[4]

[3] Mining Magazine (London). V. 124, No. 3, March 1971, p. 215.

[4] Aase, J.H. Transportation of Iron Ore, Limestone, and Bituminous Coal on the Great Lakes Waterway System, With Projections to 1995. BuMines Inf. Circ. 8461, 1970, 61 pp.

Transport of iron ore by pipeline and by slurry ships continued to be a subject of high interest. The 53-mile pipeline operated by Pickands Mather International in Tasmania completed 3 years of successful operation. A 232-mile pipeline was planned by Canadian Javelin, Ltd., to move 12 million tons of iron ore per year from mines in Labrador and Quebec to a pelletizing complex on the St. Lawrence River. A study by the Bureau of Mines of the cost of pipelining magnetite concentrate from the Mesabi Range to the Chicago area suggested that the cost may be competitive with that of rail-vessel systems currently used.[5]

Transport of slurried iron ore concentrates by ocean carriers, with either loading or unloading accomplished by pipeline, began in 1970 when the Marcona Corp. shipped 42,000 tons of magnetite concentrate from Tasu, British Columbia to Portland, Oreg. The concentrate was loaded by conveyor, then converted to slurry for discharge at Portland. The 52,000-ton ship, the world's first ore/slurry/oil carrier, was converted from a conventional ore/oil carrier to use the company's Marconaflo system. A second slurry ship of 141,000 d.w.t. was being converted from a 106,000-ton ore carrier by the company. The latter vessel will be used primarily to transport slurried concentrate from Peru to Japan, to fulfill a 10-year, 10-million-ton contract negotiated by Marcona with Nippon Steel Corp., in 1970.

Offshore loading of slurried magnetite concentrate by a 1.5-mile submarine pipeline from a Waipipi iron sand deposits in New Zealand was scheduled to begin in 1971. This project, operated by a Marcona subsidiary, will produce 2 million tons of concentrate per year and will deliver 9.45 million tons to Japan under a 10-year contract negotiated in 1970.

FOREIGN TRADE

Exports of iron ore increased 6.4 percent, to about 5.5 million tons in 1970; 3.2 million tons were destined for Japan and 2 million tons for Canada.

U.S. imports of iron ore in 1970 increased 10 percent compared with 1969. Total imports were 44.8 million tons, of which 23.9 million tons came from Canada and 13 million tons from Venezuela. Imports from Canada were nearly 5 million tons more than in 1969 when Canadian mines were strikebound for part of the year. The principal U.S. centers for imports of iron ore continued to be Philadelphia, Baltimore, Cleveland, Chicago, and Mobile.

In 1970 the average value of exports was $12.36 per ton, imported ore was $10.68 per ton. These values represented increases of about 2 percent and 8 percent, respectively, compared with 1969.

WORLD REVIEW

Australia.—The Australian iron ore industry continued to grow rapidly in 1970. Production of direct-shipping ore and pellets increased to 50.3 million tons, and exports rose to 40.1 million tons; these quantities represented increases of 31 percent and 53 percent, respectively, over 1969 levels. Shipments by all producers increased in 1970, but the major increases came from Mt. Newman Mining Co. Pty. Ltd. and Hamersley Iron Pty. Ltd. Shipments by Mt. Newman rose to 11.6 million gross tons, more than twice the quantity shipped in 1969, and those from Hamersley increased to 16.7 million tons, a rise of 28 percent.

Annual production capacity of Hamersley was about 17.5 million tons of ore in 1970, including 2 million tons of pellets. The company plans to expand capacity to 37.5 million tons by 1974. This will include increasing production at Mt. Tom Price and development of the Paraburdoo mine 45 miles away; extension of the railroad to Paraburdoo, and increasing haulage capacity of the present 182-mile rail line from 20 million to 37.5 million tons per year; and construction of deepwater port facilities at East Intercourse Island to handle ships of more than 150,000 d.w.t.

[5] Polta, H.J. Mesabi Range Iron Ore Transportation. Feasibility and Estimated Cost of Pipelining. BuMines Inf. Circ. 8512, 1971, 46 pp.

The Mt. Newman project's ore production capacity was also being increased to 20 million tons per year. Ultimate capacity is designed to handle 35 million tons per year. Drilled ore reserves were estimated at 610 million tons in 1970, with an average (blended) content of 64 percent iron; potential of the Mt. Whaleback deposit was estimated at a minimum total of 1 billion tons at the same grade. In 1970 the shipping channel at Port Hedland, 265 miles by rail from Mt. Whaleback, was deepened to accommodate 100,000-ton vessels at low tide, but vessels of 150,000 tons can apparently be handled at other times.

Goldsworthy Mining Ltd. shipped 6.5 million tons of ore in 1970 and planned to increase annual shipments to 8 million tons in 1973 in order to fulfill contract commitments. Total delivery requirements, including spot sales, through 1980 were reported to be 89 million tons. The company was acquiring additional iron ore properties in 1970 near Shay Gap and Kennedy Gap, to bring its total ore reserves in the Mt. Goldsworthy area to about 115 million tons averaging 64 percent iron.

Broken Hill Pty. Co. Ltd shipped 12.4 million tons of ore from its two mines near Whyalla in South Australia and three mines in Western Australia. Two million tons of pellets were shipped, mainly to Japan.

Final agreements were made in 1970 for developing the Robe River project in Western Australia. Participants in the $300 million project include the U.S.-owned Cliffs Western Australian Mining Co. Pty. Ltd., 30 percent; Mitsui & Co. Ltd. of Japan, 30 percent; and Australian interests, 40 percent. The Robe River deposits, located about 100 miles southwest of Cape Lambert and 120 miles northwest of Mt. Tom Price, contain at least 260 million tons of proved reserves averaging 57 percent iron. The project is designed to produce annually 4.2 million tons of pellets averaging 63.5 percent iron and 6.1 million tons of fines averaging 57 percent iron by 1975. Production will begin in mid-1972 and will reach 8 million tons of pellets and fines by 1973. Long-term contracts for 87 million tons of pellets and 71 million tons of fines have already been signed with Japanese buyers. The development will include two townsites, a 104-mile railroad from the deposits to Cape Lambert (located between Port Hedland and Dampier), and port facilities to accommodate 150,000-ton ships.

The total quantity of Australian iron ore and agglomerates covered under long-term Japanese contracts for 1970 through 1979 was estimated at more than 550 million long tons.

Approximate f.o.b. prices in 1970 for Australian ore containing 64 percent iron per long ton were as follows: fines, $7.17; lump, $10.15 to $10.25; pellets, $11.72. An approximate f.o.b. price of $37.97 was quoted for metallized products. [6]

Brazil.—Production and exports of iron ore in 1970 increased about 22 and 35 percent, respectively, compared with that of 1969. Indications were that exports would probably exceed 50 million tons per year by 1975. Cia. Vale do Rio Doce (CVRD) was expanding production, shipment, and export capacities, and Mineracões Brasileiras Reunidas S.A. (MBR) was developing the Aguas Claras deposits for an output of 10 million tons per year by 1973.

In addition to increasing haulage capacity of its rail system, CVRD was expanding port facilities at Tubarão to accommodate 250,000-ton carriers and increasing shiploading capacity to 14,000 tons per hour. The company let contracts to a German consortium for construction of a concentrator for hematite ore near the Cavè mine in Minas Gerais. The plant will use high-intensity magnetic separators to produce 12 million tons per year of hematite concentrate containing about 68 percent iron. The plant is to be completed by 1973. CVRD's expansion program is being assisted by a U.S. Export-Import Bank loan of $31 million and guarantees for $38.5 million in other commercial loans.

MBR signed a contract in April 1970, to supply 105 million tons of iron ore to six Japanese companies over a 16-year period beginning in 1973. The company plans to produce 10 million tons of 65-percent iron ore per year from the Aguas Claras deposits near Belo Horizonte, of which 7 million tons per year will be shipped to Japan. The project also includes development of a deepwater port at Guaiba Island in Sepetiba Bay, about 60 miles west of Rio de Janeiro. Ultimately, the port is expected to accommodate 250,000-ton vessels. MBR is

[6] Freeman, R.D. Minerals in the Australian Economy. Comm. for Econ. Devel. of Australia, Melbourne, January 1971, 44 pp.

owned 51 percent by Companhia Auxiliar de Empresas de Mineração and 49 percent by St. John del Rey Mining Co. Ltd. The Hanna Mining Co. owns 52 percent of St. John.

Canada.—After experiencing widespread strikes in 1969, Canadian mines produced at near-capacity in 1970. Shipments rose to an estimated 48 million tons and exports to 39 million tons, both record figures. The major producers in 1970 continued to be Iron Ore Co. of Canada (IOC), with shipments of 20.1 million tons; Quebec Cartier Mining Co. (QCM), with shipments of 8.87 million tons; and Pickands Mather, with shipments of 8.0 million tons including 5.4 million tons from Wabush Mines.

In 1970, IOC announced plans to increase its annual production capacity to 33 million tons of ore, including 16 million tons of pellets, 12 million tons of concentrate, and up to 5 million tons of direct-shipping ore. The expansion, to be completed by 1973, is expected to cost $270 million. Principal objectives include nearly doubling the output capacity at Carol Lake to 23 million tons of concentrate per year, and constructing a 6-million-ton pelletizing facility at Sept Iles. The pellet plant will be equipped with two Allis-Chalmers grate-kiln systems, each having an annual capacity of 3 million tons. Ore feed to the pelletizers will be hematite concentrate obtained by flotation of Labrador (Knob Lake) ore. IOC also completed a $14 million dock at Sept Iles in 1970 which can accommodate 250,000-ton carriers.

IOC export contracts with U.S. and foreign buyers through 1995 were reported to have a total value of more than $7 billion. This included a 15-year, 75-million-ton contract negotiated in 1970 with Japanese steel companies.

QCM began construction of a 75-mile railroad from Lac Jeannine to Mt. Wright. This was the second phase of development for the Mt. Wright project, which is scheduled to begin production in 1974–75. The railroad will be completed in 1972, and the mine and concentrator in 1974. Output capacity in 1975 is expected to be 16 million tons of concentrate per year.

Canadian Javelin Ltd. was negotiating with iron ore buyers in Europe and Japan, relative to its plans to develop the Julian and Star-O'Keefe iron ore deposits in Labrador. The Star-O'Keefe property is owned by Dominion Jubilee Corp., in which Canadian Javelin has a 34.8-percent share. The project is estimated to cost around $400 million and would produce 12 million tons of iron ore products per year. Concentrates produced at the mines would be transported by a 232-mile pipeline to a pelletizing facility to be built at Pointe Marmite, near Sept Iles.

Exploration of iron deposits on Melville peninsula in the Canadian arctic was continued by Borealis Exploration Ltd. Indicated reserves of magnetite ore in the western sector of the deposits were reported to be 2.6 billion tons containing 35 to 49 percent iron, and in the eastern sector, 1.1 billion tons containing 25 to 30 percent iron.

Chile.—Production and shipments of iron ore in 1970 were slightly below the levels of 1969. A change in government policy late in 1970 led to acquisition of 100 percent of Ciá. de Acero del Pacifico (CAP) by the state-owned Corporación de Fomento de la Produción (CORFO) firm, and government acquisition of the mines operated by Bethlehem Chile Iron Mines Co. appeared to be likely. Iron ore shipped by CAP and Bethlehem in 1970 amounted to 3.3 million tons and 2.64 million tons, respectively, about half of total Chilean output. Development of the Chanar Boqueron deposit by CAP appeared to be delayed, but increased ore shipments by the company suggested that construction of the magnetic concentrator at El Algarrobo was completed in 1970. Bethlehem was engaged in a $25 million expansion program, scheduled for completion in 1972, which included raising production capacity at El Romeral by 50 percent to 4.5 million tons of concentrate per year.

In September 1970, the Chilean Government authorized an investment of $55.8 million by Mitsubishi Metal Mining Co. Ltd. and Ataka & Co. Ltd. to develop the Santa Clara iron deposits in Atacama province. Production was scheduled to start by 1973 at the rate of 2.4 million tons of concentrate per year. Reserves of magnetite ore were estimated at 40 million tons containing 35 to 45 percent iron.

Finland.—Two iron mines were being developed by Rautaruukki Oy. One, at

Leveäselkä near Raajärvi, will begin production in 1971. The ore will be processed at Raajärvi. The other was the Rautavaara mine, near the Swedish border at Kolari. Production at Rautavaara will begin by 1975 at the rate of 400,000 tons of concentrate per year.

India.—Production and exports of iron ore increased by 4 percent and 25 percent, respectively, compared with 1969. Domestic consumption was down 10 percent, to 10.2 million long tons. The average value of export shipments dropped to $7.57 per long ton, compared with $7.78 the previous year. Exports of iron ore to Japan in 1970 were 16.2 million long tons, or about 81 percent of total exports.

Expansion of the Kiriburu mine in Orissa was continued in 1970. The mine, screening plant, and ore loading facilities were being enlarged to provide an output of 5.5 million tons per year by 1972, an increase of 65 percent over capacity in 1970.

Output of the Bailadila mine, largely for export, was scheduled to increase to 10 million tons per year by 1976. At that time, from Kiriburu is planned to be diverted for domestic consumption at the Bokaro works in Bihar.

Concentration of iron ore from the Kudremukh deposits in Mysore was reported to be successful in pilot plant tests. Under a project submitted for the approval of the Government, 4 million tons of concentrate averaging 66 percent iron will be produced annually for export to Japan, starting by 1975. Slurry transport will be used. The pelletizing will be done in Japan. Participants in the project include the National Minerals Development Corp. (51 percent), the Marcona Corp. (25 percent), and three Japanese firms (24 percent).

Liberia.—Shipments of iron ore by Liberian American-Swedish Mining Co. (LAMCO) Joint Venture in 1970 were up nearly 10 percent, and the Grängesberg Co. reported prices were up 19 percent compared with the previous year. Estimates of 1971 exports by the four producing companies indicated essentially no change from the 1970 level.

The pelletizing plant being built for the Bong Mining Co. was expected to begin production early in 1971. LAMCO's plant produced 1.8 million tons of pellets in 1970. Both plants have nominal production capacities of 1.8 million tons per year.

Development of a major new mine may be undertaken in the Wologisi Range of northwestern Liberia by 1974. Exploration by the Liberian, Iron and Steel Corp. (LISCO) indicated reserves of approximately 1 billion tons of material containing about 35 percent iron. As of April 1970, proven reserves of readily minable ore, concentratable to 66 percent iron, were estimated at 375 million tons. Ore in some areas was considered concentratable to 70 percent iron. Proposed facilities for development included a 130-mile railroad, a 10-million-ton pelletizing plant, and port facilities capable of loading 350,000-ton vessels in 24 hours. To accommodate vessels of this size, a 2-mile pier would be constructed from a shore base near Robertsport to reach a water depth of 100 feet. Three Japanese companies were reportedly negotiating wih Liberian International American Corp. (LIAC) for a 51-percent equity in LISCO. LIAC owns 80 percent of LISCO.

Mauritania.—Mines de Fer de Mauritanie (MIFERMA) was deepening the port at Point Central to accommodate 150,000-ton ore carriers by April 1971. The company was also studying the feasibility of increasing iron ore production from the F'Derik (Ft. Gouraud) area to 12 million tons per year by 1973. Output in 1970 was approximately 9 million tons.

Mexico.—Production of iron ore increased 25 percent in 1970 to an estimated 4.3 million tons. Cia. Fundidora de Fierro y Acero de Monterrey S.A. began production of ore from its new Hercules mine in Coahuila early in 1970. Shipments of ore from this mine were expected to be 600,000 tons in 1971. At Alzada, Colima, Hojalata y Lamina S.A. (HyLSA) began operating its new pellet plant on February 16, 1970. Shipments of pellets during the year totaled 650,000 tons, most were destined for HyLSA sponge iron plants at Monterrey and Puebla. Annual production capacity of the Colima plant is about 1.1 million long tons of pellets containing 66 percent iron.

Morocco.—A $26 million iron ore concentration and pelletizing project was underway at the Vixan deposits, near Nador. The Vixan mines, operated by La Société d' Exploitation des Mines du Rif (SEFERIF) are currently the only producers in Morocco. In March 1970, a contract was awarded to the Midrex division of Midland-Ross Corp. for installation of a shaft-furnace pelletizing system. Annual production of 840,000 tons of pellets was planned to start early in 1972. Contract for design of a 1,312-foot circular shaft to be sunk at the Vixan deposit was awarded to Powell Duffryn Technical Services of the United Kingdom.

New Zealand.—Marcona Corp. contracted with a group of Japanese firms to deliver 9.45 million tons of magnetic concentrate to Japan over a period of 10 years beginning in 1971. The concentrate will be produced from the Waipipi beach sands on the west coast of North Island and transported as slurry by pipeline to a loading point 1.5 miles offshore.

Late in 1970, a similar contract was negotiated between New Zealand Steel Ltd. and a group of Japanese firms for delivery of 11.6 million tons of concentrate over a 10-year period beginning in 1972. The beach sand concentrate will be produced from the Lake Taharoa area west of Hamilton on North Island. Mining and shipping methods will be similar to those used at Waipipi.

Peru.—Marcona Corp. was expanding production capacity at San Nicolas by about 20 percent, to 10.5 million tons of concentrate per year. Pelletizing capacity was being raised 700,000 tons, to 4 million tons per year. Shipping facilities were also being increased, both for dry ore products and for slurried concentrate that will be transported by the Marconaflo slurry system. The $25 million project was to be completed by 1972.

In 1970 the Marcona Co. signed a 10-year, $113 million contract with the Nippon Steel Corp. for delivery of 10 million tons of concentrate beginning in April 1972. The concentrates will be shipped as slurry and will be pelletized in Japan.

Spain.—Increased output and efficiency at iron mines continued to be a major objective of Spain's development plan, but progress was difficult. The national output increased, but exports continued to drain a large proportion of the higher grade ore. Consequently, imports in 1970 rose to more than twice the 1969 level in order to satisfy rising domestic demand.

Expansion of pyrite production and processing in southwest Spain was expected to yield a byproduct of as much as 3 million tons of pelletized iron oxide (63 to 65 percent iron) per year by 1975.

Sweden.—Swedish output and exports of iron ore fell below 1969 levels partly because the strike at Luossavaara-Kiirunavaara AB (LKAB) mines was not settled until February, and partly because of a decline in export demand during the last half of the year. Compared with 1969, production was down 4 percent to 31.3 million long tons and exports were down 12 percent to 27.5 million tons. Prices were higher, however; the Grängesberg Co. reported an average price rise of 14 percent in contracts for 1970 deliveries, and LKAB reported an average price rise of 10 percent.

Grängesberg's plant for production of cold-bonded pellets did not come on stream until the fall of 1970. Production at the planned rate of 1.5 million tons per year was not expected until late 1971.

Venezuela.—Increased iron ore output by Orinoco Mining Co. was responsible for a 12-percent rise in Venezuelan production in 1970. Shipments by Orinoco and the Iron Mines Co. of Venezuela totaled nearly 21.5 million gross tons, of which about 60 percent was destined for the United States.

Construction of the iron ore reduction plant by Orinoco was again delayed by strikes, but completion was expected by 1972. Capacity of the plant will be 1 million tons per year of briquetted concentrate containing about 86 to 92 percent iron.

New tax laws passed by the Government in late 1970 were expected to raise income taxes paid by the iron mining companies, but whether iron ore valuations would be raised by the Government was uncertain. The new law gave the Government power to establish theoretical prices (called Tax Reference Values) for iron ore, which would be used to determine income tax liability of exporting companies.

TECHNOLOGY

The demand for agglomerated iron ore products continued to increase. U.S. output of agglomerates at or near the mines rose to 64 percent of domestic output of usable ore, compared with 62 percent in 1969, and pellets made up at least 37 percent of U.S. consumption of iron ore in 1970, compared with 34 percent in the previous year.

The value of close sizing of ores and agglomerates in blast furnace burdens has been recognized for some time; however, considerable attention is now being paid to physical properties of these materials at elevated temperatures and under reducing conditions. Compressive strength of ores and agglomerates as received, for example, often appears to have little relationship to compressive strength under reducing conditions.[7] This is becoming increasingly important in maintaining permeability in the large burdens now being charged. In Japan, the need for strong sinter and coke was repeatedly cited as a critical factor in obtaining high blast-furnace productivity.[8]

Further investigations of the relationship between strength of self-fluxing sinter and the crystal size of fluxstone (limestone or dolomite) used to produce it, yielded direct evidence that relatively large crystal size prevented adequate sintering reactions and indicated that for strong sinter, the fluxstone should have a crystal size as small and as uniform as possible.[9] Results of a British study on the effect of soluble and unsoluble additives on properties of unfired pellets was published.[10] Mill design and operating parameters for fine dry grinding of iron ore for pelletizing were discussed in another paper, which considered recent developments in Australia, Japan, and the Netherlands.[11]

Developments in the field of direct reduction of iron ore continued to increase. Armco Steel Corp. started construction of a plant in Houston, Tex., designed to produce 1,000 tons per day of metallized iron ore or pellets for feed to electric steel furnaces.[12] Ore reduction will be accomplished in shaft furnaces fueled by natural gas. A Japanese company, Kubota Ltd., announced that it had developed a new technique for producing agglomerated iron ore containing 95 percent iron. The process was tested 6 months, using "refined iron ore containing a reducing agent." The firm plans to build two plants, having a total production capacity of about 235,000 long tons per year, for operation in 1971.[13] Midland-Ross Corp. continued to produce metallized iron ore pellets at its 400,000-ton-per-year facility in Portland, Oreg. and was building new plants of similar capacity at Georgetown, S.C., and Hamburg, West Germany. The company also purchased a site near Taft, La., for an additional plant and was planning to build a fifth in Japan.

Reduction of red and brown iron ore concentrates from Alabama, in fluidized-bed reactors using carbon monoxide and hydrogen reductants, indicated that reduction was fastest when hydrogen was used at temperatures of 725° C or higher.[14] Bench-scale studies and pilot plant development of a Bureau of Mines process for reducing nonmagnetic iron ores with ferrous scrap were also described.[15] A summary of Bureau research on production and smelting of partially reduced pellets, with an economic evaluation of iron production using these materials and a survey

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[7] Harrison, W. R. International Conference on the Science and Technology of Iron and Steel. Sec. 1—Ironmaking. Iron and Steel, v. 43, No. 6, December 1970, p. 378.

[8] Work cited in footnote 7.

Nakamura, N. The Modern Blast Furnace. Thirty-Second Annual Mining Symposium, Univ. of Minn., Duluth, Minn. January 1971, pp. 91–103.

Yamada, T. Blast Furnace Practices at Mizushima Works. Iron and Steel Eng., v. 47, No. 11, November 1970, pp. 53–67.

[9] Blair, T. C., and G. H. Denton. The Influence of Fluxtone Crystal Size Upon Its Reactivity in Iron Ore Sintering. Blast Furnace and Steel Plant, v. 58, No. 3, March 1970, pp. 179–184.

[10] Ball, D. F., P. R. Dawson and J. T. Fitton. Additives in Iron Ore Pelletizing. Trans. Inst. Min. and Met. Sec. C, v. 79, No. 766, September 1970, pp. 189–196.

[11] Rathburn, D. R., and Jung K. Mok. Fine Dry Grinding of Iron Ore for Pelletizing. Trans. AIME, v. 247, No. 4. December 1970, pp. 335–339.

[12] Metals Week. V. 41, No. 50. Dec. 14, 1970, p. 5.

[13] Skillings' Mining Review. V. 59, No. 43. Oct. 24, 1970, p. 25.

[14] Hansen, J. P., J. E. Berryhill, and J. A. Aufman. Batch Reduction of Iron Ore in Fluidized Bed. BuMines Rept. of Inv. 7461, December 1970, 25 pp.

[15] Prasky, C., R. E. Peterson, and D. L. Siebert. Reduction Roasting of Nonmagnetic Taconites With Automobile Scrap. BuMines Rept. of Inv. 7389, May 1970, 19 pp.

of the state of the art, was also published during the year. [16]

In ore preparation, a four-pole magnetic separator, which separates ore particles from gangue by deflection from a free-falling stream, was being developed for commercial use by Bethlehem Steel Corp.[17] A radiometric device for determining silicon content of iron ore slurries was being marketed by Texas Nuclear Division of Nuclear-Chicago, a subsidiary of G. D. Searle & Co. Based on neutron activation, the device measures silicon content of a sample in less than 10 minutes and expresses the result as percent silica by weight. For an iron ore slurry containing 50 percent solids, accuracy of silica determination is guaranteed to be ±4.0 percent relative at the 95-percent confidence level for silica concentrations greater than 4 percent by weight. The device was said to be operating satisfactorily on a 24-hour basis in certain U.S. and Canadian ore processing plants.

A new pelletizing system developed by Arthur G. McKee & Co. was undergoing pilot plant tests during 1970. The system was designed to improve pellet quality by providing better control of heat distribution and loss; it is claimed to offer savings in operating and capital costs compared with other pelletizing systems. It employs a circular traveling grate, water-sealed to prevent air leakage, enclosed in a continuous, refractory-lined shell. Several sizes of circular grates have been designed, with mean diameters of 170 feet, 200 feet, 230 feet, and 300 feet. The first three are designed for magnetite feed and have pellet production capacities of 4.5, 5.0, and 6.0 million tons respectively, per year. The fourth is designed for hydrated hematite feed and an annual pellet production of 4.5 million tons. [18]

Flotation experiments on hematite ores (42 to 47 percent Fe), using hydroxamate and fatty acid collectors, indicated hydroxamate may be a superior collector when treating finely ground red hematite ores. Essentially no difference in performance was found when specular ore was treated.[19] The Bureau of Mines continued to test flotation characteristics of hematitic taconite from Marquette County, Mich., in cooperation with the Cleveland-Cliffs Iron Co.

Laboratory tests on samples of manganiferous iron-bearing materials from the Cuyuna range indicated that most of the manganese could be extracted by selective chlorination without the use of a reductant. The phosphorus content was also reduced by more than 50 percent, but silica content was unaffected. [20]

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[16] Fine, M. M., N. B. Melcher, and others. Prereduced Iron Ore Pellets: Preparation, Properties, Utilization. BuMines Bull. 651, 1970, 63 pp.

[17] Aubrey, W. M. and R. M. Funk. The Quadruple Magnetic Separator—A New Concept in Magnetic Separation Equipment. Thirty-Second Annual Mining Symposium, Univ. of Minn., Duluth, Minn. January 1971, pp. 55–59.

[18] Northern Miner. No. 9, May 21, 1970, p. 23.

[19] Fuerstenau, M. C., R. W. Harper, and J. D. Miller. Hydroxamate vs. Fatty Acid Flotation of Iron Oxide. Trans. AIME, v. 247, No. 1, March 1970, pp. 69–73.

[20] Okahara, Y. and I. Iwasaki. Chlorination of Manganiferous Iron Ores. Trans. AIME, v. 247, No. 1, March 1970, pp. 73–80.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man, by districts and States, in 1970

District and State	Employment ᵖ: Average number of men employed (thousands)	Employment ᵖ: Time employed: Average number of days	Time employed: Total man shifts (thousands)	Time employed: Man hours: Average per shift	Man hours: Total (thousands)	Production: Crude ore (thousand long tons)	Usable ore (Thousand long tons)	Usable ore: Iron contained [1] (Thousand tons)	Iron contained [1]: Percent (natural)	Average per man: Crude ore: Per shift	Crude ore: Per hour	Usable ore: Per shift	Usable ore: Per hour	Usable ore: Iron contained: Per shift	Iron contained: Per hour
Lake Superior:															
Minnesota	9	329	2,803	8.0	22,424	138,052	56,073	32,951	58.8	49.25	6.16	20.00	2.50	11.76	1.47
Michigan	3	336	881	8.0	7,047	29,269	12,757	7,950	62.3	33.22	4.15	14.48	1.81	9.02	1.13
Wisconsin	(2)	330	50	8.0	401	2,208	806	508	63.0	44.16	5.51	16.12	2.01	10.16	1.27
Total	12	331	3,734	8.0	29,872	169,529	69,636	41,409	59.5	45.40	5.68	18.65	2.33	11.09	1.39
Southeastern States: Alabama and Georgia [3]	1	251	130	8.5	1,106	3,278	1,484	678	45.7	25.22	2.96	11.42	1.34	5.22	.61
Northeastern States: New York and Pennsylvania	2	285	544	8.0	4,350	9,177	3,491	2,202	63.1	16.87	2.11	6.42	.80	4.05	.51
Western States: Arizona, Montana, Utah, Wyoming	1	291	229	8.0	1,832	9,782	3,976	2,229	56.1	42.72	5.34	17.36	2.17	9.73	1.22
Undistributed [4]	3	317	801	8.0	6,419	20,694	10,338	6,312	61.0	25.84	3.22	12.91	1.61	7.88	.98
Grand total [5]	17	319	5,438	8.0	43,579	212,460	88,925	52,830	59.4	39.07	4.88	16.35	2.04	9.71	1.21

ᵖ Preliminary.
[1] Excludes byproduct ore.
[2] Less than ½ unit.
[3] Includes small quantity of ore produced in North Carolina.
[4] Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.
[5] Data may not add to totals shown because of independent rounding.

Table 3.—Crude iron ore mined in the United States, by districts, States, and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1969					1970				
	Number of mines	Hematite	Limonite	Magnetite	Total [1]	Number of mines	Hematite	Limonite	Magnetite	Total [1]
Lake Superior:										
Michigan	10	W	--------	W	29,584	7	W	--------	W	29,269
Minnesota	37	37,856	--------	97,626	135,483	28	35,527	--------	102,525	138,052
Wisconsin	1	--------	--------	472	472	1	--------	--------	2,208	2,208
Total reportable	48	37,856	--------	98,098	165,539	36	35,527	--------	104,733	169,529
Southeastern States: Alabama, Georgia, North Carolina	9	W	2,065	W	3,127	8	1,125	W	W	3,277
Northeastern States: New York, Pennsylvania	5	--------	--------	9,575	9,575	5	--------	--------	9,177	9,177
Western States:										
Arizona	1	18	--------	--------	18	1	12	--------	--------	12
Montana	1	--------	--------	13	13	1	--------	--------	14	14
Utah	6	W	--------	W	5,722	4	W	--------	W	5,615
Wyoming	3	W	--------	W	4,331	3	W	--------	W	4,142
Other [2]	19	W	W	W	18,818	16	W	W	W	20,693
Total reportable	30	18	W	13	28,902	74	12	W	14	30,476
Total withheld	--------	r 21,925	2,734	r 34,858	--------	--------	20,546	5,818	35,507	--------
Grand total [1]	92	r 59,799	4,799	r 142,544	207,143	74	57,210	5,818	149,431	212,459

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] Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.

Table 4.—Crude iron ore mined in the United States, by districts, States, and mining methods

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1969			1970		
	Open pit	Underground	Total [1]	Open pit	Underground	Total [1]
Lake Superior:						
Michigan	25,577	4,006	29,584	25,926	3,344	29,269
Minnesota	135,483	-------	135,483	138,052	-------	138,052
Wisconsin	472	-------	472	2,208	-------	2,208
Total	161,532	4,006	165,539	166,186	3,344	169,529
Southeastern States: Alabama, Georgia, North Carolina	2,065	1,062	3,127	W	W	3,277
Northeastern States: New York, Pennsylvania	W	W	9,575	W	W	9,177
Western States:						
Arizona	18	-------	18	12	-------	12
Montana	13	-------	13	14	-------	14
Utah	5,722	-------	5,722	5,615	-------	5,615
Wyoming	W	W	4,331	W	-------	4,142
Other [2]	W	W	18,818	W	W	20,693
Total reportable	5,753	W	28,902	5,641	W	30,476
Total withheld	24,510	r 8,215	-------	27,425	9,865	-------
Grand total [1]	193,860	13,283	207,143	199,252	13,209	212,459

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] Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.

Table 5.—Crude iron ore shipped from mines in the United States, by districts, States, and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1969			1970		
	Direct to consumers	To beneficiation plants	Total [1]	Direct to consumers	To beneficiation plants	Total [1]
Lake Superior:						
Michigan	1,972	27,592	29,565	1,512	28,426	29,938
Minnesota	5,461	130,695	136,157	3,892	134,275	138,167
Wisconsin	-------	332	332	-------	2,248	2,248
Total	7,433	158,619	166,054	5,404	164,949	170,353
Southeastern States: Alabama, Georgia, North Carolina	W	W	W	W	W	W
Northeastern States: New York, Pennsylvania	-------	9,629	9,629	-------	9,185	9,185
Western States:						
Arizona	18	-------	18	12	-------	W
Montana	13	-------	13	14	-------	14
Utah	W	W	2,460	W	W	2,639
Wyoming	W	W	4,413	W	W	4,143
Other [2]	W	18,364	W	W	20,152	W
Total reportable	31	18,364	6,904	26	20,152	6,796
Total withheld	2,233	8,205	21,928	1,967	8,342	23,679
Grand total [1]	9,697	194,817	204,515	7,397	202,628	210,013

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, Missouri, Nevada, New Mexico, and Texas.

Table 6.—Usable iron ore produced in the United States, by districts, States, and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1969				1970			
	Hematite	Limonite	Magnetite	Total [1]	Hematite	Limonite	Magnetite	Total [1]
Lake Superior:								
Michigan	W	------	W	13,417	W	------	W	12,757
Minnesota	21,894	------	33,381	55,275	20,728	------	35,345	56,073
Wisconsin	------	------	38	38	------	------	806	806
Total reportable	21,894	------	33,419	68,730	20,728	------	36,151	69,636
Southeastern States: Alabama, Georgia, North Carolina	W	626	W	1,437	W	620	W	1,484
Northeastern States: New York, Pennsylvania	------	------	3,800	3,800	------	------	3,491	3,491
Western States:								
Arizona	18	------	------	18	12	------	------	12
Montana	------	------	13	13	------	------	14	14
Utah	W	------	W	2,071	W	------	W	2,004
Wyoming	W	------	W	1,965	W	------	W	1,947
Other [2]	W	W	5,685	9,565	W	W	5,903	10,337
Total reportable	18	W	5,698	13,632	12	W	5,917	14,314
Total withheld	r 13,046	r 717	r 8,382	------	12,844	930	8,233	------
Total all States	r 34,958	r 1,343	r 51,299	87,599	33,584	1,550	53,792	88,925
Byproduct ore [3]	------	------	------	r 729	------	------	------	835
Grand total [1]	r 34,958	r 1,343	r 51,299	r 88,328	33,584	1,550	53,792	89,760

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] Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.

[3] 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 districts, States and types of products

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1969				1970			
	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)
Lake Superior:								
Michigan	2,014	10,879	523	61	940	11,172	645	62
Minnesota	5,461	33,381	16,433	59	3,892	35,345	16,836	59
Wisconsin	------	38	------	62	------	806	------	63
Total	7,475	44,298	r 16,956	59	4,832	47,323	17,481	59
Southeastern States: Alabama, Georgia, North Carolina	W	------	W	40	W	------	1,288	46
Northeastern States: New York, Pennsylvania	------	W	W	63	------	W	W	63
Western States:								
Arizona	18	------	------	59	12	------	------	58
Montana	13	------	------	45	14	------	------	45
Utah	1,361	------	710	53	W	------	W	54
Wyoming	W	W	W	57	W	W	W	58
Other [1]	613	5,141	W	61	496	5,540	W	61
Total reportable	2,005	5,141	710	60	522	5,540	W	60
Total withheld	310	4,877	5,827	61	1,625	4,286	6,028	59
Total all States [2]	9,790	54,316	23,493	59	6,979	57,149	24,797	59
Byproduct ore [3]	------	661	r 68	r 66	------	691	144	65
Grand total [2]	9,790	54,977	r 23,561	59	6,979	57,840	24,941	59

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."

[1] Includes California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.

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

[3] Mostly cinder and sinter obtained from treating pyrites.

Table 8.—Shipments of usable iron ore from mines in the United States in 1970

(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	1,512	10,963	625	13,100	784	6,886	350	8,020	$168,958
Minnesota	3,892	33,935	16,965	54,791	2,014	21,124	9,174	32,311	571,488
Wisconsin	---------	806	---------	806	---------	508	---------	508	W
Total reportable	5,404	45,704	17,590	68,697	2,798	28,518	9,524	40,839	740,446
Southeastern States: Alabama, Georgia, North Carolina	W	---------	W	1,293	W	---------	W	591	W
Northeastern States: New York, Pennsylvania	---------	W	W	2,998	---------	W	W	1,967	44,090
Western States:									
Arizona	12	---------	---------	12	7	---------	---------	7	W
Montana	14	---------	---------	14	6	---------	---------	6	W
Utah	W	---------	W	1,990	W	---------	W }	2,208 {	13,837
Wyoming	W	W	W	1,949	W	W	W }		W
Other [2]	W	5,499	W	10,223	W	3,497	W	6,258	102,238
Total reportable	26	5,499	W	14,188	13	3,497	W	8,479	116,075
Total withheld	1,967	4,288	6,699	---------	1,036	2,708	3,697	---------	41,128
Total all States	7,397	55,491	24,289	87,176	3,847	34,723	13,221	51,876	941,739
Byproduct ore [3]	---------	715	---------	715	---------	474	---------	474	7,817
Grand total [1]	7,397	56,206	24,289	87,891	3,847	35,197	13,221	52,350	949,556

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, Missouri, 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.—Iron ore produced in Lake Superior district, by ranges

(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]
1854–1965	339,781	288,179	320,172	102,622	2,513,404	67,035	7,236	-----	3,638,429
1966	9,589	4,620	113	704	51,506	1,299	772	-----	68,603
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
Total	390,098	306,038	320,334	103,528	2,776,526	70,336	8,149	844	3,975,851

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

Table 10.—Average analyses of total tonnage (bill-of-lading weights) of all grades of iron ore shipped from the U.S. Lake Superior district

Year	Thousand long tons	Content, percent [1]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1966	69,724	56.82	0.068	7.99	0.49	0.64	6.20
1967	63,845	57.81	.059	7.63	.47	.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

[1] Iron on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association.

Table 11.—Consumption of iron ore and agglomerates in the United States in 1970

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	Iron ore [1]		Agglomerates [2]		Miscellaneous [3]	Total [4]
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Tennessee, Texas	6,706	77	4,921	W	NA	11,704
California, Colorado, Utah	5,712	325	2,770	-------	NA	8,807
Ohio and West Virginia	18,680	358	5,799	W	NA	24,837
Illinois and Indiana	21,157	309	10,775	W	NA	32,241
Michigan and Minnesota	8,089	89	2,226	W	NA	10,404
Maryland, New York, Pennsylvania	20,896	1,181	23,877	W	NA	45,954
Undistributed	-------	-------	-------	635	e 419	1,054
Total [4]	81,240	2,339	50,367	635	e 419	135,000

e Estimate. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes 50,149,000 tons of pellets and nodules produced at mines.
[2] Does not include agglomerate produced at mine site.
[3] Includes iron ore used in making paint and cement, also ore consumed in ferroalloy furnaces.
[4] Data may not add to totals shown because of independent rounding.

Table 12.—Beneficiated iron ore shipped from mines in the United States [1]

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1966	70,451	90,041	78.2
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

[1] Excludes byproduct ore.

Table 13.—Usable iron ore [1] consumed in agglomerating plants and agglomerate produced from this ore in 1970, by States

(Thousand long tons)

State	Iron ore consumed [1]	Agglomerate produced
Alabama, Kentucky, Texas	3,046	3,543
California, Colorado, Utah	2,174	2,768
Ohio and West Virginia	4,102	5,373
Illinois, Indiana, Michigan	8,545	9,536
New York, Maryland, Pennsylvania	13,563	16,762
Total	31,430	37,982

[1] Does not include material used in agglomerate produced at mine site.

Table 14.—Production of iron ore agglomerates[1] in the United States, by types

(Thousand long tons)

Type	Agglomerate produced	
	1969 r	1970
Sinter, nodules, and cinder	[2] 44,949	[3] 41,661
Pellets	52,196	55,444
Total	97,145	97,105

r Revised.
[1] Production at mines and consuming plants.
[2] Includes 21,036 thousand tons of self-fluxing sinter.
[3] Includes 20,094 thousand tons of self-fluxing sinter.

Table 15.—Stocks of usable iron ore at mines[1] Dec. 31, by districts

(Thousand long tons)

District	1969 r	1970
Lake Superior	7,881	8,820
Southeastern States	643	834
Northeastern States	4,164	4,658
Western States	878	1,004
Total	13,566	15,316

r Revised.
[1] Excluding byproduct ore.

Table 16.—Average value of usable iron ore shipped from mines or beneficiating plants in the United States in 1970

(Per long ton)

District	Direct-shipping ore			Concentrates			Agglomerates
	Hematite	Limonite	Magnetite	Hematite	Limonite	Magnetite	
Lake Superior	$6.98			$7.41			$12.79
Southeastern	W			W	$6.27	W	
Northeastern						W	14.99
Western	W	W	W	W	W	W	12.33
Total	6.88	W	W	7.29	W	e 7.40	12.84

e Estimate. W Withheld to avoid disclosing individual company confidential data.

Table 17.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	(1)	$21	1	$38	127	$1,756
Canada	2,278	28,113	2,085	26,255	2,045	27,111
Germany, West	53	349	62	409	34	96
Japan	3,550	42,314	3,009	35,529	3,206	37,727
Spain					75	1,095
Other countries	3	38	3	79	5	113
Total	5,884	70,835	5,160	62,310	5,492	67,898

[1] Less than ½ unit.

Table 18.—U.S. imports for consumption of iron ore, by countries

(Thousand long tons and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola			50	$701		
Australia	131	$1,384	315	3,556	638	$7,389
Brazil	1,257	11,622	1,233	11,300	1,991	17,865
Canada	26,339	308,014	r 18,978	r 219,347	23,919	297,065
Chile	1,441	11,515	1,783	14,371	1,581	12,805
Liberia	2,942	23,389	3,144	27,227	1,873	17,216
Libya					103	789
Mauritania					72	664
Nigeria					30	152
Norway	360	2,646	269	1,937	49	356
Peru	925	9,375	1,003	10,738	1,329	13,771
Sweden	232	2,610	155	1,659	172	1,909
Uruguay [1]			39	354	49	444
Venezuela	10,313	83,153	13,751	110,745	13,026	108,493
Other	1	45	12	243	44	462
Total	43,941	453,753	r 40,732	r 402,178	44,876	479,380

r Revised.
[1] Formerly reported as Bolivia, in 1969.

Table 19.—U.S. imports for consumption of iron ore, by customs districts

(Thousand long tons and thousand dollars)

Customs district	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Baltimore	9,500	$91,586	10,068	$106,069
Buffalo	r 2,479	r 33,444	2,954	40,960
Chicago	4,399	47,542	5,922	70,857
Cleveland	6,620	69,126	6,846	76,125
Detroit	1,095	16,126	1,104	16,294
Houston	687	7,809	844	11,000
Los Angeles	--------	--------	52	401
Mobile	4,171	36,805	4,787	44,712
New Orleans	458	4,204	602	5,734
Norfolk	96	941	16	183
Ogdensburg	18	415	4	350
Philadelphia	11,070	92,470	11,419	104,034
Portland, Oreg	126	1,632	176	1,774
Puerto Rico	--------	--------	11	91
Wilmington, N.C	--------	--------	69	781
Other	13	78	2	15
Total	r 40,732	r 402,178	44,876	479,380

r Revised.

Table 20.—Iron ore, iron ore concentrates, and iron ore agglomerates:[1] World production by countries

(Thousand long tons)

Country [2]	1968	1969	1970 p
North America:			
Canada [3]	r 42,360	35,763	47,509
Guatemala	4	e 3	2
Mexico [4]	r 3,152	3,440	4,288
United States [3]	r 85,865	88,328	89,760
South America:			
Argentina	273	295	e 300
Bolivia	-------	2	4
Brazil	24,726	e 32,500	e 39,600
Chile	r 11,728	11,352	11,087
Colombia	569	346	446
Peru	8,873	9,123	9,509
Uruguay	-------	-------	1
Venezuela	15,934	19,404	21,800
Europe:			
Albania [5]	399	399	531
Austria	3,427	3,919	3,934
Belgium	81	93	93
Bulgaria	2,603	2,646	2,374
Czechoslovakia	r 1,548	1,544	1,582
Denmark	19	31	e 30
Finland [6]	838	870	846
France	54,365	54,550	55,903
Germany, East [7]	1,392	885	e 885
Germany, West	6,345	5,965	5,445
Greece	12	--------	------
Hungary	628	670	619
Italy [8]	697	750	745
Luxembourg	6,292	6,211	5,632
Norway	3,645	3,793	3,943
Poland	3,002	2,777	2,513
Portugal [9]	r 197	160	124
Romania	2,704	2,952	3,155
Spain	r 5,888	6,308	6,844
Sweden	r 31,907	32,661	31,272
U.S.S.R	r 173,827	183,194	191,133
United Kingdom	13,715	12,104	11,828
Yugoslavia	2,677	2,678	3,636
Africa:			
Algeria	r 3,031	2,923	2,818
Angola	3,167	5,391	5,995
Liberia	19,262	22,505	21,942
Mauritania	r 7,918	8,541	[10] 9,072
Morocco	794	737	859
Rhodesia, Southern e	r 700	r 500	500
Sierra Leone	r 2,457	2,337	2,259
South Africa, Republic of [11]	r 8,551	9,081	7,605
Swaziland	2,018	2,266	2,260
Tunisia	1,000	931	762
United Arab Republic	440	453	e 490

See footnotes at end of table.

Table 20.—Iron ore, iron ore concentrates, and iron ore agglomerates:[1] World production by countries—Continued

(Thousand long tons)

Country [2]	1968	1969	1970 p
Asia:			
China, mainland e	r 37,000	r 39,000	43,000
Hong Kong	159	163	168
India	27,000	29,097	30,294
Iran [12]	1	2	2
Japan [13]	r 2,138	1,824	1,558
Korea, North e	6,900	7,400	7,900
Korea, Republic of	r 816	698	562
Malaysia	5,085	5,151	4,420
Pakistan	(14)	-------	-------
Philippines	1,332	1,537	1,840
Taiwan	e 6	8	6
Thailand	492	470	22
Turkey [15]	r 1,807	1,956	e 2,155
Oceania:			
Australia	r 26,204	38,476	50,297
New Caledonia	169	-------	-------
New Zealand	3	[16] 20	[16] 140
Total	r 668,142	707,183	754,299

e Estimate. p Preliminary. r Revised.

[1] Insofar as availability of sources permits, data in this table represents 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: 1968—52, 1969—55, 1970—53.

[10] Exports.

[11] Includes byproduct magnetite as follows in thousand long tons: 1968—912, 1969—1,852, 1970—1,936; and manganiferous iron ore (20+35 percent iron, 15+30 percent manganese) as follows in thousand long tons: 1968—448, 1969—432, 1970—368.

[12] Year beginning March 21 of that stated.

[13] Concentrates, including concentrate derived from iron sand as follows in thousand long tons: 1968—1,096, 1969—884, 1970—701.

[14] Less than ½ unit.

[15] Sales.

[16] Largely concentrates from magnetite-titanium sands.

Iron and Steel

By F. E. Brantley [1]

Although down from the record 1969 outputs, domestic production of pig iron and raw steel [2] in 1970 was the second highest for the industry. Production of pig iron declined by 3 percent to 92.2 million short tons, and raw steel production declined by 7 percent to 131.5 million tons. Because of the strike against General Motors Corp. during the last half of the year, steel shipments to the automotive industry decreased. This accounted for much of the overall decline in production. Reduced demand resulted also from inflationary pressures and curbs on spending, especially for new construction.

Steel production in the rest of the world continued to rise, with the increase for 1970 over that of 1969 of 6 percent. Japan again led all countries in steel growth with an increase of approximately 13.6 percent.

Prices increased throughout the world following the 1969 trend, and reflected continued advances in raw material, labor, and transportation costs.

Pollution control remained an item of major concern in the steelmaking communities. To meet increasingly stringent enforcement of regulations, the domestic steel industry expended over $166 million for water- and air-pollution control facilities placed in operation during 1970.

Steel exports showed a marked increase over 1969, but imports declined slightly. Shipments of stainless and heat resistant products by domestic producers were off 22 percent from 1969. This segment of the domestic steel industry apparently received the greatest impact from imports in 1970, and requested government assistance to prevent plant closures.

[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)

	1966	1967	1968	1969	1970
United States:					
Pig iron:					
Production	91,287	86,799	88,767	95,003	92,213
Shipments	90,884	86,819	89,085	95,472	92,191
Exports	12	7	9	44	310
Imports for consumption	1,187	605	786	405	249
Steel: [1]					
Production of raw steel:					
Carbon	118,732	113,190	116,269	124,832	117,411
Stainless	1,651	1,451	1,432	1,569	1,279
All other alloy	13,718	12,572	13,761	14,861	12,824
Total	134,101	127,213	131,462	141,262	131,514
Index (1957–59) =100	138.1	131.0	135.0	145.4	135.4
Total shipments of steel mill products	89,995	83,897	91,856	93,877	90,798
Exports of major iron and steel products	2,144	1,898	2,460	5,515	7,352
Imports of major iron and steel products [2]	11,043	11,446	17,893	14,019	13,838
World production:					
Pig iron [3]	382,000	389,000	422,000	457,000	479,000
Raw steel (ingots and castings)	524,000	544,000	584,000	632,000	654,000

[1] American Iron and Steel Institute. Includes ingots, continuous cast steel, and all other cast forms.
[2] Data not comparable for all years.
[3] Includes blast furnace ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

Pig iron production in the United States was 92.2 million tons in 1970, compared with the 95.0-million-ton output in 1969. Average production of pig iron per blast-furnace-day increased to 1,641.6 tons, compared with 1,609.0 tons in 1969 and 1,624.5 tons in 1968, according to the American Iron and Steel Institute (AISI). A total of 169 blast furnaces were in blast at the beginning of the year, including two ferroalloy furnaces. The number of producing furnaces totaled 228, including five ferroalloy furnaces. At yearend those in blast had decreased to 152 out of a total of 219 producing furnaces, including two ferroalloy furnaces. Four furnaces were dismantled in 1970, and five were being rebuilt or relined at yearend.

Shipments of pig iron approximated total production for the year. Stocks at consumer and supplier plants increased by 21 percent to 2 million tons.

Metalliferous Materials Consumed in Blast Furnaces.—For each ton of pig iron produced in 1970, an average of 1.663 tons of metalliferous materials were consumed in the blast furnaces. Total net iron ore consumed in the blast furnaces including agglomerates, was 145 million tons. The total tonnage of iron ore including manganiferous ore, consumed by agglomerating plants at or near the blast furnaces in producing 44.0 million tons of agglomerates was 35.6 million tons. The remainder consisted of mill scale, coke, limestone, and small amounts of other materials. Pellets charged to the blast furnaces totaled 55.9 million tons and sinter amounted to 45.7 million tons.

According to the AISI, total blast furnace oxygen consumption was 13.5 billion cubic feet, compared with 9.1 billion in 1969, and 6.7 billion in 1968.

Data reported to the Bureau of Mines by the iron and steel industry showed that blast furnaces, through tuyere injection, consumed 44.4 billion cubic feet of natural gas, 2.0 billion cubic feet of coke oven gas, 141.9 million gallons of oil, and 51.3 million gallons of tar, pitch, and miscellaneous fuel in 1970.

PRODUCTION AND SHIPMENTS OF STEEL

Production of raw steel during the first quarter of the year paralleled that of 1969. There was a monthly high of 11.9 million tons in March. Output for the remainder of the year dropped below that for 1969, reaching a low of 10 million tons in November.

The 1970 steel index, based on the average production of 1957–59 as 100, was 135.4 compared with 145.4 for 1969, and 135.0 for 1968. Production in 1970 was proportioned between the basic oxygen process (BOP), 48.2 percent; open-hearth furnace, 36.5 percent; and electric furnace, 15.3 percent. At yearend over 50 percent of domestic steel was being produced in basic oxygen converters.

Steel shipments declined from 93.9 million tons in 1969 to 90.8 million in 1970, with cold rolled sheets showing a drop of 2 million tons, and pipe and tubing 1.4 million. Tin-free steel for container use increased by 10 percent, and total exported steel mill products rose by 1.8 million tons. The latter were consigned primarily to the United Kingdom and the European Economic Communities (EEC). Shipments made direct to the automotive industry totaled 15.9 percent compared with 19.5 percent in 1969, while those to service centers and distributors increased from 18.7 percent to 19.5 percent.

Materials Used in Steelmaking.—Metallics charged to domestic steel furnaces in 1970 per ton of raw steel produced averaged 1,234 pounds of pig iron, 1,011 pounds of scrap, and 51 pounds of iron ore including agglomerates. In 1969 comparable amounts were 1,192 pounds of pig iron, 1,053 pounds of scrap, and 54 pounds of iron ore.

According to the AISI, steelmaking furnaces consumed 569,732 tons of fluorspar, 2.6 million tons of limestone, 5.9 million tons of lime, and 806,693 tons of other fluxes. Oxygen consumption for steelmaking totaled 186.2 billion cubic feet.

CONSUMPTION OF PIG IRON

Pig iron consumed in steelmaking totaled 81.12 million tons. Basic oxygen converters consumed 49.14 million tons; open hearths, 31.53 million tons; and electric furnaces, 0.45 million tons. An additional 2.18 million tons was consumed by iron foundries and miscellaneous users, primarily for charging cupola furnaces. Also, 6.83 million tons in the form of molten metal was used in making ingot molds and direct castings.

PRICES

Prices continued to rise for iron and steel products in 1970. This was the result of increases in the cost of metallurgical-grade coal, fluxes, other ironmaking and steelmaking supplies, labor and transportation.

Producers of merchant pig iron announced increases equivalent to $2.68 per short ton in March, and $4.90 per short ton in September. Steel mill advances were not consistent, but varied depending on the specific products. Shapes and plates were up $7 per ton in February, sheet piling $10 per ton, and hot roll and cold rolled plate about $4 to $5 per ton. Silicon electrical sheets advanced in April $10 to $15 per ton. Increases in finished and semifinished products amounted to about 5 percent.

The composite price of pig iron, according to Iron Age, increased from $58.13 per ton at the beginning of the year to $65.71 per ton at yearend, and the composite price of finished steel rose from the equivalent of $145.04 to $156.26 per ton. Foreign steel price increases were universal in the world market. Although they were made on a selective basis, a general average appeared to be about 4 to 5 percent. Announcements were made of higher prices to begin in 1971. Price reductions were noted for various nickel-bearing steels. The prices had been raised abnormally during the world nickel shortage in 1969.

FOREIGN TRADE

Voluntary agreements by major steel producers of the European Common Market countries and Japan to limit steel shipments to the United States remained in effect during 1970. However, an increase in specialty steel imports resulted in requests by the domestic specialty steelmakers for an improvement of the voluntary agreements to include specialty steel quotas and that other countries shipping these steels to the United States be covered by the voluntary plan.

By Presidential request, the U.S. Tariff Commission conducted hearings in October to determine the impact of all imports on domestic industries. Sharp increases in imports of stainless and tool steels and high-alloy specialty products were cited by spokesmen for the U.S. producers, who indicated that many domestic facilities for making these would be forced to close unless relief was obtained. Although the voluntary agreements called for specific limits to quantities of steel that would be exported to the United States yearly through 1971, no limitations were imposed on specific products.

Exports of total steel products were 7.5 million tons in 1970, 5.6 million in 1969, and 2.5 million in 1968. Imports of total steel products in 1970 decreased to 14 million tons from 14.6 million in 1969, and 18.5 million in 1968.

Exports of iron products totaled 527,500 tons in 1970, 236,900 in 1969, and 185,300 in 1968. Imports of iron products, largely pig iron, decreased to 327,400 tons in 1970 from 495,000 in 1969, and 859,100 in 1968.

WORLD REVIEW

Argentina.—The Government-owned steel producer, Sociedad Mixta Siderúrgia Argentina (SOMISA), began its second phase of an expansion program to allow production of 2.5 million tons of steel in 1972. The program, involving expenditures of $300 million, included a 4,500-ton-per-day blast furnace, to be supplied by a British firm; an oxygen converter and a continuous casting plant, to be built by West German groups; and other plant units will be furnished by Belgian and Japanese groups. Iron and steel production has not kept pace with domestic demands. With an announced goal of an 8-percent rate of growth for the Argentine economy, additional domestic steel capacity has a high priority.

Australia.—The plan of the consortium headed by Armco Steel Corp. to establish a large steel complex in Australia was still under consideration. Other members of the proposed combine were Kaiser Steel Corp. and August Thyssen-Hütte A.G. (ATH) of West Germany. The proposed plant would have a capacity of 4 million tons annually, and initially would produce semifinished steel for export.

Broken Hill Pty. Co., Ltd. operated 11 blast furnaces to produce approximately 5.8 million tons of iron. These furnaces operated at four locations. The plants at New Castle and Port Kembla each had four. Expansion at Port Kembla progressed during the year, and by 1972 capacity is expected to reach 5.5 million tons. New equipment will include a 36-foot-diameter blast furnace, and a BOP shop with two 200-ton-capacity converters. Also, tinplate capacity will be expanded twofold to provide about 500,000 tons to meet domestic demands into the 1980's.

A fifth location, on Westernport Bay, Victoria, is expected to begin production of cold-rolled strip and galvanized products by 1973. Remaining sections are to be installed later with Broken Hill's plants initially supplying the slabs and billets necessary for the operation, estimated to cost $92 million. Overall costs for the complex when completed will be about $1 billion.

Australia's domestic demand for raw steel has risen from a per capita consumption of 530 pounds in 1950 to approximately double that in 1970.

Belgium.—A merger was approved by the stockholders of two major Belgium steel companies, Cockerill-Ougrée-Providence and Metallurgique d'Espérance-Longdoz. Total steel production of the two companies has been about 6.5 million tons annually. The new group, designated as Cockerill, will be the fifth largest in the EEC.

The country's second largest steel group, Sté Métallurgique Hainaut-Sambre S.A., added blast furnace capacity and put two new basic oxygen converters into service at its Couillet plant.

Belgium's steel production declined about 2 percent from 1969, following sharp increases of 11 percent in 1969, and 19 percent in 1968. The decrease was attributed to domestic coal mine strikes early in the year, and declining demand later in the year. Investment in new steel projects and plant modernization for 1970 amounted to $134 million. BOP steel increased from 45 percent of the total in 1969 to 53 percent in 1970, owing to continued decrease in the Thomas method and increase in the basic oxygen capacity.

Brazil.—Steel production increased by 9 percent over 1969, and expansion plans were made to keep pace with expected future requirements. A Government program called for an expenditure of $800 million to raise capacity from 3.2 million long tons to 6.9 million by 1976, at the three largest Government-controlled steel mills, Cia. Siderúrgica Nacional (CSN), Cia. Siderúrgica Paulista (COSIPA), and Usinas Siderúrgicas de Minas Gerais (USIMINAS). About one-half of the cost was expected to be financed by world lending agencies.

The private sector also planned expansions and projected new mills for the future, with West German, Japanese, and U.S. interests mentioned as participants. One steelworks was to be designed by the German firm Schloemann A.G., Düsseldorf, and would be located near Rio de Janeiro. The first stage included electric furnaces and a rolling mill capacity of 220,000 tons per year. This would be raised in subsequent stages to 1 million tons.

Swindell-Dressler Co. of the United States signed a major contract to supply a 600-ton-per-day HyL direct-reduction plant for Usina Siderúrgica da Bahia S.A.

(USIBA). The process would be under license from Hojalata y Lámina S.A. of Mexico. The output would provide feed to the electric furnaces of a $50 million integrated steelworks under construction near Salvador, Bahia.

Canada.—The Steel Company of Canada, Ltd. (STELCO), continued a $102 million expansion program at its Hilton works in Hamilton. Three basic oxygen converters and a $50-million bloom and billet mill were included in this program.

The Algoma Steel Corp. Ltd. had a new blast furnace and a basic oxygen shop nearing completion at Sault Ste. Marie, and Dominion Foundries & Steel Ltd. was proceeding with a new blast furnace and mill facilities. Sydney Steel Corp. had a modernization program underway that included a basic oxygen shop and vacuum degassing facilities.

Finland.—In April, the Lake Ontario Steel Co. of Canada submitted a formal request to the Minister of Trade and Industry to establish a small local steel mill with an output of about 150,000 tons annually.

Outokumpu Oy completed a feasibility study on construction of Finland's first stainless steel plant, which was reported as favorable. The size of the plant would depend on sales prospects to be developed, but press reports indicated a possible $100 million investment.

Rautaruukki Oy continued expansion work and expected to have its cold-rolling plant and galvanizing plant at Hameelinna completed before 1972. Armco Steel was to train key personnel in the United States for this plant, under an agreement concluded during the year. The possibility of Rautaruukki Oy constructing a pipe mill at Raahe was under consideration.

France.—Plans proceeded for construction of the Fos-sur-Mer steel complex to be built by Solmer, a subsidiary of the Lorraine steel group Sollac (Wendel-Sidelor), near Marseilles, with an overall investment figure of about $1.2 billion. The plant, planned to begin production in 1973, would produce 7.5 million tons annually after a few years. The Port of Fos would be designed to handle up to 300,000-ton ore vessels. Three giant blast furnaces were to be erected with engineering done by a Japanese group.

The Dunkirk complex of Union Sidérurgique du Nord de la France (Usinor), second of the principal French steel expansion projects, was scheduled to increase its crude steel capacity by 1975, to 9,000,000 tons. The two plants would supply a large percentage of the country's proposed 30,000,000-ton steel output by 1975. These projects and other smaller plant expansions would help reduce dependency on French steel imports, especially coils and sheet steel, and place the French steel industry in a better overall position to meet foreign competition.

A prospective merger of Péchiney, Europe's largest aluminum producer, and Ugine Kuhlmann, Europe's major specialty steel producer, was announced during the year. This combine would create France's largest single industry.

India.—No increases were reported in steel capacity by India's three largest steel producers, and output of raw steel was approximately 6 percent less than in 1969. The steel industry has been producing at about 65 to 70-percent capacity, with strikes and lockouts contributing to the low production rate. A goal of a 10-percent increase in production was set by the Minister of Steel. The Government banned further exports of certain types of steel because shortages continued and black market conditions developed in mid-1970. Imports for the fiscal year 1969–70 amounted to 459,000 tons of iron and steel, and 1.9 million tons were exported. Imports from the United States doubled to 67,000 tons, essentially all of which was financed by the U.S. Agency for International Development (AID).

The Bokaro plant was scheduled to start production in 1973, but difficulties experienced left the date uncertain. Initial planned production of 1.7 million tons was to be followed by a second phase of construction to reach 2.5 million tons by 1973–74.

An announcement was made of site selection for three new plants, all in the public sector. One is to be located at Kanjamalai near Salem in Tamil Nadu. It would produce alloy and special steels. Hospet, in Mysore, would be the site of a second plant and Vizagapatnam, in Andhra, the third site. These two were planned with a 2-million-ton capacity for each. All three plants would have separate corporate structures, with the respective state governments possibly given equity shares.

Italy.—Steel expansion had a high priority in government investment plans, and crude steel capacity is expected to increase from an estimated 21 million tons in 1970 to more than 27 million by 1975.

At the Taranto plant of the Government-controlled Finsider group, a new blast furnace similar to one that added 1.5-million-ton-per-year pig iron capacity in 1969, was under construction. A loan of $55 million was approved by the Export-Import Bank to be used principally in financing 50 percent of this plant's expansion. The loan was made to Instituto Mobiliare Italiano (IMI), an Italian credit agency of Rome. Italsider S.p.A. of Genoa operates the Taranto complex and three additional integrated steel production facilities. The Taranto plant plans include two additional blast furnaces to be completed by 1976, and a basic oxygen shop by 1972. The total expansion would raise steel capacity at Taranto to 11,350 tons.

The Inter-Ministerial Committee for Economic Planning (CIPE) decided to spend about $1.6 billion to construct Italy's fifth steel center in the province of Reggio Calabria. This would be built in the period 1971–75.

Japan.—The upward trend of Japan's steel production continued through 1970, with the year's output totaling 102.9 million tons, an increase of 13.5 percent over that of 1969. Although this was less than the previous year, reflecting the worldwide economic slowdown, a high growth rate is expected to continue. Output in 1975 would reach 130 to 150 million tons if plans continue as scheduled. Actual capacity may total 130 million tons before the end of 1971. New plant construction in fiscal 1971 was set at $2.8 billion.

Three additional giant blast furnaces were completed in 1970 as follows: Nippon Steel Corp.'s 2,548-cubic-meter furnace at Hirohata, Kobe Steel Works, Ltd. 2,840-cubic-meter furnace at Kakogawa, and the 3,667-cubic-meter furnace of Kawasaki Steel Corp. at Mizushima. Four additional blast furnaces in the 3,000- to 4,000-cubic-meter range are scheduled for completion in 1971.

With the United States export market stabilized by mutual consent, Japan sought additional export steel outlets. It was successful in increasing exports compared with 1969 as follows: East Europe, 145 percent; mainland China, 24.8 percent; and Africa, 47 percent. Sales also were increased to the U.S.S.R., Romania, and Yugoslavia.

Japanese per capita consumption advanced and approached that of the United States. Shipbuilding was at maximum capacity in a pronounced seller's market. A total of 29 shipyards were in full operation and two others were under construction.

Japan's capital steel investments were estimated at $2.3 billion for 1970, compared with $1.9 billion in 1969. The steel industry employs about 460,000 workers, or 6.4 percent of the nation's total industrial workers.

Capital investment by the Japanese steel industry in Spain was announced. One joint venture would produce stainless steel, and another would involve new steel facilities in Greece.

Korea, Republic of.—Construction of various installations at the integrated iron and steel complex of Pohang Iron and Steel Co. Ltd. at Pohang, proceeded on schedule. Harbor facilities to serve the complex were about 70 percent complete.

Initial pig iron capacity of the plant (approximately 1 million tons) was expected to meet 60 percent of the country's requirements by the startup date of 1973. Japanese and Austrian financing is involved, and Korean technicians are to be given training in Japan for technical operation duties as the plant units start up.

Mexico.—Hojalata y Lámina S.A. operated its new plant near Puebla, which represented an $80 million investment. Altos Hornos and Fundidora, the other leading steel producers, had expansion programs underway to meet the country's rising steel demand. A blast furnace and basic oxygen plant was included in Altos Hornos' Monclova expansion.

Work proceeded in preparing for a new steel plant on the Pacific coast. It will be an integrated facility to be operated by Siderúrgica Las Truchas, S.A. Mexico's steel demand for the next 10 years has been estimated by the National Chamber of Iron and Steel to rise to 9 million tons; that is, to increase at an average rate of about 9 percent per year. A record monthly production rate of 388,500 tons was reached in October. A Presidential decree published July 2, set as a minimum 51 percent Mexican capital that must be invested in all new iron and steel industries in Mexico. Aluminum and several other commodities were included in the same decree.

South Africa, Republic of.—Recent plans by the South African Iron and Steel Industrial Corp. Ltd. (ISCOR), called for a minimum expenditure of $1.8 billion over a 9-year period to increase production of steel to 8 million short tons by 1980. The Vanderbijlpark works of the company is presently raising capacity by adding two 135-ton electric furnaces, and a fourth blast furnace has been contracted for. The Pretoria works was being modernized, and plans for the New Castle works called for construction to start in 1971 with production in 1973. The African Metals Corp. Ltd. (AMCOR) works at New Castle, taken over previously, would form a part of the New Castle works as a producer of pig iron.

The Southern Cross Steel Co. (Pty.) Ltd. was expected to increase output of stainless steel from 3,500 to 4,500 tons per month with installation of a new electric arc furnace. The Southern Africa Stainless Steel Development Association reported domestic consumption of stainless steel to be rising at a rate of 25 percent per year, which justified the expansion.

Spain.—Two Japanese steel firms, Nissho-Iwai Co., Ltd., and Nisshin Steel Co., Ltd., combined with the Spanish Banco Español de Credito to form the Compañia Española para la Fabricacion de Acero Inoxidable (ACERINOX) to construct Spain's first stainless steel plant. Initial output would be at a rate of 2,750 tons per month in 1972, and increase to 11,000 tons per month by 1977.

Plans for the new steel complex at Sagunto were progressing. The Instituto Nacional de Industria (INI) completed a detailed study, which included a timetable and financing arrangements. An opening date was set for 1978 with a 5-million-ton estimated capacity. Both Japan and France have indicated interest in cooperating with the Government in construction and financing of the complex.

A current expansion program calls for a 10-million-ton output in 1973. An estimate of crude steel requirements in 1980 totaled 18 million tons.

United Kingdom.—Ashmores (Davy-Ashmore group) concluded an agreement with Nippon Steel of Japan to utilize Nippon's design information and know-how to build large high-output blast furnaces of the type now operating in Japan. Ashmore's contracts of major significance were to build a furnace larger than any in the United Kingdom at the Llanwern works near Newport for the British Steel Corporation (BSC), and another to be erected at the Vanderbijlpark works of ISCOR in South Africa. The company is also installing the largest argon oxygen-decarburizing furnace in the world for the BSC. This furnace is for the production of stainless steel and is based on the Linde development. It is expected to be followed by other installations.

The BSC ceased open-hearth steelmaking in the latter part of the year in favor of basic oxygen converters at its Port Talbot plant. For the period up to 1975, the corporation plans to spend between $360 million and $420 million each year for improvement of production facilities and expansion. Improvements initiated at Scunthorpe total $312 million, and include three 300-ton converters. As part of cost reduction plans, unit trains will operate to move imported ore from a deep-water terminal at Immingham to the Scunthorpe works 23 miles away.

U.S.S.R.—The Soviet Minister for Iron and Steel indicated that the steel industry was producing as projected during 1970. The crude steel production target was revised downward to 117 million tons for the final year of the 1966–70, 5-year plan. Original plans called for 124 million tons in 1970. Construction of new facilities continued, and the new 5-year plan beginning in 1971 is to maintain the rapid rate of growth.

A new steel plant was underway at Birjuss, in East Siberia. Several large blast furnaces were in various phases of completion at other sites, and various steelmaking facilities were being constructed. More electric furnaces were said to be needed, to replace cupolas.

TECHNOLOGY

Blast Furnace.—The production of pig iron in an experimental blast furnace without use of coke was accomplished by Rheinstahl Hüttenwerke A. G., West Germany. The furnace used as a fuel "hot-briquettes." These consisted of a 70–30 mixture of degasified coal fines and coking coal, and were formed at about 500°C, but not coked.

Ratios of coke consumed to pig iron removed from blast furnaces in 1969, amounted to 0.504 for Japan, 0.685 for France, 0.656 for the United Kingdom, 0.577 for West Germany, and 0.626 for the United States. These ratios have decreased each year for the past decade and can be expected to continue as injection techniques and substitute fuels are improved. Japan reported economic pig iron production in a 4,000-ton-per-day furnace operated with a coke to pig iron ratio of 0.393; heavy oil supplied the additional fuel requirements. Laboratory blast furnace operation had a lower coke ratio of 0.360. Present target for the Japanese furnace operators is for a ratio of less than 0.400.

Japanese steel companies at the end of 1970 had the world's seven largest blast furnaces. A productivity record of 2.74 tons per day per cubic meter of furnace volume was made at Nippon Kokan's Fukuyama works, and the Nagoya works of Nippon Steel established a record of 10,095 tons produced by its No. 3 blast furnace in 1 day. A brief discussion of Japan's larger blast furnaces and the steel industry's future plans was published.[3]

ATH, operators of Europe's largest blast furnace at Ruhrort, West Germany, was using a combination of manual and automatic inputs in a computer control system to obtain maximum efficiency. An increase in production from 100,000 tons per month to 150,000 tons per month was expected to be obtained.

Bethlehem Steel Corp.'s second large furnace was under construction at Burns Harbor, near Chicago. The hearth diameter is to exceed the 35-foot diameter of the first, which started operation in 1970. United States Steel Corp. was reported to have plans for a blast furnace at its Gary, Ind., location that would rank among the largest now in operation.

Basic Oxygen Process.—In 1970, 48.2 percent of the domestic steel was produced by the BOP compared with 42.7 percent in 1969. Open-hearth furnaces were retired or placed on standby as the oxygen converters went on line. Open-hearth production dropped from 43.1 percent in 1969 to 36.5 percent in 1970.

Companies building converter shops or those in the process of installation during the year included National Steel Corp., Youngstown Sheet and Tube Co., Republic Steel Corp., and Inland Steel Co.

The Steel Company of Canada Ltd. was installing three 120-ton converters at its Hilton works. In Canada, Algoma Steel was planning for two larger converters at Sault Ste. Marie.

Altos Hornos of Mexico scheduled a third converter in its expansion plans for 1971. The BSC followed installation of two 300-ton converters at Port Talbot with plans for additional units of this size to be located at the Scunthorpe works.

Japan remained the leading basic oxygen steelmaking country, with installed and planned capacity of over 90 million tons. The practice of Japanese steelmakers in preheating scrap before charging into the basic oxygen converter in order to decrease pig iron requirements has been followed by a few companies in the United States. Scrap increases of 6 to 12 percent over the normal scrap additions allowable have been reported.

Electric Furnaces.—The electric furnace continued to be used more in the production of steel with 15.3 percent of the domestic total, compared with 14.3 percent in 1969. Opportunities for small steelworks, commonly known as mini-mills, have increased because of improved transformers, refractories, electrodes, and overall efficiency of the electric operation and better pollution control.

Electric furnaces that range from 20 to 400 tons are in use. Some of the major steelworks are beginning to depend on the larger furnaces for an increasing part of their capacity. These can be equipped with highly advanced control equipment giving constant tap-to-tap intervals essential for continuous casting.

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[3] Masubuchi, K. Japan's Mammoth Blast Furnace. Iron Age, v. 206, No. 24, Dec. 10, 1970, pp. 85–89.

The Ford Motor Co. contracted for what was reported to be the largest number of electric furnaces to be installed in a single location; 11 electric-arc furnaces at the Flat Rock, Michigan, casting plant. These were to be used for both melting and holding of the liquid steel in the casting operations.

Use of the electric furnace for smelting iron ore to produce hot metal or pig iron was described in a Canadian publication.[4] Increasing the world iron capacity by use of this method does not appear to be gaining in favor.

Direct Reduction.—Pig iron production by the direct-reduction method received a setback in the United States as McWane Cast Iron Pipe Co.'s plant on the Gulf Coast, using the D–LM process, was sold to the Air Reduction Co. (Airco). The plant was to be converted to the production of ferroalloys by Airco's Alloys and Carbide Division.

Steel via the direct reduction route, using metallized iron ore products, gained headway as Armco Steel announced that a facility to produce 1,000 tons of iron product per day for direct charge into electric-arc furnaces would be constructed at Houston, Tex. This would supplement present blast furnace production at the company's Houston works. Electric furnace steelmaking by the Oregon Steel Mills in Portland using a 90 to 95 percent metallized pellet product from the adjacent plant of Midland-Ross Corp. was started. A second steelmaking plant designed to use the Midland-Ross metallized product was near the operating stage in Georgetown, S.C. Another facility was being constructed at Hamburg, West Germany. A third metallized pellet plant was to be built in Japan. The latter would have three Japanese firms, Mitsui & Co., Ltd., Daido Steel Co., Ltd., and Chugai-Ro Kogyo Kaisha as joint venture signers with Midland-Ross.

The Brazilian firm, USIBA contracted for a steel plant using the HyL process to furnish sponge iron to electric-arc steelmaking furnaces. Swindell-Dressler would build the plant, which is scheduled to start at a production rate of one-half million tons and reach 2 million tons by 1975. Products would consist of bars, rods, wire, and structural shapes.

Iron and Steel Refining.—A process for desulfurization of large volumes of molten pig iron was developed and placed in operation by the Japanese firm, Nippon Kokan, at the company's Keihin works. The process provides for interface mixing only by means of surface stirring, and depends on the filling of the transfer ladle to give adequate mixing action over the entire hot metal volume. A stabilized desulfurization rate of over 90 percent is obtained.[5]

The Airco Vacuum Metals Division of AIRCO placed its combined refining process, Electron-Beam Continuous Hearth Refining, in commercial production to produce high-performance alloy steels. One nickel-free product containing 26 percent chromium was described as unchallenged by the chromium-nickel austenitic stainless steels for many uses.[6]

Refining without formation of the brown fumes normally associated with oxygen injection was accomplished by the injection of powdered iron oxide into molten steel by a carrier gas. The process was announced by a British group, Steel Castings Research and Trade Association. The injection of other metal oxides to combine alloying and refining was another novel feature of the process. Control of the carbon boil was said to be possible. Also, injection of powdered lime and fluorspar along with the metal oxide allowed low-phosphorus steel to be produced.

Continuous Casting.—Continuous casting in the United States gained additional units with startups or construction reported during the year at 12 sites. New installations also were underway in several European locations.

Although less spectacular than the blast furnace growth, the rapid increase in continuous casting in Japan has resulted in 30 installations in operation at yearend, including five completed in 1970.

A report on United States Steel Corp.'s caster at Gary, Ind., and an evaluation of various aspects of the company's development was given in a speech by the chairman.[7]

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[4] Loe, L. T. Aspects of Smelting Pig Iron in Electric Reduction Furnaces. Canadian Min. Met. Bull., v. 63, No. 700, August 1970, pp. 911–919.

[5] Japan Iron and Steel Monthly. New Pig Iron Desulphurization Process Developed by NKK. No. 191, December 1970, p. 14.

[6] Knoth, Roy J. Electron Beams, Ultra Vacuum Score Pluses for Steelmaking. Chem. Eng., v. 77, No. 14, June 29, 1970, pp. 46–48.

[7] Gott, Edwin H. The Economic Importance of Continuous Casting of Steel Slabs. Iron and Steel Review (India)—12th Anniversary Number, 1969, pp. 17–30.

A continuous casting facility for producing gray iron was discussed from the standpoint of cost, metallurgy, and tensile strength.[8]

Powder Metallurgy.—A new method of producing steel, based on compacting steel powder under high temperature and pressure, was undergoing pilot plant tests in Sweden. Developed jointly by the Swedish firms Allmanna Svenska Elektriska Aktiebolaget (ASEA) and Stora Kopparbergs Bergslags AB, commercial production was to start in 1971.[9]

Kobe Steel Ltd. offered new atomized powder products for sale under technical agreement with A. O. Smith-Inland, Inc. These included pure iron powder, and both low- and high-alloy steel powders. Uses were expected to be mainly in manufacturing automobile parts.

Discussions at the International Powder Metallurgy Conference in New York indicated that technological advances would rapidly expand iron powder market possibilities. For example, the use of powder in roll compaction and in isostatic pressing would allow steel alloys of any composition to be blended and formed to customer specifications.

High-speed steel production, using isostatic processing methods, was announced by Colt Industries, Inc., Crucible Specialty Steels Division, which scheduled an annual production rate of 600 tons. The powder method was said to give tool steels that outperform those made by conventional methods; the ingots have maximum density and are devoid of carbide separations.

Consumable electroslag melting was the basis of a new process by the Arcos Corp. for producing tool steel ingots from powder.[10] The Tin Research Institute announced results that showed sintering of iron powder compacts could be improved by prior addition of tin powder.

Foundry.—Studies by the Gray and Ductile Iron Founders' Society indicated gray iron foundries to number about 1,500, compared with 3,000 20 years ago. About 400 more will probably close in the next 5 years. This is in spite of the tonnage increase, from 10 million tons in 1960 to about 16 million tons in 1969, which has been largely in captive foundries.[11] The relative high cost of installing equipment in the smaller installations to meet air pollution requirements is one factor in the decline.

A new pattern of operation for ductile and gray iron foundries was forecast with an arrangement whereby a large shredded scrap processor leased ground and installed facilities at a foundry to supply processed scrap directly to the foundry for iron production. The special-grade shredded product is said to be ideal for furnace melting, free flowing but with sufficient density to cut melting time.

A resumé of nodulizing processes in worldwide use for making ductile iron was presented.[12]

The last maker of wrought iron in the United States, A. M. Byers Co., permanently closed its wrought iron manufacturing facilities in Pennsylvania the first of the year.[13] Operating losses over the last 4 years were attributed to increasing competition from other materials. The company used the Aston process for making wrought iron and also operated one of the last surviving Bessemer converters.

Research.—Research by the Bureau of Mines continued on improving continuous steelmaking by electric furnace methods. Studies to recover values from steelmaking dusts, and to improve metal produced from ferrous scrap were underway during 1970. Published reports by the Bureau included a cost study[14] of disposing of steel slag, estimated at 21 percent of steel ingot production for a mill in the Pittsburgh area. Another report[15] deals with the effects of variables in basic oxygen steelmaking. Progress in steelmaking technology and improvements made in the quality of finished steel products was covered in a

[8] Krall, H.A., and B. R. Douglas. Continuous Casting of Gray Iron. Foundry, v. 98, No. 11, November 1970, pp. 50–53.

[9] Metallurgia. High Speed Steel Produced by Powder Metallurgy Technique. V. 82, No. 489, July 1970, pp. 11–13.

[10] Metal Bulletin. Powder's Promising Future. No. 5518, July 24, 1970, pp. 31, 33.

[11] Industry Week. Foundry Failures Worry Users of Iron Castings. V. 167, No. 17, Oct. 26, 1970, pp. 14–16.

[12] Modl, Erich K. Comparing Processes for Making Ductile Iron. Foundry, v. 98, No. 7, July 1970, pp. 43–48.

[13] Business Week. Wrought Iron on Scrap Heap. No. 2105, Jan. 3, 1970, p. 18.

[14] Baker, E. C. Estimated Costs of Steel Slag Disposal. BuMines Inf. Cir. 8440, 1970, 18 pp.

[15] Spironello, V. R., H. A. Tucker, and W. C. Hill. An Evaluation of Variables in Basic Oxygen Steelmaking. BuMines Rept. of Inv. 7345, 1970, 35 pp.

publication by the United Nations.[16] Another presentation covered problems concerned with pollution in the steel industry. Sections dealing with technological improvements in the various iron and steelmaking processes, as well as cost aspects are included.[17]

[16] United Nations, Economic Commission for Europe. Development of Production Technology and New Properties of Steel Products, New York, 1970, 49 pp.

[17] United Nations, Economic Commission for Europe. Problems of Air and Water Pollution Arising in the Iron and Steel Industry, New York, 1970, 86 pp.

Table 2.—Pig iron produced and shipped in the United States, in 1970, by States

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces	
		Quantity	Value
Alabama	4,654	4,709	$300,544
Illinois	7,388	7,384	470,339
Indiana	13,348	13,293	874,673
Ohio	16,331	16,353	1,120,028
Pennsylvania	20,793	20,774	1,332,856
California, Colorado, Utah	5,150	5,098	336,888
Kentucky, Maryland, Texas, West Virginia	11,451	11,426	717,533
Michigan, Minnesota	7,550	7,569	472,635
New York	5,548	5,585	365,760
Total	92,213	92,191	5,991,256

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	1969 [1]	1970 [2]
Brazil	477	751
Canada	1,487	1,756
Chile	1,155	1,080
Peru	9	198
Venezuela	4,882	5,012
Other countries	3,272	1,673
Total	11,282	10,470

[1] Excludes 22,455 tons used in making agglomerates.
[2] Excludes 20,600 tons used in making agglomerates.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

(Thousand short tons and thousand dollars)

Grade	1969			1970		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	2,380	$135,888	$57.10	1,780	$110,281	$61.96
Basic	89,580	5,237,698	58.47	87,010	5,663,791	65.09
Bessemer	1,228	72,075	58.69	1,346	88,772	65.95
Low-phosphorus	147	8,885	60.44	130	8,717	67.05
Malleable	1,730	100,536	58.11	1,548	95,763	61.86
All other (not ferroalloys)	407	23,677	58.17	377	23,932	63.48
Total	95,472	5,578,759	58.43	92,191	5,991,256	64.99

[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 States

State	Jan. 1, 1970			Jan. 1, 1971		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	12	7	19	11	8	19
California	4	----	4	4	----	4
Colorado	4	----	4	4	----	4
Illinois	14	4	18	13	6	19
Indiana	21	4	25	21	4	25
Kentucky	2	1	3	2	----	2
Maryland	8	2	10	8	2	10
Michigan	9	----	9	9	----	9
Minnesota	1	1	2	1	1	2
New York	12	3	15	9	6	15
Ohio	31	15	46	27	17	44
Pennsylvania	41	15	56	33	22	55
Tennessee	----	3	3	----	----	----
Texas	2	----	2	2	----	2
Utah	2	1	3	3	----	3
West Virginia	4	----	4	3	1	4
Total	167	56	223	150	67	217
Ferroalloy blast furnaces	2	3	5	2	----	2
Grand total	169	59	228	152	67	219

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 States

(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	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
1969:																
Alabama	2,103	W	4,832	8,520	175	13	8,708	3,776	935	4,894	1.741	0.036	0.003	1.779	0.772	0.191
Illinois	W	------	9,778	13,855	215	280	14,350	4,396	1,169	7,134	1.942	.030	.039	2.011	.616	.164
Indiana	W	W	15,843	19,949	392	637	20,978	7,434	1,497	12,680	1.573	.031	.050	1.654	.586	.118
Ohio	4,527	1,041	20,030	24,957	1,140	1,624	27,721	11,021	3,477	16,878	1.479	.068	.096	1.642	.653	.206
Pennsylvania	6,016	4,118	24,452	33,788	973	1,835	36,596	14,077	2,761	22,335	1.513	.044	.082	1.639	.630	.124
California, Colorado, Utah	3,906	------	W	8,895	155	161	9,211	2,978	916	5,031	1.768	.031	.032	1.831	.592	.182
Maryland, West Virginia, Kentucky, Texas	W	W	14,416	18,440	232	1,026	19,698	7,454	1,329	12,067	1.528	.019	.085	1.632	.618	.110
Michigan and Minnesota	1,096	W	10,951	11,714	235	215	12,164	4,668	1,282	7,642	1.533	.031	.028	1.592	.611	.168
New York	1,892	108	W	9,872	226	299	10,397	3,884	931	6,341	1.557	.036	.047	1.640	.613	.147
Total [4]	28,599	11,282	113,475	149,990	3,743	6,092	159,825	59,689	[5] 14,297	95,003	1.579	.040	.064	1.682	.628	.150
1970:																
Alabama	1,482	W	4,632	7,741	137	9	7,886	3,519	800	4,654	1.663	0.029	0.002	1.694	0.756	0.172
Illinois	W	------	10,270	14,677	203	337	15,217	4,551	1,439	7,388	1.987	.027	.046	2.060	.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	23,263	775	1,440	25,478	10,101	3,177	16,331	1.424	.047	.088	1.560	.619	.195
Pennsylvania	5,544	4,033	22,896	31,719	884	1,714	34,317	13,132	2,866	20,793	1.525	.042	.082	1.650	.632	.138
California, Colorado, Utah	4,212	------	W	9,413	68	148	9,629	3,097	860	5,150	1.828	.013	.029	1.869	.601	.167
Maryland, West Virginia, Kentucky, Texas	W	W	13,837	17,015	298	998	18,311	7,133	1,287	11,451	1.486	.026	.087	1.599	.623	.112
Michigan and Minnesota	923	W	10,714	11,317	214	260	11,792	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 [4]	25,169	10,470	112,349	144,586	3,045	5,689	153,320	57,324	[6] 14,391	92,213	1.568	.033	.062	1.663	.622	.156

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] Data may not add to totals shown because of independent rounding.
[5] Fluxes consisted of the following: 7,711 limestone, 6,003 dolomite, and 583 other fluxes excluding 4,988 limestone, 3,647 dolomite, and 423 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[6] 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.

Table 7.—Steel production in the United States, by type of furnace [1]
(Thousand short tons)

Year	Open hearth		Bessemer	Basic oxygen process	Electric	Total
	Basic	Acid				
1966	84,804	221	278	33,928	14,870	134,101
1967	70,550	140	(2)	41,434	15,089	127,213
1968	65,836	(2)	(2)	48,812	16,814	131,462
1969	60,894	(2)	--------	60,236	20,132	141,262
1970	48,022	(2)	--------	63,330	20,162	131,514

[1] Excludes castings produced in foundries not covered by AISI.
[2] Included with basic open hearth.

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces in the United States
(Thousand short tons)

Year	Iron ore		Agglomerates		Pig iron	Ferro-alloys [1]	Iron and steel scrap
	Domestic	Foreign	Domestic	Foreign			
1966	1,348	3,768	870	348	83,947	1,915	68,778
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	81,118	1,641	66,451

[1] Includes ferromanganese, spiegeleisen, silicomanganese, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.

Table 9.—Consumption of pig iron [1] in the United States, by types of furnace

Type of furnace or equipment	1970	
	Thousand short tons	Percent of total
Open hearth	31,529	37.9
Basic oxygen converter	49,136	59.0
Electric	453	.5
Cupola	2,076	2.5
Air	94	.1
Other [2]	10	------
Total	83,298	100.0

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes vacuum melting furnaces and miscellaneous melting processes.

Table 10.—Average value of pig iron at blast furnaces in the United States, by States
(Per short ton)

State	1970
Alabama	$63.82
California, Colorado, Utah	64.71
Illinois	63.69
Indiana	65.80
New York	65.49
Ohio	68.49
Pennsylvania	64.16
Other States [1]	62.65
Average	64.99

[1] Includes Kentucky, Maryland, Michigan, Minnesota, Texas, and West Virginia.

Table 11.—Consumption of pig iron [1] in the United States, by States
(Thousand short tons)

State	1970
Alabama	4,026
California	2,334
Connecticut	21
Delaware	(2)
Georgia	11
Illinois	7,363
Indiana	13,400
Iowa	28
Kansas	3
Louisiana	(2)
Maine	(2)
Massachusetts	21
Michigan	7,470
Minnesota	478
Missouri	21
Montana	(2)
Nebraska	(2)
Nevada	(2)
New Jersey	52
New York	4,998
Ohio	15,071
Oregon	1
Pennsylvania	21,366
Rhode Island	10
Tennessee	132
Texas	95
Vermont	5
Wisconsin	155
Undistributed [3]	13,065
Total	90,126

[1] Includes molten pig iron used for ingot molds and direct castings.
[2] Less than ½ unit.
[3] Includes Colorado, Florida, Kentucky, Maryland, New Hampshire, North Carolina, Oklahoma, South Carolina, Utah, Virginia, and Washington.

Table 12.—U.S. exports of major iron and steel products

Products	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
SEMIMANUFACTURED				
Ingots and other primary forms:				
Puddled bars and pilings, blocks, lump and other primary forms of iron or steel, n.e.c.	8,643	$1,015	11,425	$1,721
Blooms, billets, ingots, slabs, sheet bars and roughly forged pieces	1,810,490	142,767	3,177,922	270,368
Coils for rerolling	421,531	61,911	340,630	49,903
Blanks for tubes and pipes, iron or steel	12,159	1,400	2,175	280
Total	2,252,823	207,093	3,532,152	322,272
Bars, rods, angles, shapes and sections:				
Wire rods	r 98,245	r 16,348	163,520	20,147
Bars, rods, and hollow-drill steel	215,674	51,797	216,362	48,415
Concrete reinforcing bars	86,762	11,592	80,077	11,194
Angles, shapes and sections	170,424	29,261	212,402	37,552
Plates and sheets:				
Steel plates	25,441	12,603	27,111	14,021
Steel sheets	1,040,381	146,923	1,268,402	190,100
Black plate	49,723	6,789	50,718	7,579
Iron and steel plates, n.e.c.	403,715	66,152	292,631	57,469
Tinplate and terneplate	339,606	52,264	341,275	61,844
Tinplate circles, cobbles, strip and scroll	26,080	2,577	23,910	2,628
Hoop and strip	100,595	38,160	376,050	73,297
Total	r 2,556,646	r 434,466	3,052,458	524,246
MANUFACTURES				
Rails and railway track material	73,136	12,995	81,829	15,867
Wire	85,227	37,518	72,868	38,479
Cast-iron pressure pipe, soil pipe and fittings	32,419	9,340	33,571	11,863
Steel tube and pipe fittings, union and flanges	29,985	46,105	44,541	64,942
Malleable iron tube and pipe fittings, n.e.c.	2,087	2,290	1,560	1,857
Electrical conduit fittings of iron or steel	12,317	7,965	10,453	7,971
Iron tube and pipe fittings, n.e.c.	7,191	10,562	7,929	10,402
Seamless tubes and pipe	251,996	99,235	243,822	100,291
Welded, clinched or riveted tubes and pipe	73,767	28,992	93,335	43,552
Castings and forgings	137,454	67,824	177,232	86,471
Total	705,579	322,826	767,140	381,695
Grand total	r 5,515,048	r 964,385	7,351,750	1,228,213

r Revised.

Table 13.—U.S. imports for consumption of pig iron, by countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Australia	-------	-------	674	$31	-------	-------
Brazil	33,240	$976	-------	-------	-------	-------
Canada	416,383	18,043	295,076	14,449	249,129	$13,720
Finland	77,762	2,658	69,843	2,422	-------	-------
Germany, West	107,704	3,961	r 36,484	r 1,436	112	9
Netherlands	330	15	-------	-------	-------	-------
Norway	61,616	2,037	2,811	107	-------	-------
Spain	21,221	741	-------	-------	-------	-------
Sweden	41,219	1,252	-------	-------	-------	-------
United Kingdom	26,424	798	-------	-------	-------	-------
Total	785,899	30,481	r 404,888	r 18,445	249,241	13,729

r Revised.

Table 14.—U.S. imports for consumption of major iron and steel products

Products	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Iron products:				
Cast iron pipes, tubes and fittings	34,395	$9,451	28,181	$9,763
Bars of wrought iron	617	153	428	123
Total	35,012	9,604	28,609	9,886
Iron and steel products:				
Ingots, blooms, billets, slabs and sheet bars	195,176	37,514	170,647	29,917
Bars of steel:				
Concrete reinforcing bars	470,807	40,563	202,699	21,200
Other bars	903,756	119,510	727,741	117,152
Plates and sheets:				
Black plate	11,657	1,684	6,928	3,585
Steel plates	1,202,168	121,105	1,391,046	492,433
Steel sheets	3,943,628	423,318	4,290,683	554,913
Plates, sheets and strip of iron or steel	960,183	139,714	1,046,042	167,690
Strip of iron or steel	96,167	32,921	92,335	37,935
Hollow drill steel	5,412	2,036	4,212	1,687
Wire rods of steel	1,260,890	129,803	1,055,570	127,099
Sheet piling	65,957	6,854	52,335	6,189
Pipes, tubes and fittings	1,691,384	265,431	1,966,917	340,054
Angles, shapes and sections	1,992,410	206,875	1,644,560	207,919
Tinplate and terneplate	300,664	51,339	327,725	59,066
Rails and railway track material	44,141	4,043	39,878	4,312
Wire	822,162	167,602	777,070	185,241
Castings and forgings	17,242	7,859	12,728	6,101
Total	13,983,804	1,758,171	13,809,116	2,362,493
Grand total	14,018,816	1,767,775	13,837,725	2,372,379

Table 15.—Pig iron and blast furnace ferroalloys: World production, by countries

(Thousand short tons)

Country [1]	1967	1968	1969	1970 [p]
North America:				
Canada [2]	7,108	r 8,550	7,665	9,296
Mexico [2] [3]	r 1,813	2,228	2,378	2,575
United States [4]	86,799	88,767	95,003	92,213
South America:				
Argentina [4]	657	633	643	898
Brazil [4]	3,383	3,714	4,297	4,632
Chile [4]	549	487	535	503
Colombia	228	218	227	e 260
Peru [5]	34	122	194	e 90
Venezuela	465	r 677	573	562
Europe:				
Austria [6]	2,359	2,727	3,104	3,267
Belgium	r 9,813	r 11,432	12,468	11,955
Bulgaria [6]	1,135	1,195	1,209	1,325
Czechoslovakia	7,520	r 7,629	7,726	8,320
Denmark	r 127	r 205	228	237
Finland [7]	1,174	1,218	1,357	1,347
France	r 17,322	18,133	20,075	21,188
Germany, East [8]	2,783	2,572	2,313	2,200
Germany, West	30,166	33,406	37,218	37,067
Greece	e 300	e 300	320	331
Hungary [6]	1,835	1,818	1,932	2,015
Italy [7]	8,060	8,644	8,593	9,209
Luxembourg	4,365	4,749	5,370	5,307
Netherlands	2,853	3,110	3,815	3,962
Norway [5]	702	743	754	747
Poland [9]	6,974	7,225	7,423	7,699
Portugal [7]	321	317	381	347
Romania [8]	2,708	3,314	3,843	4,642
Spain [6]	2,953	3,063	3,674	4,590
Sweden [3]	r 2,771	r 2,919	2,949	3,079
Switzerland	26	24	28	31
U.S.S.R.[8]	82,466	r 86,849	89,986	94,688
United Kingdom [8]	16,971	18,404	18,357	19,480
Yugoslavia [6]	1,297	1,324	1,321	1,405
Africa:				
Algeria [e]	11	11	66	77
Rhodesia, Southern [e] [10]	220	r 290	300	310
South Africa, Republic of [2]	4,177	4,546	4,801	4,795
Tunisia	108	141	144	e 140
United Arab Republic	e r 220	e 220	466	e 500
Asia:				
China, mainland [e] [10]	15,400	20,900	22,000	24,300
India [4]	7,618	7,883	8,114	7,754
Israel [e] [10]	40	40	40	40
Japan [6]	44,197	51,144	64,096	75,010
Korea, North [e] [10]	1,930	2,200	2,500	2,600
Korea, Republic of [10]	r 36	r 25	57	67
Malaysia [e] [10]	20	70	70	70
Taiwan [10]	95	r 86	88	67
Thailand [10]	7	19	12	12
Turkey	934	1,003	1,045	1,140
Oceania:				
Australia	5,671	6,214	6,819	[5] 6,777
New Zealand (all sponge iron)	-------	-------	NA	25
Total	r 388,721	r 421,508	456,577	479,151

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

[1] In addition to the countries listed, North Vietnam and a few other countries presumably have facilities to produce pig iron, but available information is inadequate to make reliable estimates of output.

[2] Includes electric furnace ferroalloy output.

[3] Includes sponge iron output as follows in thousand short tons: Mexico: 1967–359; 1968–412; 1969–444; 1970–679; Sweden: 1967–168; 1968–167; 1969–196; 1970–204.

[4] Series revised to exclude all ferroalloy production, for which see table 16.

[5] Excludes all ferroalloys.

[6] Series revised to exclude electric furnace ferroalloys.

[7] Series revised to include blast furnace ferroalloys, and, in the case of Finland, pig iron output by some producers not included previously.

[8] Series may include electric furnace ferroalloys as well as pig iron and blast furnace ferroalloys.

[9] Series revised to conform with data reported by the Polish Government to the United Nations' Economic Commission for Europe.

[10] Includes electric furnace ferroalloys if any are produced.

Table 16.—Electric furnace ferroalloys: World production, by countries [1]
(Thousand short tons)

Country [2]	1967	1968	1969	1970 [p]
North America: United States [3]	2,750	2,621	2,629	2,595
South America:				
Argentina	20	27	27	[e] 27
Brazil [2]	65	74	81	[e] 85
Chile [3]	11	11	13	[e] 15
Europe:				
Austria	6	6	7	6
Bulgaria	[e] 31	31	41	55
Czechoslovakia	107	111	107	115
Finland	-----	9	29	36
France	289	301	341	374
Germany, West	177	230	277	297
Hungary	15	10	15	11
Italy	168	168	168	193
Norway [3]	605	726	773	562
Poland	119	115	126	131
Spain	89	107	105	[e] 120
Sweden	230	255	272	257
Switzerland	2	7	7	[e] 10
Yugoslavia	87	94	99	112
Asia:				
India [3]	167	186	221	236
Japan	1,042	1,175	1,430	1,835
Turkey	9	9	10	10
Total	5,989	6,273	6,778	7,082

[e] Estimate. [p] Preliminary.
[1] Excludes some countries as indicated by footnote 2, and includes blast furnace ferroalloys for five countries as indicated by footnote 3.
[2] In addition to the countries listed, Canada, Mexico and the Republic of South Africa also produce electric furnace ferroalloys, but output is reported in sources as an inseparable part of a total ferroalloy production figure together with blast furnace ferroalloys and is included in table 15 with pig iron and blast furnace ferroalloys. East Germany, Romania, the U.S.S.R. and the United Kingdom also produce electric furnace ferroalloys, but data on output are not available and sources do not clearly indicate if output is simply unreported or if it is included with blast furnace ferroalloys in table 15. Electric furnace ferroalloy production, if any, from Australia, Israel, North Korea, Republic of Korea (South Korea), Malaysia, Southern Rhodesia, Taiwan, and Thailand is included with pig iron and blast furnace ferroalloy production in table 15.
[3] Total ferroalloy production, including blast furnace ferroalloys.

Table 17.—Raw steel:[1] World production, by countries

(Thousand short tons)

Country	1968	1969	1970 p
North America:			
Canada	11,251	10,307	12,346
Cuba e	55	60	60
Mexico	3,621	3,825	4,238
United States [2]	131,462	141,262	131,514
South America:			
Argentina	r 1,711	1,871	2,012
Brazil [3]	4,909	5,429	5,917
Chile [3]	628	713	603
Colombia	282	290	e 330
Peru	r 117	212	e 90
Uruguay	10	15	e 20
Venezuela	r 948	905	1,017
Europe:			
Austria	3,822	4,328	4,496
Belgium	r 12,752	14,145	13,897
Bulgaria	r 1,614	1,670	1,984
Czechoslovakia	11,635	11,907	12,655
Denmark	r 504	531	521
Finland	r 804	1,067	1,289
France	r 22,497	24,814	26,205
Germany, East	5,175	5,318	e 5,540
Germany, West	45,370	49,952	49,649
Greece	240	496	480
Hungary	3,200	3,342	3,428
Ireland	r 75	89	e 90
Italy	r 18,700	18,109	19,045
Luxembourg	5,329	6,086	6,021
Netherlands	4,086	5,204	5,558
Norway	r 895	936	959
Poland	12,133	12,446	12,998
Portugal	345	440	424
Romania	5,237	6,107	7,184
Spain	r 5,428	6,619	8,144
Sweden	5,616	5,866	6,058
Switzerland	499	551	578
U.S.S.R.	r 117,437	121,616	127,868
United Kingdom	r 28,965	29,593	31,213
Yugoslavia	2,201	2,447	2,456
Africa:			
Algeria	31	20	e 20
Rhodesia, Southern e	150	r 160	180
South Africa, Republic of	r 4,749	5,323	e 5,620
Tunisia	r 88	110	e 110
United Arab Republic	r 209	e 540	e 550
Asia:			
Burma e	20	20	20
China, mainland e	16,500	17,600	18,700
India [3]	r 7,108	7,122	6,722
Israel e	r 110	r 130	130
Japan	r 73,737	90,572	102,870
Korea, North e	1,930	r 2,200	2,400
Korea, Republic of	410	412	530
Lebanon e	20	20	20
Malaysia e [3]	r 65	r 65	65
Pakistan e	110	110	110
Philippines e	95	95	95
Taiwan	267	299	324
Thailand	6	10	7
Turkey	1,222	1,290	1,446
Vietnam, North e	8	8	8
Oceania:			
Australia	7,167	7,735	7,520
New Zealand e	75	75	75
Total	r 583,630	632,484	654,409

e Estimate. p Preliminary. r Revised.
[1] Steel formed in first solid state after melting suitable for further processing or sale.
[2] 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): 1968–1,557; 1969–1,906; 1970–1,723.
[3] Excludes castings.

Iron and Steel Scrap

By Harold J. Polta[1]

Domestic consumption of iron and steel scrap in 1970 declined in line with the general decline in U.S. business conditions, but record exports partially offset the decrease in domestic consumption. Although scrap processors continued expansion of facilities for shredding and fragmentizing junked automobiles and other obsolescent scrap, there was evidence that additional innovations would be required to further increase recycling of materials. Presidential, Congressional, and public concern about the quality of our environment and the need for conserving natural resources resulted in several legislative acts pertinent to the ferrous scrap industry. As a result, both industry and Government continued studying ways to increase reclamation and consumption of iron and steel scrap.

Table 1.—Salient iron and steel scrap, and pig iron statistics in the United States
(Thousand short tons and thousand dollars)

	1969	1970
Stocks Dec. 31:		
Scrap at consumer plants	6,552	7,668
Pig iron at consumer and supplier plants	1,723	2,082
Total	8,275	9,750
Consumption:		
Scrap	94,816	85,559
Pig iron	94,635	90,126
Exports:[1]		
Scrap (excludes rerolling material)	9,036	10,113
Value	$291,856	$431,905
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	335	301
Value	$13,488	$11,200

[1] 1965–1969 included ships, boats, and other vessels for breaking up for scrap.

Legislation and Government Programs.—The Mining and Minerals Policy Act of 1970 gave the Secretary of the Interior the responsibility, among other things, to foster and encourage private enterprise in (1) the development of sound and stable metal reclamation industries, (2) the orderly reclamation of metals, and (3) research on the use and recycling of scrap.

The National Environmental Policy Act of 1969, signed by the President January 1, 1970, established a national policy on the environment, created the Council on Environmental Quality in the Executive Office of the President, and placed new responsibilities on Federal Agencies by directing them to take into consideration environmental factors in decision making. The first annual report of the newly created Council was transmitted to Congress in August. It included several items pertinent to the iron and steel scrap industry: (1) an average of 9 million cars are retired each year; (2) 2.5 million to 4.5 million cars are abandoned each year; (3) although the President recommended a bounty system (on old automobiles to the processor, wrecker, or owner) the Council concluded a bounty system is not practical; (4) the Council recommended firm penalties against abandonment and improvement of State title and transfer laws to put abandoned autos more promptly in the scrapping cycle.

The Resource Recovery Act of 1970 directs the Secretary (of Health, Education and Welfare; and of the Interior) to carry out an investigation and study to determine recommended incentives for accelerating recycling of solid wastes; the effect of existing public policies such as subsidies and tax incentives on recycling; and the necessity and method of imposing disposal charges on packaging containers, vehicles, and other goods. Several state and local governments passed laws which were directed toward accelerating recycling, and many more had such legislation under consideration.

The Environmental Protection Agency

[1] Mining engineer, Division of Ferrous Metals.

was established in line with a reorganization plan sent to the Congress by the President on July 9, 1970. Of particular interest to ferrous scrap consumers, are items pertaining to redirecting research on solid waste management to place greater emphasis on recycling and reuse of materials.

The Export Administration Act of December, 1969, allows the Department of Commerce to stop exports to prevent an excessive drain of scarce materials so as to avoid serious inflationary impact from abnormal foreign demand. Although the Department of Commerce requires licensing of stainless and other nickel-containing scrap exporters, it had imposed no quotas or embargoes on ferrous scrap in recent years.

AVAILABLE SUPPLY

The 86.7 million tons of iron and steel scrap reported available for consumption at consumers' plants in 1970 consisted of 52.6 million tons of home, and 34.1 million tons purchased scrap (net receipts). Home scrap production was down 7 percent from that in 1969, and scrap purchased was down 8 percent.

CONSUMPTION

Consumers reported consumption of 85.6 million tons of iron and steel scrap in 1970. This was 10 percent less than in 1969. Consumption statistics are given in tables 2 through 9.

STOCKS

Consumers' stocks reported on hand December 31, 1969 were 7.7 million tons, up 17 percent from the year before.

PRICES

Iron and steel scrap prices, which started to rise rapidly early in 1969, continued upward in the first months of 1970 and then generally declined the rest of the year. The American Metal Market composite price of No. 1 heavy melting scrap, which rose from $26 to over $36 per ton in 1969, went to $46 in February 1970. Thereafter, prices generally declined, No. 1 heavy melting scrap reaching a low of $35 per ton in December. However, at yearend price increases had No. 1 heavy melting at $38 per ton.

Scrap prices generally followed demands for export. Demands for export were high in the early months of 1970, then generally decreased the rest of the year.

FOREIGN TRADE

Exports of iron and steel scrap (excluding rerolling material) in 1970 reached a record 10.1 millon tons. This was an increase of 13.3 percent over 1969 exports. Principal destination of U.S. scrap was Japan which received 5.2 million tons or 51.5 percent of the total exported. Next largest importers of U.S. scrap were Spain (11.5 percent), and Mexico (8.1 percent). Monthly exports were well above those of the comparable months in 1969 from January through July but, thereafter, were generally either below or only slightly above those in the comparable 1969 months.

Largest indicated export tonnage increases were in the shredded and No. 2 bundle classes. Exports of No. 2 bundles increased 343,000 tons (33 percent) over those of 1969. No similar direct comparison of 1970 shredded exports can be made with those of 1969, because shredded scrap exports were not reported as a separate scrap class prior to 1970. However, if 1970 exports of shredded (1,165,000 tons) had

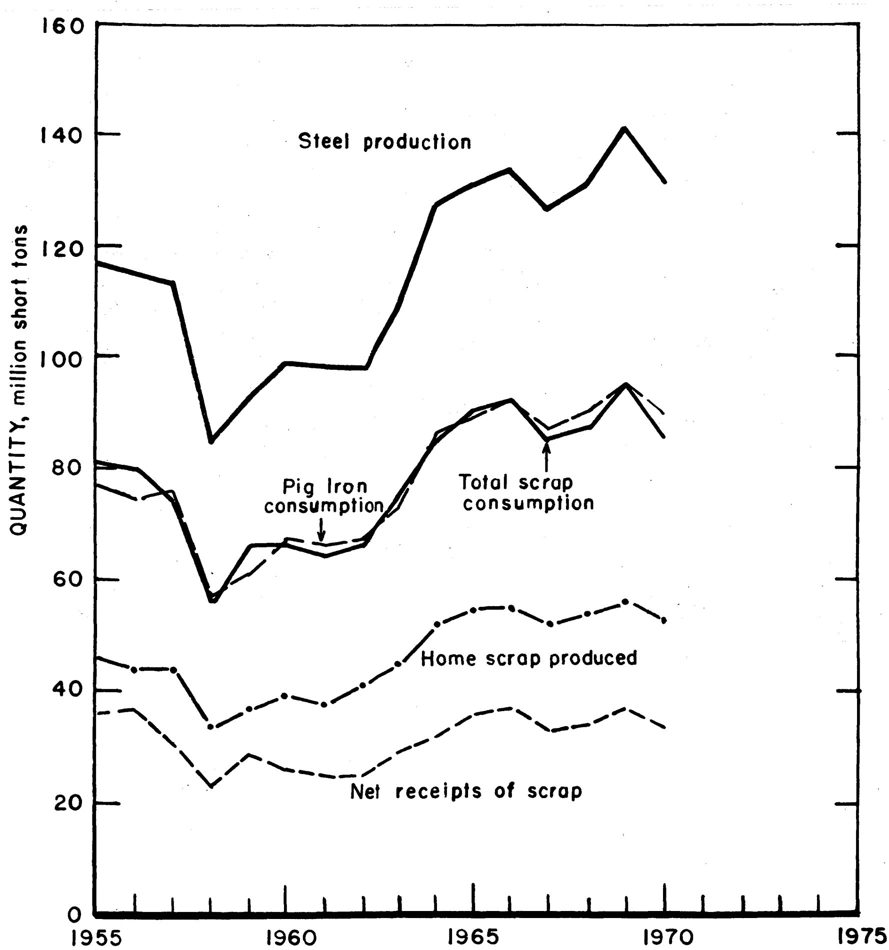

Figure 1.—Steel production (AISI); total iron and steel scrap consumption; pig iron consumption; home scrap production; and net scrap receipts.

been included under "other steel scrap," as in former years, this catchall category would have increased 50 percent.

Because of the significant increase in scrap exports, the Department of Commerce, on November 23, 1970, began to require exporters of iron and steel scrap to submit weekly quantity reports. However, at yearend it had imposed no quotas or embargoes on ferrous scrap, but continued to require licensing of stainless and other nickel-containing scrap exporters.

WORLD REVIEW

Conditions around the world apparently paralleled those in the United States, according to delegates at the Bureau International de la Récupérations conference in Brussels near yearend. Delegates reported strong demand for ferrous scrap, efforts to upgrade scrap quality, and awareness of the need for recycling to improve the environment.

Austria was reported requiring 500,000 tons of scrap, 400,000 tons of which were supplied from domestic sources. In West Germany scrap deliveries declined in the second half of 1970, and processors were finding it difficult to sell lower quality scrap. The British reported high scrap demand and expected to continue importing from the United States until spring.

The Netherlands reported steelworks reducing stocks. Swiss processors, who rely heavily on labor from outside the country, were concerned about Government action relating to foreign workers. Sweden reported that most of its imports were from the Soviet Union and the United States and that it had imported large quantities of fragmentized scrap in order to acquaint the steelworks with this material. A fragmentizer was being erected at Halmstads Jarnverks AB, in Sweden, and a second Scandinavian fragmentizer was being installed in Norway. Belgium reported increases in scrap imports. Czechoslovakian processors were reportedly producing over 2 million tons of ferrous scrap; most of it was for domestic steelworks, but some was for export.

TECHNOLOGY

Spurred by the President, Congress, and the general public, both industry and Government accelerated research directed toward increasing the use of scrap.

Research by Jones & Laughlin Steel Corp.[2] determined that the elements with most significant effects on the mechanical properties of low-carbon sheet steels are tin and sulfur, that the rate of No. 2 bundle consumption (in a plant with basic oxygen and electric furnace shops) is set by the hot metal composition and quantity of No. 1 heavy melting scrap, and that consumption is influenced by the variability of composition of this form of automobile scrap.

National Steel Corp. ended a test program,[3] sponsored by the American Iron and Steel Institute (AISI) and Carbonated Beverage Container Manufacturers Association (CBCMA), that proved scrap cans are suitable for primary steelmaking. AISI and CBCMA proposed that Congress include in the Resource Recovery Act of 1970, $2 million to build a demonstration plant near a large city for studying commercial use of the process for recovering, separating, and shredding incinerator residues developed by the Bureau of Mines.

General Motors Corp. and its Traverse City, Mich. dealers cooperated in an experimental campaign to clean the area of abandoned automobiles.[4] The program involved finding, hauling, and processing junked automobiles. Its objective was to determine costs. According to reports, General Motors concluded that crushed cars can be hauled to processing centers economically from within a radius of about 150 miles. General Motors is making a similar study in California in cooperation with Southern Pacific Railroad. The scrap equipment manufacturing industry was responding by developing smaller equipment

[2] Silver, Jerry. Using More Bundles in Steelmaking. Secondary Raw Materials, v. 8, No. 3, March 1970, pp. 29-35.

[3] Industry Week. Steel, Can Makers Move to Clean Up Old Can Problem. V. 166, No. 24, June 15, 1970, p. 15.

[4] Industry Week. GM Rounds Up Auto Hulks. V. 167, No. 6, Aug. 10, 1970, pp. 67-69.

designed for operation at production limits imposed by economic haul distance of scrap feed. In a cooperative research effort with United States Steel Corp., General Motors reportedly has developed a process whereby quality hot rolled sheet products can be made directly from scrap iron skipping the conventional first remelting process.

Bureau of Mines research directed toward conservation of minerals through recycling which has been underway for many years was continued and expanded. The smokeless junk car incinerator developed at Salt Lake City [5] was operated to determine amounts of nonferrous metals melted during incineration, and to find ways of increasing the capacity and lowering operating costs of the unit. At College Park, Md., research on processing of municipal residues [6] and refuse, started in 1965, continued in several directions. Success with pilot plant processing equipment prompted development of a flow sheet for a prototype processing plant containing shredding, magnetic separation, and other conventional equipment. The objective of prototype plant operation would be not only to develop procedures, but also to determine costs. Additional effort was directed toward developing economical methods for copper removal from ferrous scrap; toward developing methods for identifying, sorting, and separating metals; and toward developing chemical processes for preparing premium grades of scrap from ferrous residues.

At the Bureau's Twin City Metallurgy Research Center, efforts to increase use of ferrous scrap included studies on production of synthetic pig iron from scrap,[7] on use of ferrous scrap in foundry operations, on high-temperature oxidation of ferrous scrap, and on using ferrous scrap in the processing of low-grade nonmagnetic iron ores.[8] With a grant from the Bureau of Mines, the University of Wisconsin was investigating the effect of residual elements on the use of ferrous metals from incinerated refuse.

In 1970, the Department of Health, Education, and Welfare (1) granted funds to Gulf Southwest Research Institute to study the use of old autos to stabilize levees;[9] (2) in cooperation with the Department of Commerce, studied the problems of the dismantler; (3) through a grant to the Maryland State Health Department for a junked auto study was indirectly involved in enactment of legislation relating to junked automobiles; (4) was participating with other groups in the formulation of a nationwide abandoned automobile policy; and (5) in cooperation with the Institute of Scrap Iron and Steel, gave a $150,000 grant to Battelle Memorial Institute for a research project entitled: "A Study to Identify Opportunities for Increased Recycling of Ferrous Waste."[10]

In Canada a chemical process was developed to produce iron powder from scrap iron,[11] and in Belgium scrap dealer Robert George found that cooling scrap to −190° C makes steel brittle, whereas the nonferrous metals and nonmetallic material retain some elasticity at that temperature. Subsequent shredding results in scrap easily separable by magnetic separation to produce high-quality scrap.[12]

Major equipment manufacturers continued to develop more economical and efficient scrap processing equipment, the trend was toward both larger and smaller equipment: larger for most economic operation in areas of large scrap supply and smaller for economic operation in areas of lesser scrap supply.

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[5] Chingren, C. J., K. C. Dean, and J. W. Sterner. Construction and Testing of a Junk Auto Incinerator, BuMines Tech. Prog. Rept. 21, February 1970, 8 pp.

[6] Stanczyk, Martin H., and A. Ruppert. Continuous Physical Beneficiation of Metals and Minerals Contained in Municipal Incinerator Residues. Proc. Second Mineral Waste Utilization Symp., Cosponsored by U.S. BuMines and ITT Research Institute, Chicago, March 1970, pp. 255–260.

[7] Mahan, Warren M. Foundry Iron Production from Automobile Scrap. Proc. Second Mineral Waste Utilization Symp., Cosponsored by U.S. BuMines and ITT Research Institute, Chicago, March 1970, pp. 66–78.

[8] Prasky, Charles. New Developments in Use of Ferrous Scrap. Proc. Second Mineral Waste Utilization Symp., Cosponsored by U.S. BuMines and ITT Research Institute, Chicago, March 1970, pp. 59–66.

[9] Vaughan, Richard D. The Administration Looks at the Abandoned Automobile. Secondary Raw Materials, v. 8, No. 4, April 1970, pp. 135–136, 232.

[10] American Metal Market. Metal Market Bureaus, Ferrous Waste Objectives Defined. V. 77, No. 144, July 29, 1970, p. 14.

[11] Gravenor, C. P., T. Rigg, and J. N. Stone. A Hydrometallurgical Process to Produce Iron Powder from Scrap Iron. Canadian Mining and Metallurgical Bulletin, v. 63, No. 693, January 1970, pp. 59–64.

[12] Industrial Research. Fresh Frozen Scrap Produced by INCH. December 1970, p. V10.

Table 2.—Iron and steel scrap supply [1] available for consumption in 1970, by States

(Thousand short tons)

State	Receipts	Production	Total new supply	Shipments [2]	New supply available for consumption
Alabama	1,580	2,041	3,621	144	3,477
Arizona	W	W	W	W	W
Arkansas	W	W	W	------	W
California	1,629	1,599	3,228	96	3,132
Colorado	W	W	W	W	W
Connecticut	82	56	138	5	133
Delaware	W	W	W	W	W
Florida	W	W	W	W	W
Georgia	W	W	W	W	W
Illinois	4,383	4,532	8,915	481	8,434
Indiana	2,575	8,226	10,801	615	10,186
Iowa	417	163	580	1	579
Kansas	65	45	110	5	105
Kentucky	W	W	W	W	W
Louisiana	W	W	W	W	W
Maine	W	W	W	W	W
Maryland	W	W	W	W	W
Massachusetts	41	52	93	2	91
Michigan	4,126	4,092	8,218	191	8,027
Minnesota	276	216	492	8	484
Mississippi	W	W	W	------	W
Missouri	798	283	1,081	8	1,073
Montana	W	W	W	------	W
Nebraska	W	------	W	W	W
Nevada	W	W	W	------	W
New Hampshire	W	W	W	------	W
New Jersey	517	137	654	17	637
New York	1,077	2,030	3,107	174	2,933
North Carolina	126	47	173	------	173
Ohio	6,842	8,716	15,558	1,374	14,184
Oklahoma	225	52	277	(3)	277
Oregon	136	59	195	14	181
Pennsylvania	7,392	11,522	18,914	1,815	17,099
Rhode Island	W	W	W	W	W
South Carolina	W	W	W	------	W
Tennessee	287	163	450	13	437
Texas	1,683	1,680	3,363	158	3,205
Utah	W	W	W	W	W
Vermont	9	7	16	------	16
Virginia	W	W	W	W	W
Washington	559	152	711	11	700
West Virginia	W	W	W	W	W
Wisconsin	417	413	830	34	796
Undistributed	4,426	6,292	10,718	354	10,364
U.S. total [4]	39,668	52,575	92,243	5,520	86,723

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

Table 3.—Consumption of iron and steel scrap and pig iron [1], by States, by type of manufacturers in 1970

(Thousand short tons)

State	Steel ingots and castings [2]		Steel castings [3]		Iron foundries and miscellaneous users		Total [4]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Alabama	2,401	3,506	160	(5)	906	520	3,467	4,026
Arizona	W	------	W	------	W	------	W	------
Arkansas	------	------	W	------	------	------	W	------
California	2,641	2,228	128	3	254	103	3,023	2,334
Colorado	W	W	W	------	W	------	W	W
Connecticut	69	------	3	(5)	63	21	135	21
Delaware	W	------	W	W	------	------	W	W
Florida	W	------	------	------	W	W	W	W
Georgia	W	------	W	(5)	W	11	W	11
Illinois	6,831	7,067	449	4	1,060	292	8,340	7,363
Indiana	8,839	13,222	153	2	651	176	9,643	13,400
Iowa	------	------	42	------	530	28	572	28
Kansas	------	------	87	(5)	17	3	104	3
Kentucky	1,127	W	------	------	218	W	1,345	W
Louisiana	------	------	------	------	------	------	W	(5)
Maine	------	------	------	------	W	W	W	(5)
Maryland	2,808	W	29	------	79	W	2,916	W
Massachusetts	------	------	10	(5)	82	21	92	21
Michigan	5,019	7,045	100	1	2,938	424	8,057	7,470
Minnesota	327	442	56	1	81	35	464	478
Mississippi	W	------	------	------	------	------	W	------
Missouri	870	2	113	1	79	18	1,062	21
Montana	------	------	------	------	W	(5)	W	(r)
Nebraska	------	------	W	W	W	------	W	W
Nevada	------	------	W	W	------	------	W	W
New Hampshire	------	------	W	------	W	W	W	W
New Jersey	216	------	38	(5)	374	52	628	52
New York	2,172	4,912	143	11	587	75	2,902	4,998
North Carolina	W	------	------	------	W	W	W	W
Ohio	11,787	14,438	426	28	1,843	605	14,056	15,071
Oklahoma	W	------	W	------	W	W	W	W
Oregon	127	------	55	(5)	6	1	188	1
Pennsylvania	16,051	21,221	385	33	724	112	17,160	21,366
Rhode Island	74	------	------	------	58	10	132	10
South Carolina	------	------	------	------	47	W	47	W
Tennessee	------	------	18	2	410	130	428	132
Texas	2,539	22	53	1	592	72	3,184	95
Utah	W	W	W	W	W	W	W	W
Vermont	------	------	------	------	17	5	17	5
Virginia	------	------	184	W	435	W	619	W
Washington	634	W	17	W	18	(5)	669	W
West Virginia	1,638	W	33	W	48	W	1,719	W
Wisconsin	------	------	245	7	558	148	803	155
Undistributed	3,153	12,844	183	5	451	216	3,787	13,065
U.S. total [4]	69,323	86,949	3,110	99	13,126	3,078	85,559	90,126

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] Data may not add to totals shown because of independent rounding.
[5] Less than ½ unit.

Table 4.—Consumption of iron and steel scrap and pig iron[1] in the United States in 1970, by States, by 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	223	444	998	1,438	2,415	479	1	843	346	26	-	13	-
Arizona	-	-	-	-	-	W	-	-	-	-	-	W	-
Arkansas	-	-	-	-	-	W	-	-	-	-	-	-	-
California	45	374	1,218	1,269	1,009	1,078	43	249	64	-	-	8	-
Colorado	W	W	W	W	W	W	W	W	W	-	-	-	-
Connecticut	-	-	-	-	-	94	6	39	16	2	(3)	-	-
Delaware	-	-	-	-	-	W	(3)	-	-	-	-	-	-
Florida	-	-	-	-	-	W	W	-	-	-	-	-	-
Georgia	-	-	-	-	-	W	(3)	W	W	-	-	W	-
Illinois	265	2,229	5,445	790	915	4,071	24	863	69	7	7	115	8
Indiana	1,190	4,545	8,190	2,584	4,992	668	10	644	152	11	15	2	-
Iowa	-	-	-	-	-	236	(3)	337	28	-	-	-	-
Kansas	-	-	-	-	-	87	(3)	16	2	-	-	-	-
Kentucky	19	543	W	-	-	591	-	155	W	-	-	36	-
Louisiana	-	-	-	-	-	W	(3)	W	-	-	-	-	-
Maine	-	-	-	-	-	-	W	W	-	-	-	-	-
Maryland	114	799	W	1,792	W	106	W	105	W	-	-	-	-
Massachusetts	-	-	-	-	-	18	(3)	70	19	4	2	-	-
Michigan	296	2,678	6,439	535	546	1,071	22	3,461	343	14	7	2	-
Minnesota	2	-	-	325	442	46	2	91	34	-	-	-	-
Mississippi	-	-	-	-	-	W	-	-	-	-	-	-	-
Missouri	-	-	-	47	1	946	2	69	18	-	-	-	-
Montana	-	-	-	-	-	-	-	W	(3)	-	-	W	-
Nebraska	-	-	-	-	-	W	(3)	W	-	-	-	-	-
Nevada	-	-	-	-	-	W	(3)	-	-	-	-	-	-
New Hampshire	-	-	-	-	-	W	(3)	-	-	(3)	W	-	-
New Jersey	-	-	-	-	-	319	2	293	48	1	1	15	2
New York	269	1,154	3,934	666	774	228	6	531	74	(3)	-	53	-
North Carolina	-	-	-	-	-	W	(3)	W	W	-	-	-	-
Ohio	1,182	3,039	8,204	3,916	5,881	3,725	107	2,115	165	55	26	23	-
Oklahoma	-	-	-	-	-	W	W	W	W	-	-	-	-
Oregon	-	-	-	-	-	185	(3)	4	1	-	-	-	-
Pennsylvania	1,264	3,580	7,248	6,553	9,469	4,614	194	909	113	68	12	172	-
Rhode Island	-	-	-	-	-	74	-	58	10	-	-	-	-
South Carolina	-	-	-	-	-	1	-	46	W	-	-	-	-
Tennessee	-	-	-	-	-	32	12	396	120	-	-	-	-
Texas	174	-	-	1,248	15	1,300	5	462	74	-	-	1	-
Utah	W	-	-	W	W	W	W	W	W	-	-	W	-
Vermont	-	-	-	-	-	-	-	17	6	-	-	-	-
Virginia	-	-	-	-	-	181	(3)	436	W	-	-	2	-
Washington	-	-	-	-	-	666	W	3	(3)	-	-	-	-
West Virginia	130	1,298	W	15	-	209	W	40	W	9	W	W	-
Wisconsin	-	-	-	38	6	286	6	449	125	30	18	-	-
Undistributed	129	441	7,460	1,097	5,064	1,703	11	287	249	-	6	149	-
U.S. total[4]	5,302	21,124	49,136	22,313	31,529	23,014	453	12,988	2,076	227	94	591	10

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

Table 5.—Consumption of iron and steel scrap and pig iron [1] in the United States in 1970, 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 [4]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace [5]	5,302	------	------	------	------	------	5,302	------
Basic oxygen converter [6]	21,124	49,136	------	------	------	------	21,124	49,136
Open-hearth furnace	21,935	31,494	378	35	------	------	22,313	31,529
Electric furnace	18,834	288	2,381	37	1,799	128	23,014	453
Cupola furnace	1,695	115	307	18	10,986	1,943	12,988	2,076
Air furnace	41	6	44	8	142	80	227	94
Other furnaces [7]	392	8	------	------	199	2	591	10
U.S. total [4]	69,323	81,047	3,110	98	13,126	2,153	85,559	83,298

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes only those castings made by companies producing steel ingots.
[3] Excludes companies that produce both steel ingots and steel castings.
[4] Data may not add to totals shown because of independent rounding.
[5] Includes consumption in all blast furnaces producing pig iron.
[6] Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[7] Includes vacuum melting furnaces and miscellaneous melting processes.

Table 6.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1970	
	Scrap	Pig iron
Basic oxygen converter	30.1	69.9
Open-hearth furnace	41.4	58.6
Electric furnace	98.1	1.9
Cupola furnace	86.2	13.8
Air furnace	70.7	29.3

Table 7.—Receipts, production, consumption, shipments and stocks of iron and steel scrap and pig iron, by type of manufacturer, in 1970

(Thousand short tons)

	Manufacturers of steel ingots and castings [1]	Manufacturers of steel castings [2]	Iron foundries and miscellaneous users	Total
Scrap:				
Receipts	29,129	2,155	8,384	39,668
Production	46,394	1,032	5,149	52,575
Consumption	69,323	3,110	13,126	85,559
Shipments	5,127	52	341	5,520
Stocks Dec. 31	6,515	292	861	7,668
Pig iron:				
Receipts	4,893	98	3,223	8,214
Production	89,667	------	------	89,667
Consumption	86,949	99	3,078	90,126
Shipments	7,428	1	4	7,433
Stocks Dec. 31	1,623	13	446	2,082

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and castings.

Table 8.—Consumer stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1970, by grades

(Thousand short tons)

Grades of scrap	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
Carbon steel:					
Low phosphorous plate and punchings	1,611	250	1,861	14	126
Cut structural and plate	1,477	77	1,530	8	106
No. 1 heavy melting steel	8,175	20,961	26,544	2,129	2,617
No. 2 heavy melting steel	2,262	1,038	3,228	90	388
No. 1 and electric furnace bundles	5,379	775	5,943	67	621
No. 2 and all other bundles	3,607	373	3,918	148	388
Turnings and borings	2,355	591	2,779	226	242
Slag scrap (Fe content)	1,307	2,042	3,292	57	113
Shredded or fragmentized	879	------	841	1	56
All other carbon steel scrap	5,228	13,715	17,449	1,046	965
Stainless steel	481	500	950	49	104
Alloy steel (except stainless)	609	2,447	2,841	250	366
Cast iron (includes borings)	5,607	9,228	13,194	1,354	1,514
Other grades of scrap	691	578	1,189	81	62
U.S. total [1]	39,668	52,575	85,559	5,520	7,668

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

Table 9.—Consumer stocks of iron and steel scrap, by grades, and pig iron, Dec. 31, 1970, by States

(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 [1]	Pig iron stocks
Alabama	151	-----	(2)	73	(2)	224	168
Arizona	W	-----	(2)	W	W	W	-----
Arkansas	(2)	-----	-----	-----	-----	(2)	-----
California	181	1	2	102	3	289	207
Colorado	W	-----	W	W	-----	W	W
Connecticut	2	3	1	6	W	13	2
Delaware	W	-----	W	(2)	-----	W	-----
Florida	W	-----	-----	(2)	-----	W	(2)
Georgia	W	-----	-----	W	-----	W	1
Illinois	650	3	15	70	1	739	71
Indiana	858	6	5	246	4	1,119	80
Iowa	48	(2)	(2)	7	1	56	3
Kansas	5	-----	-----	(2)	-----	5	(2)
Kentucky	92	(2)	20	11	11	134	W
Louisiana	W	-----	-----	-----	-----	W	-----
Maine	(2)	-----	-----	(2)	-----	(2)	(2)
Maryland	205	13	17	90	-----	325	W
Massachusetts	3	-----	(2)	2	-----	5	5
Michigan	202	11	1	116	2	332	140
Minnesota	87	-----	(2)	12	1	100	6
Mississippi	W	-----	-----	-----	-----	W	-----
Missouri	157	(2)	1	30	4	192	7
Montana	-----	-----	-----	W	W	W	(2)
Nebraska	(2)	-----	-----	W	-----	W	(2)
Nevada	(2)	-----	-----	(2)	-----	(2)	(2)
New Hampshire	(2)	-----	-----	-----	-----	(2)	(2)
New Jersey	30	(2)	4	19	(2)	53	9
New York	216	9	8	146	(2)	379	260
North Carolina	W	-----	-----	W	-----	W	2
Ohio	851	10	64	165	2	1,092	534
Oklahoma	W	-----	-----	W	(2)	W	3
Oregon	8	4	1	(2)	-----	13	(2)
Pennsylvania	1,104	44	181	270	25	1,625	315
Rhode Island	W	-----	W	W	(2)	W	1
South Carolina	1	-----	-----	(2)	-----	1	W
Tennessee	8	-----	(2)	11	2	21	12
Texas	236	(2)	24	47	(2)	307	58
Utah	W	-----	W	W	-----	W	W
Vermont	1	-----	-----	-----	1	2	1
Virginia	19	-----	(2)	10	-----	29	W
Washington	87	-----	4	12	(2)	103	1
West Virginia	96	-----	4	4	-----	104	4
Wisconsin	20	(2)	(2)	7	1	28	29
Undistributed	304	-----	14	58	4	378	163
U.S. total [1]	5,622	104	366	1,514	62	7,668	2,082

W Withheld to avoid disclosing individual company confidential data, included in "Undistributed."
[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

Table 10.—Stocks of iron and steel scrap and pig iron at major consuming industries' plants Dec. 31

(Thousand short tons)

Year	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
Scrap stocks:				
1969	5,413	270	869	6,552
1970	6,515	292	861	7,668
Pig iron stocks:				
1969	1,467	16	240	1,723
1970	1,623	13	446	2,082

Table 11.—Average monthly price and composite price for No. 1 heavy melting scrap in 1970

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$41.00	$40.25	$40.25	$40.50
February	49.00	47.50	42.00	46.17
March	44.90	43.90	42.70	4 .83
April	40.00	41.75	41.50	41.08
May	43.75	42.50	43.00	43.08
June	43.70	42.30	43.30	43.10
July	40.50	39.50	41.00	40.33
August	41.30	39.90	39.60	40.27
September	45.63	42.75	39.50	42.63
October	41.00	42.00	37.25	40.08
November	34.70	37.30	34.50	35.50
December	36.83	37.50	34.17	36.17
Average:				
1970	41.86	41.43	39.90	41.06
1969 [r]	30.12	31.26	31.22	30.87

[1] Composite price, Chicago, Pittsburgh, Philadelphia.

Source: Iron Age, Jan. 1, 1971.

Table 12.—U.S. exports of iron and steel scrap [1], by countries

(Thousand short tons and thousand dollars)

Country	1966		1967		1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	1	$107	2	$198	21	$769	33	$1,844	21	$3,563
Canada	732	21,236	530	14,684	516	12,009	616	15,286	707	21,525
France	9	381	14	487	15	1,633	47	2,868	57	2,785
Germany, West	5	238	1	211	58	2,952	93	5,345	45	2,069
Italy	322	8,888	204	5,347	729	20,364	879	25,781	491	22,657
Japan	3,079	88,721	5,300	173,259	3,383	92,098	4,204	126,254	5,208	208,601
Korea, Republic of	279	7,060	307	10,773	304	10,004	553	20,347	667	30,971
Mexico	777	25,095	747	25,748	525	18,074	580	20,210	821	35,368
Spain	82	1,999	85	1,609	306	6,939	1,034	29,052	1,158	45,790
Sweden	46	2,368	28	4,200	105	16,068	204	19,766	160	24,709
Taiwan	129	5,217	85	2,973	157	4,604	95	3,658	151	7,097
Thailand	(2)	11	12	380	47	1,323	61	1,950	45	1,950
Turkey	35	979	29	770	77	1,940	79	2,013	72	3,530
United Arab Republic	42	1,141	64	1,938	30	668	27	689	(2)	463
United Kingdom	1	60	1	130	3	268	310	10,514	251	10,909
Venezuela	26	833	18	516	30	783	58	1,683	179	5,587
Yugoslavia	101	2,909	------	------	65	1,876	11	450	22	1,006
Other	84	4,664	46	1,774	73	2,528	39	1,827	58	3,325
Total	5,750	171,907	7,473	244,997	6,444	194,900	8,923	289,537	10,113	431,905

[1] Does not include rerolling material and ships, boats and other vessels for breaking up for scrap.
[2] Less than ½ unit.

Table 13.—U.S. exports of rerolling material (scrap), by countries

(Thousand short tons and thousand dollars)

Country	1966		1967		1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3	$95	1	$55	(1)	$28	(1)	$8	5	$208
Japan	22	842	18	817	10	343	15	588	13	584
Korea, Republic	14	577	92	3,846	101	4,728	174	8,318	187	11,737
Mexico	3	156	9	425	9	447	22	1,103	33	2,036
Taiwan	61	3,236	16	686	7	298	3	156	(1)	10
Thailand	------	------	------	------	------	------	12	707	6	398
Venezuela	------	------	26	105	------	------	2	65	2	99
Other	4	137	------	------	------	------	26	2,225	5	392
Total	107	5,043	162	5,934	127	5,844	254	13,170	251	15,464

[1] Less than ½ unit.

Table 14.—U.S. exports of ships, boats, and other vessels for breaking up for scrap

(Thousand short tons and thousand dollars)

Country	1966		1967		1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Bahamas	---	---	---	---	8	$137	5	$78	---	------
Canada	7	$102	12	$116	7	97	3	20	18	$338
Denmark	---	---	7	130	---	-----	---	-----	---	------
Germany, West	10	296	---	---	---	-----	---	-----	15	197
Hong Kong	---	---	---	---	8	275	12	210	---	------
Italy	---	---	13	54	---	-----	---	-----	48	913
Japan	---	---	---	---	3	125	---	-----	6	100
Mexico	3	70	---	---	---	-----	3	51	---	------
Netherlands	---	---	---	---	---	-----	---	-----	15	275
Spain	3	42	---	---	51	725	70	1,098	357	7,637
Taiwan	---	---	---	---	38	734	20	849	58	1,607
Other	(1)	1	2	6	5	12	1	13	14	407
Total	23	511	34	306	120	2,105	114	2,319	531	11,474

1 Less than ½ unit.

Table 15.—U.S. exports and imports for consumption of iron and steel scrap, by classes [1]

(Thousand short tons and thousand dollars)

Class	1966		1967		1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	2,207	$69,591	2,762	$89,365	2,482	$72,286	3,452	$114,646	3,657	$158,597
No. 2 heavy melting scrap	965	26,261	1,151	33,064	783	20,384	1,009	29,760	1,139	45,449
No. 1 baled steel scrap	215	6,940	392	12,536	269	7,151	593	19,679	377	16,290
No. 2 baled steel scrap	1,226	26,389	1,511	33,272	969	18,999	1,038	22,038	1,381	41,902
Stainless steel scrap	40	10,209	124	33,334	113	26,305	76	22,868	87	30,926
Shredded steel scrap [2]	------	------	------	------	------	------	------	------	1,165	49,344
Borings, shovelings, and turnings	377	7,989	462	9,009	439	8,359	767	13,135	623	15,401
Other steel scrap [3]	r 460	r 16,812	r 624	r 21,640	r 973	r 30,548	r 1,361	r 46,930	878	44,306
Iron scrap	260	7,716	447	12,777	416	10,868	627	20,481	806	29,690
Total	5,750	171,907	7,473	244,997	6,444	194,900	8,923	289 537	10,113	431,905
Rerolling material	107	5,043	162	5,934	127	5,844	254	13,170	251	15,464
Grand total	r 5,857	r 176,950	r 7,635	r 250,931	r 6,571	r 200,744	r 9,177	r 302,707	10,364	447,369
Imports:										
Iron and steel scrap	390	7,672	216	8,181	276	10,784	311	r 12,571	279	10,609
Tinplate scrap	16	535	14	381	18	541	24	917	22	591
Total	406	8,207	r 230	8,562	294	11,325	335	r 13,488	301	11,200

r Revised.
[1] Iron and steel scrap (exports) excludes ships, boats, and other vessels for scrap.
[2] Separately classified Jan. 1, 1970, formerly part of other steel scrap.
[3] Includes terneplate and tinplate.

Table 16.—U.S. imports for consumption of iron and steel scrap, by countries

Country	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Austria	115	$63	-------	-------
Canada	324,562	r 11,474	294,122	$10,906
Dominican Republic	501	10	4	1
French West Indies	786	25	-------	-------
Germany, West	4,644	991	1	1
India	50	38	-------	-------
Japan	1,047	r 289	968	25
Korea, Republic of	56	14	-------	-------
Mexico	440	155	4,332	101
Sweden	2,107	152	1,358	114
United Kingdom	676	r 252	414	49
Other	215	25	94	3
Total	335,199	r 13,488	301,293	11,200

r Revised.

Iron Oxide Pigments

By Henry E. Stipp [1]

Sales of crude and finished iron oxide pigments decreased in 1970; however, prospects for a substantial increase in sales by 1975 reportedly were good. Projections of paint sales in the United States indicated an increase of approximately 33 percent in value from an estimated $2.53 billion in 1970 to an estimated $3.36 billion in 1975. Demand for hard ferrites, an important consumption category for iron oxide pigments, was said to be significantly larger in 1970 than in 1969. Hard ferrites are replacing copper-wire-wound fields in many small motors used in autombiles and home appliances.

Legislation and Government Programs— The Bureau of Customs started withholding appraisement of ferrite cores imported from Japan pending a decision as to whether the ferrites were being sold at less than fair value. If the ferrites are found to be sold at less than fair value the case will be referred to the Tariff Commission for a determination of injury. Dumping duties could then be assessed effective after the withholding date.

DOMESTIC PRODUCTION

Crude iron oxide pigments production decreased for the second consecutive year to 38,600 tons, down 5 percent from the 40,600 tons of 1969 and a drop of 33 percent from the 57,600 tons output of 1968. Seven companies operating eight plants in six states reported production of crude iron oxide pigments. Cleveland-Cliffs Iron Co. produced the largest quantity of crude iron oxide pigments from mines in Michigan. Production of manufactured finished iron oxide pigments (as indicated by sales) decreased only 2 percent to 69,138 tons, compared with 70,507 tons in 1969. Total sales of finished iron oxide pigments decreased 13 percent to 123,988 tons in 1970, compared with 142,893 tons in 1969. Twelve companies operating 17 plants in nine states produced finished iron oxide pigments. Charles Pfizer & Co., Inc., with plants in Pennsylvania, Illinois, and California was the major producer.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient iron oxide pigments statistics in the United States

	1966	1967	1968	1969	1970
Mine production short tons	63,200	39,900	57,600	40,600	38,600
Crude pigments sold or used do	63,900	41,800	57,600	40,800	39,200
Value thousands	$476	$326	$457	$362	$442
Finished pigments sold short tons	130,700	127,300	132,400	142,900	124,000
Value thousands	$24,841	$26,720	$30,676	$32,289	$28,200
Exports short tons	4,800	3,100	3,300	4,000	4,565
Value thousands	$1,307	$1,312	$1,257	$1,439	$1,621
Imports for consumption short tons	24,600	23,400	29,900	33,400	32,684
Value thousands	$3,163	$3,203	$4,117	$5,044	$5,759

CONSUMPTION AND USES

The decrease in consumption of both crude and finished iron oxide pigments could have been the result of sluggish economic activity, particularly in the automobile and building materials fields. Inventory adjustments also could have contributed to the drop in demand for finished pigments.

In addition to its use as pigments in paint, enamel, linoleum, wood fillers, plastics, rubber, paper, and wood stains, iron oxide pigments were used in ferrite applications. Generally, ferrites are compounds of iron oxide and strontium, barium, lead, nickel, magnesium, manganese, or copper that are used for their magnetic properties in computers, inductor and microwave devices, color television sets, small motors, closure devices, cordless appliances, and a number of other applications.

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 pigments.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kinds

Pigment	1969		1970	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
Natural:				
Brown:				
Iron oxide (metallic) [2]	15,240	$2,419	11,600	$2,049
Umbers:				
Burnt	4,341	970	4,258	1,014
Raw	1,192	270	1,087	262
Red:				
Iron oxide	36,301	2,245	23,177	1,647
Sienna, burnt	1,035	377	963	352
Pyrite cinder	(3)	(3)	(3)	(3)
Yellow:				
Ocher [4]	5,527	379	4,718	312
Sienna, raw	600	188	619	201
Total natural	64,236	6,848	46,422	5,837
Manufactured:				
Black: Magnetic	3,527	1,196	6,480	1,387
Brown: Iron oxide	7,163	4,110	4,661	1,732
Red:				
Pure red iron oxides:				
Calcined copperas	18,558	5,609	14,199	4,602
Other chemical processes [5]	14,322	3,909	18,131	3,952
Venetian red	603	110	592	124
Yellow: Iron oxide	26,334	7,903	25,075	8,004
Total manufactured	70,507	22,838	69,138	19,801
Unspecified including mixtures of natural and manufactured red iron oxides	8,150	2,603	8,428	2,559
Grand total	142,893	32,289	123,988	28,197

[1] Data may not add to totals shown because of independent rounding.
[2] Includes black magnetite and vandyke brown.
[3] Pyrite cinder included with red iron oxide for 1969 and 1970.
[4] Includes yellow iron oxide.
[5] Includes other manufactured red iron oxide.

PRICES

Price increases on most grades of iron oxide pigments became effective on April 17. Further adjustments of these prices took place on May 22, and prices were firm throughout the remaining part of the year. Demand for iron oxide pigments apparently was strong until the latter half of 1970.

Table 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise noted, as of December 31, 1970

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Pure	$0.1575	$0.1775	Domestic primers	$0.0725	------
Synthetic	.1600	.1770	Persian Gulf [1]	.0825	$0.0900
Brown:			Pure synthetic	.1675	.1725
Pure, synthetic	.1875	.1925	Sienna, American, burnt	.1325	.2600
Metallic	.0775	.0950	Yellow:		
Umber, American, burnt	.1125	.1350	Ocher, domestic	.0550	------
Umber, American, raw	.1150	.1350	Ocher, French type	.1050	------
Vandyke, American [1]	.1450	------	Pure, light lemon	.1600	------
Sienna, American, burnt	.1325	.2600	Other shades	.1500	------

[1] Barrels.

Source: Oil, Paint and Drug Reporter and American Paint Journal.

FOREIGN TRADE

United States exports of iron oxide pigments in 1970 increased 14 percent to 4,565 short tons, compared with 3,992 short tons in 1969. The value of exports increased 13 percent to approximately $1.6 million from about $1.4 million in 1969. Canada received almost half of iron oxide pigment exports, followed by Australia, the United Kingdom, and France, which received over 300 tons each.

Imports of iron oxide pigments into the United States in 1970 totaled 32,648 short tons, a decrease of 2 percent from the 33,431 short tons imported in 1969. The value of iron oxide imports totaled about $5.8 million in 1970, compared with $5.0 million in 1969. Approximately 74 percent of total imports consisted of synthetic iron oxide pigments. Imports of natural iron oxide pigments, which constituted about 26 percent of total iron oxide imports, consisted mainly of crude and refined umber.

Table 4.—U.S. exports of iron-oxide and hydroxides, by countries, 1970

Destination	Pigment grade		Other grade	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	41	$17	1	$1
Australia	368	198	191	106
Belgium-Luxembourg	10	4	145	87
Brazil	100	60	202	100
Canada	2,160	478	1,643	696
Chile	14	6	-----	-----
Colombia	44	16	70	22
France	306	156	135	101
Germany, West	124	55	333	211
Guatemala	30	9	3	1
Hong Kong	17	7	-----	-----
India	-----	-----	333	160
Iran	3	2	-----	-----
Italy	41	49	434	482
Japan	115	40	1,412	1,004
Mexico	132	72	115	141
Netherlands	48	9	347	259
New Zealand	10	7	-----	-----
Panama	7	4	46	6
Philippines	95	38	2	2
Sweden	10	3	6	2
United Kingdom	354	168	367	289
Venezuela	144	48	38	17
Vietnam, South	212	111	62	66
Other	180	64	313	149
Total	4,565	1,621	6,198	3,902

Table 5.—U.S. imports for consumption of selected iron-oxide pigments

Kinds	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Natural:				
Ocher, crude and refined	87	$6	62	$4
Siennas, crude and refined	1,341	146	1,051	115
Umber, crude and refined	6,240	235	4,883	171
Vandyke brown	472	42	435	50
Other[1]	2,736	225	2,115	155
Total	10,876	654	8,546	495
Manufactured (synthetic)	22,555	4,390	24,138	5,264
Grand total	33,431	5,044	32,684	5,759

[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 and pigments, n.s.p.f., by countries

Country	Natural 1969 Short tons	Natural 1969 Value (thousands)	Natural 1970 Short tons	Natural 1970 Value (thousands)	Synthetic 1969 Short tons	Synthetic 1969 Value (thousands)	Synthetic 1970 Short tons	Synthetic 1970 Value (thousands)
Belgium-Luxembourg	-----	-----	-----	-----	-----	-----	15	$2
Canada	1	$1	10	$10	7,169	$1,513	7,742	1,383
Finland	-----	-----	-----	-----	240	87	-----	-----
France	-----	-----	(1)	1	21	4	20	4
Germany:								
East	-----	-----	-----	-----	-----	-----	18	3
West	2	5	13	10	13,824	2,553	14,797	3,119
Jamaica	-----	-----	(1)	1	-----	-----	-----	-----
Japan	11	30	1	2	14	56	183	535
Netherlands	-----	-----	-----	-----	10	1	28	17
Portugal	-----	-----	22	1	-----	-----	-----	-----
Spain	2,517	160	1,848	109	85	6	5	1
Switzerland	-----	-----	-----	-----	(1)	1	1	(1)
United Kingdom	205	29	221	21	1,192	169	1,329	200
Total	2,736	225	2,115	155	22,555	4,390	24,138	5,264

[1] Less than ½ unit.

TECHNOLOGY

The properties of micaceous iron oxide used as a pigment in protective paints for iron and steel, was described.[2] Although micaceous iron oxide pigment has been used extensively in the United Kingdom and European countries, its use in the United States reportedly has been negligible.

Research on iron oxide ferrites was concentrated mainly on improving physical and magnetic properties by controlling composition,[3] amd size and distribution of grains.[4] The chemical compound $PbO \cdot 5Fe_2O_3$, had the best permanent magnetic properties of any lead ferrite tested.[5] Small quantities of silica and boron oxide added to the lead ferrite composition formed low melting phases and gave a denser magnetic material.

A method of studying the reaction of zinc oxide and iron oxide by measuring the release of radioactive inert gas was reported.[6]

A computer was used to monitor various steps in manufacturing iron oxide ferrites.[7] This method of supervision gave better yield, inventory control, and utilization of equipment than conventional methods.

[2] American Paint Journal. Micaceous Iron Oxide. V. 54, June 22, 1970, pp. 68–81.

[3] Brockman, F. G., and K. E. Matteson. Nickel-Zinc Ferrites: I, Effect of Composition on the Magnetic Properties of a Nickel-Zinc-(Cobalt) Ferrite. J. Am. Ceram. Soc., v. 53, No. 9, September 1970, pp. 517–520.

[4] Johnson, D. W., and F. J. Schnettler. Characterization of Freeze-Dried Al_2O_3 and Fe_2O_3. J. Am. Ceram. Soc., v. 53, No. 8, August 1970, pp. 440–444.

[5] Tokar, Michael. Micro-Structure and Magnetic Properties of Lead Ferrite. J. Am. Ceram. Soc., v. 52, No. 6, June 1969, pp. 302–306.

[6] Balek, Vladimir. Emanation and Surface Gas Labeling Methods of Studying the Solid-State Reaction of ZnO and Fe_2O_3. J. Am. Ceram. Soc., v. 53, No. 10, October 1970, pp. 540–543.

[7] Getto, Allan, and John H. Labick. Computerized Ferrite Process. Ceram. Age, v. 86, No. 10, October 1970, pp. 39–41.

Kyanite and Related Minerals

By J. Robert Wells [1]

Kyanite, sillimanite, andalusite, dumortierite, and topaz are conveniently considered as a group, because they are natural silicate minerals with many similarities in composition and properties. In common with synthetic mullite, they all can be used as materials for the manufacture of mullite-type refractories.

The United States and India are the world's principal suppliers of kyanite. Large-scale production of sillimanite is mostly confined to India and the Republic of South Africa, the latter being also the most important source of andalusite. Minor quantities of kyanite-group minerals are produced from time to time in some half dozen other countries, but no industrial utilization of dumortierite or of non-gem topaz has been reported in recent years.

In the United States, the quantity of kyanite sold or used by domestic producers increased notably in 1970, exceeding by approximately 11 percent (with regard to both total tonnage and total value) the previous alltime high attained in 1969. This new record was all the more impressive in view of the closing in South Carolina of the Henry Knob mine of Combustion Engineering, Inc., hitherto the source of a consistently substantial share of the national total. The South Carolina deficit was more than counterbalanced by briskly stepped-up production at the same company's operation in Georgia—an increase that coincided with significant gains achieved elsewhere by each of the other two producing firms.

Legislation and Government Programs.—The Office of Emergency Preparedness announced on March 4, 1970, that kyanite-mullite had been removed from the list of strategic materials for stockpiling. Approximately 4,800 short tons of kyanite-mullite remained in the Government's stockpile inventory at that date, and no disposal of this material had been made as of December 31, 1970.

The Government's Office of Minerals Exploration offered to provide loans of up to 50 percent of the approved costs of exploration of eligible kyanite deposits, but no loans for that purpose were made in 1970.

DOMESTIC PRODUCTION

Kyanite was mined in 1970 in two States and was recovered as a coproduct mineral in a third. Kyanite Mining Corp., the largest domestic producer, operated two mines in Virginia, one at Dillwyn in Buckingham County and the other at Farmville in adjacent Prince Edward County. In Georgia, Aluminum Silicates, Inc., a subsidiary of Combustion Engineering, Inc., produced kyanite from the Graves Mountain mine in Lincoln County. Kyanite was also recovered as an accessory product at the Trail Ridge, Florida plant of E. I. du Pont de Nemours & Co., Inc., during the extraction of heavy minerals from complex sands of an extensive deposit in Clay County. In California, small quantities of quartz-kyanite rock are quarried occasionally and marketed as building stone, without separation of the component minerals.

Domestic output of kyanite in 1970, riding the 16th annual increase in the last 20 years to the largest total ever recorded, was more than 10 percent greater than in 1969. Actual kyanite production figures must be withheld to avoid disclosure of individual company confidential data.

Synthetic mullite, totaling 14 percent more in tonnage than in 1969 and 29 per-

[1] Physical scientist, Division of Nonmetallic Minerals.

cent higher in total value, was produced in 1970 by eight firms: The Babcock & Wilcox Co., Refractories Division, New York, N.Y. (plant at Augusta, Ga.); The Carborundum Co., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.); C–E Minerals, a division of Combustion Engineering, Inc., King of Prussia, Pa. (plant at Andersonville, Ga.); Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Eufaula, Ala.); Norton Co., Worcester, Mass. (plant at Hunstville, Ala.); H. K. Porter Co., Inc., Refractories Division, Pittsburgh, Pa. (plant at Shelton, Conn); Remmy Division of A. P. Green Refractories Co., Philadelphia, Pa. (plant at Philadelphia, Pa.); and The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio (plant at South Shore, Ky.).

The extra-quality grades of synthetic mullite were manufactured by high-temperature treatment of mixtures of Bayer-process alumina with pure silica sand, while siliceous bauxite and bauxite-clay mixtures served for products intended to meet less exacting specifications. Rotary, periodic, and tunnel kilns were used in the making of sintered material, but the production of fused mullite was carried out in electric-arc furnaces because of the higher temperatures that are needed.

Plans were announced in 1970 by C–E Minerals, a division of Combustion Engineering, Inc., for a substantial increase in production capacity at its recently constructed Andersonville, Ga. plant. Three additional calcining furnaces will be installed for processing aluminum silicate raw materials for the manufacture of ceramics and mullite-type refractories.

Table 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1966	49,551	$5,961
1967	40,288	4,811
1968	36,014	5,758
1969	48,588	6,847
1970	55,516	8,840

CONSUMPTION AND USES

Kyanite, either domestically produced or imported, and mostly ground to 35 mesh or finer, was consumed chiefly in the preparation of refractory mortars, ramming mixes, and plastic refractories. For the most part, synthetic mullite was used in the fabrication of high-alumina refractory brick and shapes for structures exposed to extreme and long-continued heat. These refractories were used in furnaces for ferrous and nonferrous smelting, in the electric-arc preparation of special alloys, and the manufacturing of glass.

In addition to the refractories applications, kyanite was incorporated in certain ceramic mixtures, in which it confers a number of important advantages. Its presence in a ceramic body often improves the workability, and the interwoven texture of the mullite crystals that are formed on firing, also provides superior mechanical strength in the finished products. The increase in volume brought about upon firing by the conversion of kyanite to mullite is often advantageous, furthermore, in that it can compensate for the reduction caused by the shrinkage of the clays that usually are the principal components of the ceramic mixture.

PRICES

Ceramic Industry Magazine, January 1971, showed the current price range for kyanite to be from $53 to $91 per ton. The December 1970 issue of Engineering and Mining Journal quoted the following prices per short ton for kyanite, f.o.b. shipping point, South Carolina or Georgia, in bags (bulk shipments $4 less per ton):

35 mesh	$57
48 mesh	$59
100 mesh	$60
200 mesh	$65
325 mesh	Nominal

Published prices for imported kyanite have been largely conjectural for a number of years and have not appeared in the Journal since November 1969.

FOREIGN TRADE

Kyanite imports and exports, which started into the 1950's with imports far in the lead and then crossed paths after coming briefly to a balance about 10 years ago, continued to diverge (after the minor reversal recorded in 1969). Imports declined to their lowest level in the 34 years of published data, while exports climbed to an alltime high that was 12 percent above the previous record established in 1967. It seems worthy of note that in 1951 the approximate ratio of imports to exports was 20/1 and that by 1970 the relationship had been precisely inverted, 1/20.

Tariff regulations applicable in 1970 continued to provide for duty-free importation of kyanite, sillimanite, and dumortierite. The ad valorem duty on mullite, fixed at 12 percent at the start of 1969, was reduced to 10 percent on January 1, 1970 and was scheduled for a further reduction in 1971.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1968		1969		1970	
	Short tons	Value	Short tons	Value	Short tons	Value
EXPORTS						
Argentina	22	$1,420	19	$1,462	245	$18,375
Australia	704	46,743	692	49,438	715	55,642
Belgium-Luxembourg	876	61,464	487	34,480	739	48,004
Canada	3,861	252,084	4,342	306,801	6,765	443,911
Colombia	182	11,566	209	9,381	-----	-----
France	398	49,074	157	26,045	285	34,240
Germany, West	1,740	104,527	2,559	168,145	2,707	170,246
Hong Kong	-----	-----	-----	-----	50	2,353
Italy	1,557	116,490	2,845	211,864	2,996	229,425
Japan	5,576	331,262	2,338	151,762	2,168	167,869
Mexico	1,438	88,987	1,498	105,796	2,435	164,591
Netherlands	61	3,990	22	634	-----	-----
Philippines	37	4,020	20	2,190	75	5,877
South Africa, Republic of	144	8,404	77	6,319	41	6,044
Sweden	575	27,082	1,124	64,673	1,217	72,775
Taiwan	-----	-----	589	20,750	309	8,823
Thailand	582	35,973	-----	-----	61	3,800
United Kingdom	1,687	79,481	1,476	85,989	2,213	122,757
Venezuela	621	39,675	740	67,923	780	46,437
Other countries	416	48,452	502	39,733	223	20,864
Total	20,477	1,310,694	19,696	1,353,385	24,024	1,622,033
IMPORTS						
Canada	-----	-----	306	17,921	-----	-----
France	-----	-----	-----	-----	1	290
India	1,391	49,414	1,167	48,439	1,178	55,264
Mozambique	-----	-----	277	9,921	-----	-----
South Africa, Republic of	59	1,967	338	11,928	-----	-----
Total	1,450	51,381	2,088	88,209	1,179	55,554

WORLD REVIEW

India.—Kyanite production in India during 1969, the last year for which complete data are available, amounted to 92,457 short tons valued at $2.3 million, approximately 30 percent more in quantity than in 1968 and 22 percent higher in total value. About 54 percent of the 1969 output was exported to 17 countries, among which Japan received 25 percent of the tonnage exported and the United States, 3 percent. Italy, the United Kingdom, West Germany, and Belgium each received 12 to 15 percent of the exported mineral. India's sillimanite production in 1969 was 4,349 short tons, of which 2,316 short tons, with a declared value of $182,000, was exported.

Concern has been expressed in regard to the present validity of the published figure for proved kyanite reserves in India, which have been reported for a number of years at 700,000 tons with no adjustment for actual extraction in the meanwhile. It now appears that this figure—the equivalent of less than a decade of production at the present rate—may be too high and that conservation measures may be advisable to ensure supplies for rising domestic consumption.

South Africa, Republic of.—According to data released by the Republic's Department of Mines,[2] production of andalusite amounted to 46,793 short tons in 1969, greater by 89 percent than the output in 1968. Local sales of the mineral outweighed exports by a ratio of about 7 to 6; compared with 1968 figures, both exports and local sales were more than doubled with respect to tonnage and total value. Andalusite production in the first three quarters of 1970 totaled 31,391 short tons, marginally higher than in the corresponding period of 1969. Sillimanite production, reported at 31,192 short tons for all of 1969, was about 15 percent below the 1968 output, and exports were lower in approximately the same proportion. Local sales of sillimanite were of minor importance. Data for January through September suggest that sillimanite production in 1970 may have been substantially higher than in 1969 and about abreast of the 36,591 short tons mined in 1968.

TECHNOLOGY

Research conducted by the Bureau of Mines in cooperation with the University of Alabama resulted in the development of an advantageous procedure for the beneficiation of a Georgia kyanite ore. The sample used in the investigation, representing material from a deposit in Georgia's Lincoln County, contained about 28 percent kyanite in a gangue that consisted essentially of quartz, clay, and pyrophyllite, together with 2 to 3 percent of iron minerals. Laboratory flotation tests, both batch and continuous, were carried out in which successive variations in conditioning speed, conditioning time, percent solids, and pulp pH were studied in conjunction with differing types and quantities of flotation reagents. By applying a system of treatment, for which optimum parameters and a recommended flowsheet were detailed in a published report,[3] concentrate fractions were obtained that assayed 56 percent Al_2O_3 (equivalent to approximately 90 percent kyanite) and about 5 percent acid-soluble iron (calculated as Fe_2O_3). A subsequent high-intensity wet magnetic separation upgraded the concentrate to the equivalent of about 93 percent kyanite with less than 1 percent of residual Fe_2O_3, for an overall kyanite recovery in the neighborhood of 83 percent.

The results of another Bureau research project, this one a study of methods for reclaiming magnetic kyanite rejects, are available for reference at the Bureau's Tuscaloosa Metallurgy Research Laboratory, Tuscaloosa, Ala.

The technology of mullite and other refractories was exceptionally well presented in a sound and color film titled "Fahrenheit 3300", made available for free loan by the Bureau of Mines and sponsored by Kaiser Refractories Division of Kaiser Aluminum & Chemical Corp. The film illustrated in a vivid manner the technical aspects of the versatile materials that are being custom-made to contain and bring into the service of mankind the extremes of temperature used in present-day technology.[4] The Bureau of Mines issued an important publication on the rapidly evolving technology and utilization of refractories, including those containing mullite, for modern high-temperature processing of metallic and nonmetalic materials.[5]

Two patents were issued in the United States that may foretell major new outlets for kyanite-group minerals. The respective

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[2] Republic of South Africa, Department of Mines. Quarterly Information Circular, October–December 1969, pp. 26–31, July–September 1970, pp. 26–31.

[3] Browning, James S., and Paul E. Bennett. Beneficiation of Georgia Kyanite Ore. BuMines Rept. of Inv. 7376, 1970, 8 pp.

[4] Prospective borrowers, who must have available a 16-millimeter sound projector and an experienced operator, should address applications for short-time loans as follows:
Motion Pictures
Bureau of Mines
U.S. Department of the Interior
4800 Forbes Avenue
Pittsburgh, Pa. 15213

[5] Kusler, David J., and Robert G. Clarke. Impact of Changing Technology on Refractories Consumption. BuMines Inf. Circ. 8494, 1970, 68 pp.

texts described independent procedures by which alumina (or an alumina antecedent) can be extracted from a number of silicate mineral materials, among which andalusite and kyanite were specifically mentioned.[6]

A patent also was granted for a kyanite-based ceramic batch mixture for the manufacture of high-quality and precisely dimensioned electrical insulators.[7]

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[6] Iverson, H. G., and H. Leitch (assigned to U.S. Secretary of the Interior). Extraction of Aluminum Values From Albite, Anorthosite, Kyanite, Bauxite, or Other Low-Grade Siliceous Ores or Rocks. U.S. Pat. 3,507,629, Apr. 21, 1970.

Slatin, H. L. (assigned to Timax Associates). Production of Metallurgical Grade Alumina From Andalusite, Kaolin, Nephelite, Siliceous Bauxite, or Other Low-Grade Aluminiferous Ore. U.S. Pat. 3,489,514, Jan. 13, 1970.

[7] Elarde, V. D. (assigned to Ceram Corp., La Mesa, Calif.). Precision Tolerance Ceramic and Method of Preparing Same. U.S. Pat. 3,549,393, Dec. 22, 1970.

Lead

By Donald E. Moulds [1]

World production and consumption of lead increased to record levels in 1970. But although free world mine production increased about 5 percent, mainly in Canada and the United States, and metal production increased about 2 percent, the increase in metal consumption was modest and failed to use all of the available new supply. As production increases continued and a slackening of general business activity began to affect consumer purchasing, the market underwent a sharp reversal from the one of short supply that persisted through most of 1969 and into the first half of 1970. Free world producer stocks, which had trended upward from a low of 152,000 tons at the end of September 1969 to 185,000 tons at the start of 1970, increased rapidly, except in September and October, to 303,000 tons at yearend. A downward pressure on world price began in April 1970. The trend thereafter continued with a resultant drop of 2.4 cents per pound (U.S. equivalent) in the London Metal Market monthly average price from the December 1969 high to December 1970.

The domestic lead industry again achieved major production increases in spite of difficulties in marketing lead during the second half of the year. Mine production increased 12 percent to 571,800 tons, mainly due to larger output from the new Missouri mines despite production curtailments at some mines in the second half of the year to reduce inventories. The production of 678,000 tons of primary lead was the largest output since 1929, and domestic mines contributed 84 percent of the primary lead metal. Secondary lead output of 597,000 tons was second only to the record 1969 output. The domestic supply of lead—primary, secondary, and imports—amounted to 1.52 million tons, 21,000 above that of 1969.

The demand for lead declined in essentially all uses except transportation where battery and antiknock requirements increased about 2 percent, well below the prior growth rate. The total consumption of lead was 1.36 million tons, a decrease of 28,800 tons from that of 1969. Battery use amounted to 44 percent of the total and gasoline additives, 20 percent.

The surplus supply of lead became evident early in the year as primary plant shipments began to lag behind production and as stocks at plants increased each month except September. Because the inventories of 25,700 tons at the beginning of the year were unsatisfactorily small, the 87,100 tons held at the end of August were too large, and steps were taken by St. Joe Minerals Corp. and American Metal Climax Inc. to reduce production. Stocks, however, continued to accumulate to a total of 97,900 tons at yearend. The surplus situation was also evident in the increase in consumer and secondary stocks from 126,000 tons to about 133,500 tons. Sales from Government stockpile to commercial accounts were negligible, only 22 tons sold and shipped. Government transfers to Government plant uses, mainly for ammunition, amounted to 12,100 tons. The available domestic supply from all sources, including primary, secondary, net imports, and changes in commercial and Government stocks indicated an apparent consumption of 85,000 tons of lead in addition to the reported consumption of 1.36 million tons.

The world price of lead, as indicated by the London Metal Exchange monthly average, declined during the year from the December 1969 high of 15.4 cents per pound to an average of 12.6 cents for December 1970 and 13.8 cents for the year. The domestic price for common lead at New York held at the 16.5 cents per pound established on December 15, 1969, until reduced

[1] Physical scientist, Division of Nonferrous Metals.

to 15.5 cents on July 8. Three successive reductions during the second half of the year brought the price to 13.5 cents on December 21. All of the producers did not follow immediately the reductions initiated by American Smelting and Refining Co. (ASARCO), and the actual pricing was confused by the indicated quotation range during most of the second half of the year.

Legislation and Government Programs.—The domestic small lead and zinc mine assistance program, authorized under Public Law 89–239, was terminated on December 31, 1969. Government participation in exploration, primarily for lead, had been withdrawn in June 1962. The program under the Office of Minerals Exploration, Geological Survey, U.S. Department of the Interior, continued to be active in exploration for other base-metal deposits often in association with lead and, also, in managing repayments on production from previously certified discoveries resulting from Government participation in projects authorized prior to June 1962.

Sales of Government surplus lead from the strategic stockpile to commercial users under Public Law 91–46 decreased to 22 tons from the 22,698 tons sold in 1969. Lead authorized for sale on an off-the-shelf basis to commercial users amounted to 77,290 tons at the end of 1970. Transfers for Government use under authorization of Public Law 89–9 amounted to 12,064 tons in 1970, which was used primarily at Government-owned ammunition plants. The remaining tonnage in the authorization was 28,562 at yearend. Actual depletion of the Government stocks during 1970 was 12,117 tons leaving a total inventory of 1,140,620 tons, of which 610,620 tons is in excess of the 530,000-ton stockpile objective.

In February legislation was introduced in the House and Senate to dispose of 498,000 tons of surplus lead in Government stocks. Hearings were held, but no further action was taken.

In May, the Administration proposed a tax on lead used as a gasoline additive, which amounted to $4.25 per pound of lead. The levy on antiknock producers would amount to 2.3 cents per gallon of fuel containing 2.5 grams of lead. The tax was designed to encourage the public to use low-lead or unleaded gasoline to curtail air pollution. The proposed legislation was tabled by the House Ways and Means Committee. All Federal vehicles were, however, ordered in late October to use unleaded or low-lead gasoline whenever practical.

The International Lead and Zinc Study Group convened in Geneva, Switzerland, for its 14th session on November 16. The Study Group sessions during November 16–20 were preceded by meetings of the various subcommittees during the period November 11–15. A review at the statistical subsessions of the member Governments indicated that the continued expansion of lead production in 1970 and 1971 was well above anticipated consumption, with an indicated supply surplus of 220,000 tons in 1970 and 150,000 tons in 1971. The Study Group also discussed liberalization of lead-zinc trade and environmental problems, especially in use of lead and the need for increased attention to marketing and use development. Special groups were designated to implement further study of the problems pointed out in the discussions.

The International Lead-Zinc Research Organization, incorporated in 1965 by producers and consumers of lead and zinc, continued to sponsor a broad program of cooperative research on a worldwide basis. The program provides a global approach to ecological problems, process and material improvements, development of new products, and additional basic information.

Table 1.—Salient lead statistics

(Short tons unless otherwise specified)

	1966	1967	1968	1969	1970
United States:					
Production:					
Domestic ores, recoverable lead content	327,368	316,931	359,156	509,013	571,767
Value ... thousands	$98,964	$88,741	$94,903	$151,635	$178,609
Primary lead (refined):					
From domestic ores and base bullion	318,646	258,507	349,039	513,931	528,086
From foreign ores and base bullion	122,089	121,387	118,271	124,724	138,644
Antimonial lead (primary lead content)	11,182	9,083	19,494	16,250	11,655
Secondary lead (lead content)	572,834	553,772	550,879	603,905	597,390
Imports, general:					
Lead in ore and matte	143,991	124,067	87,836	109,252	112,406
Lead in base bullion	2,012	569	8	1,993	296
Lead in pigs, bars, and old	293,085	373,887	344,601	285,342	251,480
Exports of lead materials excluding scrap	5,435	6,536	8,281	4,968	7,747
Stocks December 31 (lead content):					
At primary smelters and refineries	115,473	125,479	90,427	101,860	192,985
At consumer plants	90,306	105,786	78,900	126,404	133,502
Consumption of metal, primary and secondary	1,323,877	1,260,516	1,328,790	1,389,358	1,360,552
Price: New York, common lead, average, cents per pound	15.12	14.00	13.21	14.93	15.69
World:					
Production:					
Mine	3,138,779	3,159,343	3,314,992	3,568,602	3,750,826
Smelter	3,026,266	3,182,316	3,246,900	3,561,198	3,637,472
Price: London, common lead, average, cents per pound	11.87	10.28	10.88	13.09	13.76

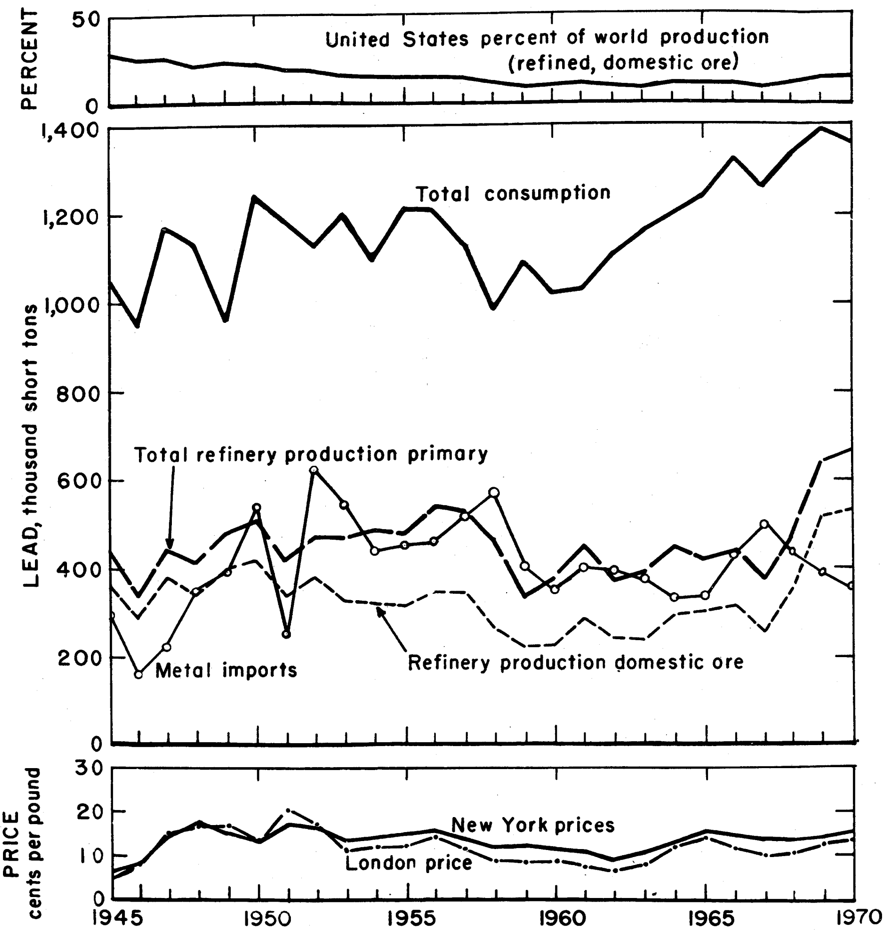

Figure 1.—Trends in the lead industry in the United States.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of recoverable lead reached a monthly peak of 51,800 tons in March and held at a high level throughout the year. The 571,800 tons produced in 1970 was the largest total since 1929, and the 47,600-ton monthly average indicated a 12-percent increase compared with 1969. Production from Missouri mines registered a gain of 66,300 tons compared with 1969, a 19-percent increase, as uninterrupted operations continued. The 421,800 tons from Missouri represented 74 percent of total domestic lead in ore. Idaho, the second largest producer, provided 11 percent; Utah, 8 percent; and Colorado, 4 percent. These four States combined supplied 97 percent of domestic primary lead.

The "New Lead" belt in southeastern Missouri has more than tripled Missouri's lead production during the past 5 years, even though the 1970 total was reduced. During the second half of the year, St. Joe Minerals Corp. and Missouri Lead Operating Co., a joint venture of American Metal Climax Inc. and Homestake Mining Co. curtailed production in order to reduce metal inventories. Due to a strike at

ASARCO's concentrate processing smelter that began on September 1 and continued through the remainder of the year, production at Ozark Lead Co., a subsidiary of Kennecott Copper Corp., also was reduced.

The Fletcher mine of St. Joe Minerals Corp. was the leading lead producer in 1970, and the five leading mines, all in Missouri, contributed 64 percent of the total domestic mine production. The 10 leading mines produced 86 percent, and 25 mines contributed 97 percent.

Although production was curtailed about 14 percent during the second half of the year, St. Joe Minerals Corp. produced 318,400 tons of lead concentrate and 206, 300 tons of lead and lead alloy during the year, essentially all from company mines. Portions of the old Federal mines were closed during the year owing to depletion of reserves. The first phase of the new Brushy Creek development was completed, and the mine shaft was down the initial 550 feet of the planned 1,391 feet.[2] The plant when completed in January 1973 will be a duplicate of the efficient Fletcher mine and will cost about $19 million.

The Ozark Lead Co. produced 66,900 tons of lead, compared with 41,200 tons in 1969. The strike at the Glover smelter necessitated the stockpiling of concentrates and reduction of mining operations during the last 4 months of the year. The total production of lead by Kennecott from both Missouri and Utah mines was 83,700.[3]

According to the 1970 annual report of American Metal Climax, Inc.,[4] the first full year of production at the Missouri Lead Operating Co's. Buick mine resulted in the mining and milling of 941,000 tons of ore from which 75,000 tons of lead concentrate was produced. Lead output was more than triple the 1969 output, although a production cutback of 10 percent was in effect during the fourth quarter.

The Magmont mine at Bixby, Mo., a joint venture of Cominco American Inc. and Dresser Industries Inc., also increased lead production by approximately 37 percent compared with 1969.

Idaho, the second largest State in output, posted a 4,400-ton reduction compared with 1969. The Page mine, which produced 3,600 tons in 1969, was closed in October of that year. Production at the Bunker Hill and Star mines increased, and a new mining method utilizing ramps and trackless equipment was initiated at the Bunker Hill mine. Output of the Lucky Friday mine owned by the Hecla Mining Co., continued at a stable rate; however, output by Day Mines, Inc., decreased owing to the closure of the mine in July and August for mine development and repair. A great effort continued in deep and lateral development of the Coeur d'Alene mining district by ASARCO, Bunker Hill Co., Hecla Mining Co., and Day Mines, Inc.

Lead output in Utah increased slightly in 1970. The Mayflower mine of Hecla Mining Co., United Park City Mines Co., and the mines of United States Smelting Refining & Mining Co. all reported reduced lead production compared with 1969. The Tintic Division of Kennecott Copper Corp., however, approximately doubled the metal output of 1969 despite continuing adverse mining conditions and a shortage of qualified miners at the Burgin and Trixie mines. Development work at the Trixie and Ball Park areas continued, and installation of additional pumping capacity at the Burgin mine continued to lower the ground water table.[5]

ASARCO and The Anaconda Company in a joint venture with United Park City Mines Co. have agreed to spend at least $2.5 million in the next 2 years to explore the mineral potential of this famous old Park City, Utah, silver-lead-zinc mining district.

Colorado also reported a slight increase in lead output, despite some reverses. Ore mined by the Idarado Mining Co. decreased from 403,500 tons in 1969 to 349,200 tons with a corresponding decrease in metal produced. A continuing and worsening shortage of skilled and semiskilled manpower was the major cause of the decline. In the last quarter of 1970 a sublevel stopping method was initiated in certain areas using multidrill jumbos and trackless equipment in an effort to improve productivity. Construction and development was continued throughout 1970 at the Leadville Unit, a joint venture of Newmont Mining Corp. and ASARCO at Leadville, Colo. Completion of the 700-ton-per-day plant is scheduled early in

[2] St. Joe Minerals Corp. Annual Report. 1970, pp. 5, 24.
[3] Kennecott Copper Corp. Annual Report. 1970, p. 13.
[4] American Metal Climax, Inc. Annual Report. 1970, p. 7.
[5] Page 13 of work cited in footnote 3.

1971. Ore reserves are estimated at 2.4 million tons averaging 5.13 percent lead, 9.95 percent zinc, and 2.64 ounces of silver per ton.[6] The New Jersey Zinc Co., Rico Argentine Mining Co., Homestake Mining Co., Keystone Mines Co., and Federal Resources Corp. operated mines in Colorado that supplied lead concentrates during the year.

The Van Stone mine of ASARCO at Northport, Wash., was closed in December upon exhaustion of ore reserves. The Ground Hog mine near Silver City, N. Mex., and the flotation mill at Deming, N. Mex., was reopened in 1969 by ASARCO and produced 3,174 tons of lead in concentrates during the year. Eagle-Picher Industries, Inc. closed its operations in the Tri-State area, including the Central Mill in November. The Illinois-Wisconsin operations of Eagle-Picher continued during the year, although lead output was reduced compared with 1969. The Illinois operation of Ozark-Mahoning Co. more than doubled lead output in 1970. In the eastern area, the Balmat mine of St. Joe Minerals Corp. in New York and the Virginia operation of The New Jersey Zinc Co. were the large producers of lead.

SMELTER AND REFINERY PRODUCTION

The increased availability of primary lead in domestic and foreign ores provided the base for a 4-percent increase in refined lead output, in spite of a curtailment in production of lead in concentrates at some domestic mines. St. Joe Minerals Corp., Missouri Lead Operating Co., Ozark Lead Co. and ASARCO, although that was due to a labor strike that was due to closure of the Glover smelter on September 1. The 666,700 tons of primary refined lead was the largest total since 1929 and the seventh largest in the history of the domestic industry. Over 79 percent was derived from domestic ores, compared with 80 percent in 1969. An additional 4,400 tons was refined from scrap. Production of antimonial lead was reduced for the second successive year with only 19,300 tons of lead recovered, of which 7,600 tons originated from scrap, 8,800 tons from domestic ores, and 2,800 tons from foreign ores. Of special interest was the reduction of the antimony in the antimonial lead from 8.4 percent in 1969 to 5.8 percent, thus confirming the industrial trend of using less antimony in batteries and other antimonial lead uses.

The Herculaneum smelter of St. Joe Minerals Corp. produced 196,600 tons of lead metal and alloys from 318,420 tons of lead concentrates produced from company mines and 52 tons of purchased raw materials. Output was 12 percent below the 1969 total because of scheduled production reductions. A wide variety of technical and equipment improvements were made during the year to improve the efficiency and environmental aspects of smelter operation.[7]

The Missouri Lead Operating Co. smelter at Buick, Mo., owned jointly by Amax and Homestake Mining Co., produced 115,000 tons of refined lead, of which 50,000 tons originated at the company's mine and 65,000 tons was refined on toll for other producers.[8]

ASARCO's Glover, Mo., smelter and refinery operated until September 1 when closed by a labor stoppage which continued into 1971. The East Helena, Mont., smelter of ASARCO, one of the largest custom lead smelters, processed crude ores and concentrates coming from approximately 60 small Montana mines, as well as from mines in Canada, Idaho, Utah, Colorado, Australia, and South America. The firm's Omaha refinery processed lead bullion from the East Helena and El Paso smelters. In July ASARCO announced that its Selby, Calif., smelter-refinery would be closed after 85 years of continuous operation, and production was phased out in an orderly fashion by the end of the year. Selby produced over 3 million tons of lead, 40 million ounces of gold, and 100 million ounces of silver during its many years of operation. Extensive efforts in the environmental field were made by ASARCO at all their plants during the year to improve stack emissions and meet local air purity regulations. Production at ASARCO refineries during 1970 amounted to almost 226,000 tons of lead, compared with 207,300 tons in 1969.[9]

The Bunker Hill lead smelter-refinery of Gulf Resources & Chemical Corp. at Kellogg, Idaho, produced 123,000 tons of lead during the year; this amount was slightly below the 1969 level. The new updraft sin-

[6] Newmont Mining Corp. Annual Report. 1970, pp. 7–9.
[7] Pages 8–24 of work cited in footnote 2.
[8] Page 7 of work cited in footnote 4.
[9] The American Smelting and Refining Co. Annual Report. 1970, pp. 11–18.

ter machine for lead ores was placed in operation in the fourth quarter of the year and replaces 10 downdraft machines that had been in service for almost 50 years. The new updraft machine will improve both sinter quality and sulfur recovery from stack gases.[10]

International Smelting & Refining Co., a subsidiary of The Anaconda Company, processed custom lead concentrates, of which about 12,000 tons of lead came from Anaconda and 26,100 tons of lead in bullion from other mines under contract.[11] The lead bullion was refined by the United States Lead Refinery, Inc. in East Chicago, Ind. A relatively small tonnage of primary lead was refined by Schuylkill Metals Corp., Baton Rouge, La., primarily a secondary smelter.

Antimonial lead from primary ores and scrap was produced by ASARCO at its Omaha and Selby plants, Bunker Hill Co., St. Joe Minerals Corp., and United States Lead Refinery Inc. The total of 19,800 tons was well below the 1969 output.

Secondary lead production in 1970 decreased 1 percent to 597,400 tons, compared with the record 603,900 tons in 1969. Secondary plants and foundries contributed 585,400 tons, or 98 percent of the total. The type of material produced indicated a decreasing market for various alloys and that only 15 percent of total secondary production is required. Soft lead amounted to 27 percent and antimonial lead 58 percent of the total production.

The expansion in domestic primary lead production has decreased the secondary component of domestic supply from 53 percent in 1968 to 49 percent in 1969 and to 47 percent in 1970. Secondary lead constituted 39 percent of the domestic 1.52 million-ton new supply of lead, including metal imports but excluding all stock changes. The recycling of lead has been significant in the resource utilization area, and, with increasing ecological pressure, collection and utilization of lead scrap has maintained a high position in resource recycling.

RAW MATERIAL SOURCE

Recoverable lead in concentrates delivered by domestic mines to smelters in 1970 contributed 571,800 tons, about 83 percent of the plant production of 690,400 tons of primary refined and antimonial lead, compared with 79 percent in 1969 and 74 percent in 1968. Lead in imported concentrates smelted during the year amounted to 141,500 tons, the largest input of foreign material since 1964 and an increase of 9 percent compared with 1969. The 12,000 tons of lead recovered from lead scrap processed at primary plants was slightly above the 1969 total but constituted less than 2 percent of the total lead from primary plants. Raw material stocks at the beginning of the year at primary plants amounted to 162,400 tons, of which 58,800 tons was in process and 3,600 tons was in secondary materials. Total stocks reached a low of 155,000 tons at the end of June and a high of 179,400 tons at the end of October. At yearend, stocks of primary materials awaiting processing contained 100,200 tons of lead; material in process, 71,500 tons; and secondary materials, 2,600 tons. This makes a total of 174,300 tons of lead.

Scrap materials consumed in 1970 amounted to 786,200 tons, compared with 797,800 tons in 1969. New scrap in the form of purchased drosses and residues from a wide variety of sources amounted to 121,800 tons, 15 percent of the total feed. The remainder, old scrap, was predominantly battery scrap with small amounts of cable lead, babbitt, solder, type metal, and soft and hard lead. The scrap processed was essentially all from domestic sources. Export of scrap by the United States in 1970 amounted to 4,200 tons, compared with 2,300 tons in 1969. General import of reclaimed scrap was 6,900 tons (lead content) mainly from Australia, Canada, and Mexico. Of this amount only 3,000 tons was entered for consumption during the year. Stocks of scrap at smelters held reasonably steady during the year. A low of 67,000 tons occurred at the end of June prior to the seasonal vacation period, but the year ended at 73,300 tons, compared with 73,600 tons at the start of the year.

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[10] Gulf Resources & Chemical Corp. Annual Report. 1970, p. 12.

[11] The Anaconda Company. Annual Report. 1970, p. 6.

CONSUMPTION AND USES

Lead requirements during the first 6 months of 1970 continued at the record levels of 1969, and the January–June total of 701,300 tons was about 1.6 percent above the 690,200 tons used in the same period in 1969. The second 6 months, however, was disappointing; only 659,300 tons was reported consumed. The total reported consumption for 1970 was therefore 1.36 million tons, a 2-percent drop from the record 1.39 million tons reported during 1969. All products except batteries and antiknock additives required lesser amounts of lead. The 10,900-ton increase in battery lead and 7,400-ton increase in antiknock additive requirements represented the only significant growth areas for lead in recent years. The growth in battery requirements was 1.9 percent, and growth in antiknock additives was 2.7 percent. However, 1970 was disappointingly below the 1969 growth of 13.4 percent for batteries and 3.5 percent for antiknock additives. The downtrend in requirements for all of the other metal products, pigments, and miscellaneous and other uses continued in varying degrees in 1970.

Requirements exceeded 100,000 tons during each month. The high occurred in March instead of the usual peak in October; as usual, the low occurred in July. The daily average of 3,728 tons was 78 tons below the record 3,806 tons in 1969. Soft refined lead represented 67 percent of the total, and hardened antimonial lead represented 28 percent. Lead in other alloys, mainly solder and bearing metals, was 4 percent. Lead in copper-base scrap, 1 percent, is recovered from old material and returned as marketable brass and bronze. About 35,200 tons of lead in scrap was recovered and used directly at foundries in end products and 1,200 tons of lead was consumed in leaded zinc oxide and other pigments.

The domestic supply of lead metal from all sources—production, imports for consumption, stock changes, and stockpile shipments—totaled 85,000 tons above the amount accounted for by reported consumption and exports. The unaccounted for supply in 1970, amounting to 6 percent of the reported consumption, compares with 108,000 tons in 1969 and annual average of 63,500 tons for the 1963–69 period. The difference in totals is presumed to be in unreported consumption and stock buildup especially at small users and dealers who do not report to the Bureau of Mines.

Consumption of lead during the 10-year period 1961–70 has presented a shifting growth pattern. The total average annual growth of 2.9 percent resulted primarily from the large-tonnage transportation sector, which showed a growth of 5.3 percent per year for batteries and gasoline antiknock compounds. Ammunition, solder, casting metals, collapsible tubes, and foil have also shown growth during the period. The communication and construction use of lead in cable covering, type metal, calking, plumbing, and sheet have declined significantly in tonnage. In the pigment area the use of lead in decorative paints (such as white lead and colors) has declined, but in anticorrosive and highway safety use (as red lead and lead chromates) a modest growth has occurred. Lead used for ballast and weights averaged a 5.9-percent growth, mainly in shipbuilding. The use of lead in products in terms of percentage of the total in 1960 was as follows: Ammunition, 4 percent; metal products, 32 percent; batteries, 35 percent; pigments, 10 percent; chemicals including antiknocks, 16 percent; and miscellaneous, 3 percent. During 1970 the comparative percentages were as follows: Ammunition, 5 percent; metal products, 21 percent; batteries, 44 percent; pigments, 7 percent; chemicals including antiknocks, 20 percent; and miscellaneous, 3 percent.

LEAD PIGMENTS

Production of lead oxides and pigments required 386,200 tons of lead in 1970, a 2-percent increase compared with that of 1969. All of the lead used was derived from refined pig lead except for the lead in leaded zinc oxide which was derived directly from foreign and domestic ores. The requirements, for lead in making pigments, mainly white lead and red lead, decreased almost 13 percent and comprised only 7 percent of the lead consumed in this category. White lead in all products in 1970 amounted to about one-half the quantity used in 1960. Use of red lead has been slightly more stable, remaining at about the 1960 consumption level of 22,600 tons. Litharge requirements for ceramic glazes and in oil refining increased slightly. The largest use of litharge is in battery manufacture included in "Other." This category has increased from 75,700 tons in 1960 to 118,000 tons in 1970.

Shipments of white lead and red lead were again below production, indicating reduced demand for lead-base paints. Shipments of litharge were, however, 14,000 tons above production and indicated a continued drawdown of stock.

Prices.—The quoted price of lead pigments was relatively stable during the year compared with the downward trend in the price of lead which decreased 3 cents per pound during the second half of the year. The price of basic carbonate white lead was reduced on January 5 from 22.3 cents per pound to 21.5 cents per pound in carload lots, freight allowed, and continued at that price for the remainder of the year. The price of red lead, 95 percent red-lead oxide (Pb_3O_4) in carload lots, at works, was reduced on July 20 from 19.75 cents per pound to 18.75 cents and again to 17.75 cents on September 14. Commercial grade litharge, powdered, in carload lots, at works, quoted at 19 cents per pound at the beginning of 1970 was reduced to 18 cents on July 20 and remained at that level for the rest of the year.

The value of shipments of white lead, red lead, and litharge amounted to $60.7 million, an average of $348 per ton in 1970, compared with $57.6 million and $342 per ton, respectively, in 1969.

Foreign Trade.—Exports of pigment-grade lead oxides amounted to 1,516 tons valued at $649,000, and exports of lead oxides other than pigment grade was 363 tons valued at $303,000. Shipments were made to more than 50 countries. South Vietnam, France, Republic of South Africa, Canada, and the United Kingdom were the leading importers of pigment-grade lead oxide, accounting for 53 percent of the total. South Vietnam and West Germany together imported 64 percent of the 363 tons of nonpigment-grade oxide.

Imports for consumption of lead oxides and compounds decreased 30 percent to 22,600 tons. Value decreased 27 percent, $2.1 million down from last year's total. The only increase was in the amount of red lead received; the major decrease was as litharge, which showed nearly a 10,300-ton drop. Import of lead alloys, while posting a significant decrease in gross weight and value, posted an increase of 169 tons in lead content. Mexico was the largest supplier with 87 percent of the tonnage, mainly as red lead and litharge. Canada, the United Kingdom, and West European countries provided essentially all of the remaining tonnage. Imports of lead nitrate amounted to 323 tons; lead acetate, 14 tons; white lead, 985 tons; lead sulfate, 120 tons; red lead, 6,909 tons; lead suboxide, 69 tons; litharge, 13,703 tons; orange mineral, 1 ton; leaded zinc oxide, 149 tons; and other lead compounds 318 tons.

STOCKS

Primary plant inventories of refined and antimonial lead at the end of 1969 totaled 25,700 tons, of which 21,300 tons was refined pig lead. Production exceeded shipments during each month of 1970 except September, and a buildup of stocks reached 97,900 tons by the end of the year. Of the total, 90,900 tons was refined pig lead. Stocks of base bullion decreased about 1,000 tons during the year, but ore and matte stocks increased about 20,000 tons. In addition to concentrate stocks at smelters, concentrate stocks were held at some Missouri mines owing to the labor stoppage at the Glover smelter of ASARCO.

Stocks of lead in all forms at consumer and secondary smelting plants gradually increased during the year. One reporting consumer revised the stock figure in December for the period from September 1968 to December 1970. Revised inventories indicated an increase from 126,400 tons at the beginning of the year to 133,500 tons at yearend, of which 88,100 tons was located at consumers. Refined soft lead constituted 62 percent of the inventory, compared with 53 percent of the revised total in 1969.

PRICES

The high level demand for lead at the beginning of 1970 was drastically altered by the uncertainty created early in the year, resulting from environmental actions related to the use of lead in gasoline and design proposals for automotive engines to operate on lead-free or low-lead gasolines. The uncertainty was reflected in a downward drift in London Metal Exchange price from a high of 15.77 cents per pound on February 19 to 11.86 cents on December 30.

The domestic market was also affected by the general slowdown in industrial activity and accompanying reduction in consumer inventories. The expanded domestic output of refined lead thus began accumulating at producer plants in the second quarter and on July 8 ASARCO reduced the price of common lead at New York from 16.5 cents per pound to 15.5 cents per pound. This action was followed by all domestic producers. On August 7, ASARCO initiated a price of 15 cents, which was confirmed by all producers by August 11. On September 2, ASARCO announced a price of 14.5 cents per pound. Other producers, however, did not confirm the lower price and a book price range of 14.5 to 15 cents was in effect until December 21 when ASARCO announced a price of 13.5 cents per pound. Other producers again took no public action. Most of the domestically produced lead was sold at the Metals Week average published by McGraw-Hill, and the lower ASARCO price was the top consumer bid for lead. Discounting below that average was reported for some sales.

FOREIGN TRADE

Exports of lead materials during 1970 aggregated almost 12,000 tons valued at $5.8 million, compared with 7,300 tons valued at $4.4 million in 1969. Exports of metal averaged slightly over 300 tons monthly for the period January–April. A large tonnage, 2,400 tons, was shipped in May, and shipments averaged 580 tons monthly during the June–December period. Unwrought lead and lead alloys amounted to 5,000 tons shipped principally to Spain, Canada, and India. Wrought lead and lead alloys amounted to 2,800 tons delivered mainly to the Netherlands, Turkey, Canada, Venezuela, and Mexico. Exports of scrap during 1970 was over 4,200 tons valued at more than $1 million. Shipments reached a high of 1,000 tons in November, and Italy, Canada, Belgium-Luxembourg, and the United Kingdom were the principal purchasers of scrap.

Imports of lead materials continued to decrease in tonnage and totaled 364,200 tons in 1970. Owing to the higher average price however, value increased to $99.8 million. Receipts of lead in ores was about 3,000 tons above the 1969 total, but metal receipts decreased to 244,600 tons, compared with 338,000 tons in 1968 and 278,400 tons in 1969. Essentially all of the metal was entered duty-paid for consumption. Delivery of lead in ore and bullion, however, exceeded lead ore and bullion entered duty-paid for consumption by 68,900 tons, indicating a major buildup of lead ores in bond. During the supply shortage period of 1967–69, duty-paid entries of ore exceeded general deliveries by 35,200 tons, thus demonstrating the drawdown of bonded stocks accumulated, especially in 1966. Canada continued to be the leading supplier of lead in ore with 37 percent of the total, followed by Australia, Peru, and Honduras. Canada was also the leading metal supplier with 26 percent of the total, followed by Peru, 21 percent; Australia, 21 percent; Mexico, 16 percent; and Yugoslavia, 8 percent. Australia, Canada, and Mexico were also the significant suppliers of lead-bearing scrap material.

It is noteworthy that during the 1957–61 period imports for consumption averaged 186,709 tons per year of lead in ore and 279,400 tons of lead metal for an average total of 466,100 tons. The 1966–70 average was 92,600 tons of lead in ore and 302,100 tons of lead metal for a total of 394,700 tons. The decrease in lead ore imports reflects the rising availability of domestic ores for smelting and also the rising self-sufficiency of the domestic lead industry.

WORLD REVIEW

Published statistics on the world lead industry differ in reporting base, reporting source, and scope of estimating. The Bureau of Mines reports indicate the basis, insofar as possible, used for each country; Bureau reports also depend largely on Governmental information. The International Lead and Zinc Study Group reports also use Governmental data but ore-content is the base used. The American Bureau of Metal Statistics (ABMS) relies to a large extent on company and industry association sources. Therefore, free world[12] mine production of lead ranged from the Bureau of Mines total of 2.81 million tons and through the Lead and Zinc Study Group preliminary total of 2.80 million tons, to the ABMS total of 2.74 million tons. In addition, the Bureau of Mines estimated production in Communist countries, excluding Yugoslavia, at 934,000 tons, and the world total, 3.75 million tons. Smelter output of lead is reported by the Bureau of Mines as primary output, insofar as possible, whereas the Lead and Zinc Study Group reports metal output from both primary and secondary sources. Free-world smelter output in 1970 thus ranged from the Study group preliminary total of 3.64 million tons through the ABMS total of 3.0 million tons to the Bureau of Mines total of 2.72 million tons. In addition the Bureau of Mines estimated 914,000 tons of metal produced in the Communist countries, (excluding Yugoslavia), to provide a world total of 3.64 million tons of primary lead.

The United States continued to be the leader in mine production of lead, with 15 percent of the world total, followed by Australia and the U.S.S.R. Canada, Mexico, Peru, and Yugoslavia were other leading world producers with over 100,000 tons of lead in ore mined; these seven countries produced 65 percent of the world total. The increase in free world output of 5.1 percent came mainly from mines in the United States and Canada. The North America area increase amounted to 13 percent, and the 1.18 million tons represented 42 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. was again in second place followed by Australia, Japan, Canada, Mexico, France, West Germany, Yugoslavia, and Belgium. These 10 countries each produced over 100,000 tons and together accounted for 72 percent of the world total. The North America area accounted for 38 percent of the free world metal output and 29 percent of the estimated world output (excluding U.S. secondary production). The increase in free world output amounting to 2 percent was mainly in the United States, Canada, France, Japan, and Australia. Secondary production in the free world was estimated at 800,000 tons, of which the United States accounted for almost 580,000 tons. This secondary output is included in the smelter output of some countries, particularly France, Japan, and West Germany.

Consumption of lead metal, including primary and secondary, as indicated by the Lead and Zinc Study Group preliminary totals for the free world, amounted to 3.5 million tons, an increase of 2.9 percent or 99,200 tons above the 1969 total. Europe and Asia accounted for the increase; Australia and North America posted a decrease. The Lead and Zinc Study Group free world comparative statistics on metal production and consumption reflect a supply surplus of 95,000 tons in 1970 and 122,000 tons in 1969. This was reflected in a rise in producer stocks of 22,000 tons in 1969 and 118,000 tons in 1970.

Argentina.—Compañía Minera Aguilar, S.A., a subsidiary of St. Joe Minerals Corp., completed a major expansion of mine and mill facilities and produced 46,662 tons of lead concentrates during the year, essentially at the 1969 level of output.[13]

Australia.—Sixty-two percent of the lead mined in Australia originates at Broken Hill area mines, which are operated by four major companies, and 33 percent comes from Mount Isa Mines, Ltd. The remainder comes from mines in Tasmania, 3 percent, and the remainder from several small scattered mines.

[12] As used throughout this chapter, "free world" implies all noncommunist countries plus Yugoslavia.
[13] Page 12 of work cited in footnote 2.

Mount Isa Mines Ltd., 52.7-percent owned by ASARCO, continued to expand production. During the fiscal year ending June 28, 1970, the quantity of ore treated increased almost 20 percent: The mine achieved an 18,000-ton-per-day rate, and annual lead output reached 168,400 tons an increase of 28 percent compared with the prior 12 months. Ore reserves were increased to 58.2 million tons of primary silver-lead-zinc ore compared with the previously reported 50.4 million tons. In addition, 134.4 million tons of 3-percent copper ore was estimated as reserves. Further expansion at Mount Isa is planned for the lead smelter, and additional refining facilities to process ore from the Hilton mine are being provided. Starting in 1976, production from the Hilton mine, is expected to bring the annual lead output from Mount Isa Mines' two properties to 313,000 tons per year. Reserves at the Hilton mine have been estimated at 39.2 million tons of silver-lead-zinc ore averaging 7.7 percent lead.[14]

Operations at Broken Hill area mines improved slightly during the fiscal year ending June 30 as the labor situation permitted increased working time. Production of lead from these mines with the exception of the New Broken Hill Consolidated Ltd. is smelted at the Port Pirie plant of the Broken Hill Associated Smelters Ltd.; production of metal amounted to 180,000 tons, slightly above that of previous years.

St. Joe Minerals Corp. and Phelps Dodge Corp. announced discovery of a deposit of massive sulfides with a substantial lead-zinc-silver-copper content at their joint venture in New South Wales.

Expansion at the Electrolytic Zinc Co. of Australasia Ltd. mines and mill in Tasmania was underway with the expectation of doubling production by mid-1971.

Burma.—Almost all metal production comes from mines run directly by the Government's Myanma Bawdwin Corp., whose central operation is the Bawdwin mine at Namtu, Northern Shan State. Significant production also is reportedly coming out of the Bawsaing mines and the Yadana Theingi mines in Northern Shan State. Lead concentrates produced in 1970 amounted to 16,200 tons, yielding 10,000 tons of refined and antimonial lead.

Canada.—Mine production of lead in 1970 increased over 19 percent to almost 395,000 tons; this was due mainly to the first full year of operation by Anvil Mining Corp. Ltd. in the Yukon Territory. Reserves at the Anvil mine have been calculated at 63 million tons, averaging 3.4 percent lead and 5.7 percent zinc. The remainder of the increase came largely from expanded operations at the Heath Steele Mines, Ltd., in New Brunswick. The Anvil mine and the startup of production at Venus Mines Ltd. provided the Yukon Territory with a lead output of about 69,000 tons. Northwest Territories was the leading Canadian lead-producing area, with 110,000 tons. Pine Point Mines, Ltd., was again the leading producer in the Northwest Territories, with an increase in output comparable to that of 1969. Exploration in the Nahanni Mining District by Cadillac Explorations Ltd. reportedly indicated reserves of about 2 million tons of lead-zinc-silver ore averaging 11 percent lead and 13 percent zinc.

Cominco Ltd. operating the Sullivan mine at Kimberley and the Bluebell mine at Riondel, both in British Columbia, provided 110,200 tons of lead in concentrates during 1970. Cominco also operates the Trail smelter and refinery, treating company and custom ores from several western mines.

Brunswick Mining and Smelting Corp. Ltd. continued to be the leading lead producer in New Brunswick, accounting for about 65 percent of that Province's estimated 62,000 tons of lead. Heath Steele Mines, Ltd., began operation of its expanded facilities early in 1970. East Coast Smelting and Chemical Co. Ltd. at Belledune, New Brunswick, a subsidiary of Brunswick Mining and Smelting Corp., continued operation of its Imperial smelter and associated refining facilities.

The ASARCO Buchans Unit in Newfoundland produced about 20,200 tons of lead. Byproduct lead from Hudson Bay Mining and Smelting Co. Ltd., Ecstall Mining Ltd., a subsidiary of Texas Gulf Sulphur Co., Nigadoo River Mines Ltd., and other small mines provided about 20,000 tons of Canada's total lead output.

Output of primary refined lead showed about a 10-percent increase to 205,000 tons. Export of lead in ores and concentrates principally to Japan, United States, West Germany, and Belgium were almost doubled in 1970.

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[14] Page 14 of work cited in footnote 9.

France.—Output of lead and zinc have shown opposing trends with lead increasing and zinc decreasing. Closure of the high-zinc Pierrefitte mine in May 1969 and expansion of the high-lead Largentière mine caused the change in the output pattern.

Honduras.—The El Mochito mine of New York and Honduras Rosario Mining Co. increased ore output 9.2 percent above the 1969 level. The lead content of lead and zinc concentrates amounted to 16,568 tons, a record for the mine. The increase resulted from completion of major expansion projects at the mine and mill. Additional mill and mine improvement was in progress at yearend. Exploration and development increased ore reserves by 16 percent during the year and marked the sixth consecutive year of increase in ore reserves at the mine.[15]

ASARCO Exploration Co. of Canada in a joint venture with New York and Honduras Rosario Co. began driving a 2-mile tunnel to reach projections of ore shoots at the old Rosario mine.

India.—India, with only one domestic producer, is dependent on imports of lead. Hindustan Zinc may build a new 10,000-ton-per-year lead smelter in the Sundergarh District of Orissa State following location of an ore deposit at Sargipalli estimated to contain 4.6 million tons of ore, averaging 5 to 6 percent lead. These reserves would supply the smelter for nearly 20 years. The Orissa Industrial Development Corp. is making a detailed study of the district potential. Hindustan Zinc was studying the possibility of modernizing and expanding its Tundoo lead smelter. Currently annual production is about 2,500 tons of lead, well below the 6,000-ton rated capacity, owing to obsolete equipment and low-lead content of the concentrates from its Zawar mines at Debari in Rajasthan.

Ireland.—The two large mines in Ireland supplied over 65,000 tons of lead in 1970. Continued exploration by subsidiaries of Northgate Explorations, Ltd., and Silvermines, Ltd., has encountered mineralization in County Meath and County Tipperary. Smelter Corp. of Ireland, a subsidiary of Northgate Exploration, Ltd., was studying the feasibility of building a $36 million smelter in Ireland to process the lead-zinc concentrates now being shipped to smelters on the European continent.

Japan.—Refined lead production in Japan has almost doubled since 1965: The 1970 output at 230,000 tons. The gain of 5 percent, however, was well below the prior growth rate of 11 percent. Because of stringent air-quality standards, the seven lead-zinc smelting companies are faced with major capital investment for antipollution controls. Nippon Mining Co. Ltd. discovered a promising vein deposit of silver-lead-zinc ore in its Toyoha mine near Hokkaido. A 5-year development plan will be undertaken to produce 60,000 tons of crude ore per month, thus doubling the Toyoha output.

Mexico.—Cía. Industrial Peñoles S.A. was modernizing its lead smelter at Torreón, Coahuila State, to add over 20,000 tons in annual bullion capacity, bringing total capacity to over 130,000 tons. Development of the La Negra mine in Querétaro State was in progress. It will have a capacity of 14,000 tons of silver-lead ore monthly.

Asarco Mexicana, S.A., 49-percent owned by ASARCO, continued a mine expansion and modernization program and produced 83,300 tons of refined lead, slightly above the 1969 tonnage. The new 660-ton-per-day mill at the San Martin unit began operation at midyear; the new 350-ton-per-day mill at the Santa Eulalia unit was under construction, and major mine development works continued at the Santa Barbara and Taxco units. A new updraft sintering plant was under construction at the Chihuahua lead smelter; together with other improvements at the smelter and the Monterrey lead refinery, it will provide added concentrate capacity.[16]

Morocco.—A new deposit discovered in 1968 near the Zellidja mine is being developed to produce at an estimated rate of 25,000 tons per year beginning in 1971. Reserves were estimated at 11 million tons averaging 2.75 percent lead. The concentrates will be smelted by Fonderies Peñarroya-Zellidja, in a 30,000-ton-per-year plant at Oued El Heimer.

Peru.—The Cerro de Pasco base metal complex of Cerro Corp. was adversely affected by sporadic labor disturbances during the year which reduced lead output about 7 percent to 79,300 tons. About 32 percent of the lead was derived from purchased ores. The principal mine at Cerro

[15] New York and Honduras Rosario Mining Co. Annual Report. 1970, pp. 4–11.
[16] Page 15 of work cited in footnote 9.

de Pasco dates back to the Incas who worked it for gold and silver. Cerro Corp. began operations in 1902, principally for copper. Presently the mine is operated chiefly for lead and zinc, by both open pit and underground methods. Expansion of the open pit presently involves a major construction and town moving project.[17]

Spain.—Peñarroya's lead smelting plant at Cartagena was modernized and its capacity increased from 30,000 to 100,000 tons per year. The company's 20,000-ton plant at Córdoba will be dismantled. It was estimated that Peñarroya produced about 50,000 tons of Spain's 76,000-ton lead output in 1970.

Yugoslavia.—The Yugoslav lead-zinc industry is planning to increase production significantly in 1971 as a result of developments during 1970. Lead-zinc ore is expected to reach 3.2 million tons, of which 1.75 million tons will be supplied by the Trepca combine of mines 580,000 tons by the Zletovo-Sase mines in Macedonia, and 400,000 tons by Mezica deposits in Slovenia. Lead concentrate production in 1971 is expected to be 157,000 tons compared with 131,000 tons in 1970.

TECHNOLOGY

Technological activity in the lead industry was directed not only to research and development related to new and expanded markets for lead, but significantly greater efforts were directed to solving, economically, the increasingly strict air and water quality standards and other environmental problems. Research aiming toward improving methods and equipment to control smelter-stack emission, improvement in concentration methods to alleviate water pollution and land beautification problems, and development of automotive exhaust controlling devices was intensified by industry and Government. Technical assistance was also devoted to improving solid waste reclamation and metal recycling.

The International Lead Zinc Research Organization (ILZRO) coordinates research and development on an international basis. Incorporated in 1965, the organization now has 34 supporting companies in 14 countries and is conducting about 55 lead research projects. The Environmental Health program involved many projects conducted jointly by ILZRO, other involved industries, and Government agencies.

The Library and Abstracting Service, Zinc Development Association and Lead Development Association (London) ZDA/LDA, which exists for the service of lead and zinc users throughout the world and financed by the various international lead and zinc research and development associations, provides abstracts of current world literature and published research upon inquiry to Lead Industries Association Inc., 292 Madison Avenue, New York, N.Y. 10017.

[17] Cerro Corp. Annual Report. 1970, pp. 6–7.

Table 2.—Mine production of recoverable lead in the United States, by State

(Short tons)

State	1966	1967	1968	1969	1970
Alaska	14	--------	W	2	--------
Arizona	5,211	4,771	1,704	217	285
California	1,976	1,735	4,001	2,518	1,772
Colorado	23,082	21,923	19,778	21,767	21,855
Idaho	72,334	61,387	54,790	65,597	61,211
Illinois	2,285	2,384	1,467	791	1,532
Kansas	1,109	1,031	1,227	395	80
Kentucky	484	845	W	--------	--------
Missouri	132,255	152,649	212,611	355,452	421,764
Montana	4,409	898	1,870	1,753	996
Nevada	3,581	1,500	863	1,420	364
New Mexico	1,596	1,827	1,363	2,368	3,550
New York	1,097	1,653	1,396	1,686	1,280
Oklahoma	2,999	2,727	2,387	605	797
Oregon	--------	--------	W	(1)	(1)
South Dakota	--------	--------	--------	1	3
Tennessee	181	--------	--------	--------	--------
Utah	64,124	53,813	45,205	41,332	45,377
Virginia	3,078	3,430	3,573	3,358	3,356
Washington	5,859	2,762	5,655	8,649	6,784
Wisconsin	1,694	1,596	1,126	1,102	761
Other States	--------	--------	140	--------	--------
Total	327,368	316,931	359,156	509,013	571,767

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 1970, 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	360	31	2	450	1	63	2,010	36	100
California	----------	----------	----------	----------	----------	----------	(1)	(1)	(1)
Colorado	1,429	37	2	295,321	2,390	31,456	357,247	10,337	13,315
Idaho	36,085	3,225	509	(2)	(2)	(2)	[2] 927,449	[2] 56,113	[2] 39,608
Kansas	----------	----------	----------	61,654	71	1,173	634	9	13
Missouri	[3] 8,815,880	[4] 421,764	50,721	----------	----------	----------	----------	----------	----------
Montana	11,390	636	39	4,994	147	1,361	26	3	2
Nevada	3,697	266	78	----------	----------	----------	556	27	24
New Jersey	----------	----------	----------	168,723	----------	28,683	----------	----------	----------
New Mexico	----------	----------	----------	(2)	(2)	(2)	[2] 162,190	[2] 3,546	[2] 16,054
New York	----------	----------	----------	175,965	----------	15,810	566,306	1,280	42,767
Oklahoma	----------	----------	----------	64,367	427	1,865	----------	----------	----------
Oregon	----------	----------	----------	----------	----------	----------	----------	----------	----------
Pennsylvania	----------	----------	----------	622,499	----------	29,554	----------	----------	----------
South Dakota	----------	----------	----------	----------	----------	----------	----------	----------	----------
Tennessee	----------	----------	----------	4,156,482	----------	107,922	----------	----------	----------
Utah	(5)	(5)	(5)	----------	----------	----------	[5] 456,676	[5] 40,105	[5] 31,529
Virginia	----------	----------	----------	670,395	3,356	18,063	----------	----------	----------
Washington	----------	----------	----------	(6)	(6)	(6)	[6] 661,872	[6] 6,784	[6] 11,956
Wisconsin	----------	----------	----------	749,488	761	20,634	----------	----------	----------
Other States	----------	----------	----------	325,094	536	11,205	----------	----------	----------
Total	8,868,841	425,959	51,351	7,295,432	7,689	267,789	3,134,966	118,240	155,368
Percent of total lead-zinc	----------	75	10	----------	1	50	----------	21	29

See footnotes at end of table.

Table 3.—Production of lead and zinc in the United States in 1970, by State and class of ore, from old tailings, etc., in terms of recoverable metals—Continued

(Short tons)

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [7]			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	130,953	210	9,402	40,314,819	7	51	40,448,592	285	9,618
California	----------	----------	----------	[1] 104,215	[1] 1,772	[1] 3,514	104,215	1,772	3,514
Colorado	361,002	7,180	10,553	118,078	1,911	1,368	1,133,077	21,855	56,694
Idaho	----------	----------	----------	574,392	1,873	935	1,537,926	61,211	41,052
Kansas	----------	----------	----------	----------	----------	----------	62,288	80	1,186
Missouri	----------	----------	----------	----------	----------	----------	8,815,880	421,764	50,721
Montana	----------	----------	----------	31,037	210	55	47,447	996	1,457
Nevada	673	28	13	103,384	43	12	108,310	364	127
New Jersey	----------	----------	----------	----------	----------	----------	168,723	----------	28,683
New Mexico	----------	----------	----------	1,127,137	4	547	1,289,327	3,550	16,601
New York	----------	----------	----------	----------	----------	----------	742,271	1,280	58,577
Oklahoma	----------	----------	----------	8,297	370	785	72,664	797	2,650
Oregon	----------	----------	----------	300	(8)	----------	300	(8)	----------
Pennsylvania	----------	----------	----------	----------	----------	----------	622,499	----------	29,554
South Dakota	----------	----------	----------	49	3	1	49	3	1
Tennessee	1,680,070	----------	10,338	----------	----------	----------	5,836,552	----------	118,260
Utah	115,762	5,117	3,101	11,322	155	58	583,760	45,377	34,688
Virginia	----------	----------	----------	----------	----------	----------	670,395	3,356	18,063
Washington	----------	----------	----------	(6)	(6)	(6)	661,872	6,784	11,956
Wisconsin	----------	----------	----------	----------	----------	----------	749,488	761	20,634
Other States	214,148	----------	9,114	348,171	996	9,781	887,413	1,532	30,100
Total	2,502,608	12,535	42,521	42,741,201	7,344	17,107	64,543,048	571,767	534,136
Percent of total lead-zinc	----------	2	8	----------	1	3	----------	100	100

[1] Lead-zinc ore and ore from "Other Sources" combined to avoid disclosing individual company confidential data.
[2] Zinc and lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Includes minor amount of lead tailings commingled with ore at mill; excludes barium sulfate ore.
[4] Includes lead recovered from barium sulfate ore.
[5] Lead and lead-zinc ores combined to avoid disclosing individual company confidential data.
[6] Zinc ore and ore from "Other Sources" combined with lead-zinc ore to avoid disclosing individual company confidential data.
[7] Lead and zinc recovered from copper, gold, silver, fluorspar, and uranium ores, and from smelter slags, mill tailings, and miscellaneous cleanups.
[8] Less than ½ unit.

Table 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1969	1970	Month	1969	1970
January	36,805	47,151	August	45,099	47,435
February	34,944	46,333	September	43,178	47,940
March	38,816	51,771	October	46,231	46,167
April	42,253	49,098	November	42,289	47,840
May	43,816	49,640	December	46,128	45,842
June	45,124	46,797			
July	44,330	45,753	Total	509,013	571,767

Table 5.—Twenty-five leading lead-producing mines in the United States in 1970, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Fletcher	Reynolds, Mo	St. Joe Minerals Corp	Lead ore.
2	Magmont	Iron, Mo	Cominco American, Inc	Do.
3	Viburnum	Crawford, Iron, and Washington, Mo.	St. Joe Minerals Corp	Do.
4	Ozark	Reynolds, Mo	Ozark Lead Co	Do.
5	Buick	Iron, Mo	Missouri Lead Operating 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-zinc ore.
9	U.S. and Lark	Salt Lake, Utah	U.S. Smelting Refining and Mining Co.	Lead and lead-zinc ores.
10	Burgin	Utah, Utah	Kennecott Copper Corp	Do.
11	Indian Creek	Washington, Mo	St. Joe Minerals Corp	Lead ore.
12	Star-Morning	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
13	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
14	Mayflower	Wasatch, Utah	Hecla Mining Co	Do.
15	Pend Oreille	Pend Oreille, Wash	Pend Oreille Mines & Metals Co.	Lead-zinc ore.
16	Sunnyside	San Juan, Colo	Standard Metals Corp	Do.
17	United Park City	Summit and Wasatch, Utah	United Park City Mines Co	Do.
18	Austinville and Ivanhoe.	Wythe, Va	The New Jersey Zinc Co	Zinc ores.
19	Ground Hog	Grant, N. Mex	American Smelting and Refining Co.	Lead-zinc ore.
20	Eagle	Eagle, Colo	The New Jersey Zinc Co	Zinc ore.
21	Van Stone	Stevens, Wash	American Smelting and Refining Co.	Do.
22	Dayrock	Shoshone, Idaho	Day Mines, Inc	Lead ore.
23	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
24	Darwin	Inyo, Calif	Darwin Mines	Lead-zinc ore.
25	Emperius	Mineral, Colo	Emperius Mining Co	Do.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1966	1967	1968	1969	1970
Refined lead:					
From primary sources:					
Domestic ores and base bullion	318,646	258,507	349,039	513,931	528,086
Foreign ores and base bullion	122,089	121,387	118,271	124,724	138,644
Total	440,735	379,894	467,310	638,655	666,730
From secondary sources	9,004	2,538	2,259	4,966	4,367
Grand total	449,739	382,432	469,569	643,621	671,097
Calculated value of primary refined lead (thousands) [1]	$133,278	$106,370	$123,463	$190,702	$209,220

[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
1966	24,059	2,119	8.8	6,025	5,157	10,758	21,940
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

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1970

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	2,672	52,614	--------	52,342	52,342	2,944
Hard lead	1,553	19,622	--------	18,930	18,930	2,245
Cable lead	621	27,108	--------	26,462	26,462	1,267
Battery-lead plates	42,240	506,994	--------	512,030	512,030	37,204
Mixed common babbitt	304	3,503	--------	3,372	3,372	435
Solder and tinny lead	381	10,659	--------	10,640	10,640	400
Type metals	3,279	30,309	--------	32,001	32,001	1,587
Drosses and residues	22,310	126,359	121,766	--------	121,766	26,903
Total	73,360	777,168	121,766	655,777	777,543	72,985
Foundries and other manufacturers:						
Soft lead	--------	129	--------	84	84	45
Hard lead	20	82	--------	85	85	17
Cable lead	41	88	--------	82	82	47
Battery-lead plates	36	44	--------	--------	--------	80
Mixed common babbitt	59	8,437	--------	8,427	8,427	69
Solder and tinny lead	--------	--------	--------	--------	--------	--------
Type metals	--------	--------	--------	--------	--------	--------
Drosses and residues	r 55	--------	--------	--------	--------	55
Total	r 211	8,780	--------	8,678	8,678	313
All consumers:						
Soft lead	2,672	52,743	--------	52,426	52,426	2,989
Hard lead	1,573	19,704	--------	19,015	19,015	2,262
Cable lead	662	27,196	--------	26,544	26,544	1,314
Battery-lead plates	42,276	507,038	--------	512,030	512,030	37,284
Mixed common babbitt	363	11,940	--------	11,799	11,799	504
Solder and tinny lead	381	10,659	--------	10,640	10,640	400
Type metals	3,279	30,309	--------	32,001	32,001	1,587
Drosses and residues	r 22,365	126,359	121,766	--------	121,766	26,958
Grand total	r 73,571	785,948	121,766	664,455	786,221	73,298

r Revised.

Table 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1970, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	138,890				138,890
Remelt lead	20,277				20,277
Total	159,167				159,167
Refined pig tin		2,686			2,686
Remelt tin		197			197
Total		2,883			2,883
Lead and tin alloys:					
Antimonial lead	348,358	393	16,002	414	365,167
Common babbitt	10,312	652	1,073	61	12,098
Genuine babbitt	16	113	10	4	143
Solder	33,348	5,486	823	142	39,799
Type metals	25,389	1,699	3,477	3	30,568
Cable lead	8,110	2	25		8,137
Miscellaneous alloys	864	96	14	137	1,111
Total	426,397	8,441	21,424	761	457,023
Tin content of chemical products		784			784
Grand total	585,564	12,108	21,424	761	619,857

[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)

	1966	1967	1968	1969	1970
As metal:					
At primary plants	9,004	2,538	2,259	4,966	4,367
At other plants	147,215	147,806	136,607	149,344	154,800
Total	156,219	150,344	138,866	154,310	159,167
In antimonial lead:					
At primary plants	10,758	7,808	6,862	6,409	7,599
At other plants	272,977	280,911	301,701	336,066	340,759
Total	283,735	288,719	308,563	342,475	348,358
In other alloys	132,880	114,709	103,450	107,120	89,865
Grand total:					
Quantity	572,834	553,772	550,879	603,905	597,390
Value (thousands)[1]	$173,225	$155,056	$145,542	$180,326	$187,461

[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	1969	1970	Form of recovery	1969	1970
New scrap:			As soft lead:		
Lead-base	81,672	86,753	At primary plants	4,966	4,367
Copper-base	5,898	4,144	At other plants	149,344	154,800
Tin-base	398	307	Total	154,310	159,167
Total	87,968	91,204	In antimonial lead[1]	342,475	348,358
Old scrap:			In other lead alloys	90,582	77 159
Battery-lead plates	349,507	350,273	In copper-base alloys	16,511	12,690
All other lead-base	147,796	139,365	In tin-base alloys	27	16
Copper-base	18,631	16,546			
Tin-base	3	2	Total	449,595	438,223
Total	515,937	506,186	Grand total	603,905	597,390
Grand total	603,905	597,390			

[1] Includes 6,409 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1969 and 7,599 in 1970.

Table 12.—Lead consumption in the United States, by products

(Short tons)

Product	1969	1970	Product	1969	1970
Metal products:			Pigments—Continued		
Ammunition	79,233	72,726	Pigment colors	14,670	14,407
Bearing metals	17,406	16,328	Other [1]	1,201	1,178
Brass and bronze	21,512	18,927			
Cable covering	54,203	50,772	Total	102,386	98,736
Calking lead	44,857	34,608			
Casting metals	9,918	7,498	Chemicals:		
Collapsible tubes	12,484	10,913	Gasoline antiknock additives	271,128	278,505
Foil	5,881	5,521	Miscellaneous chemicals	602	623
Pipes, traps, and bends	19,407	17,888			
Sheet lead	25,818	21,050	Total	271,730	279,128
Solder	72,626	69,707			
Storage batteries:			Miscellaneous uses:		
Battery grids, posts, etc	280,386	283,451	Annealing	4,252	4,161
Battery oxides	302,160	310,002	Galvanizing	1,797	1,792
Terne metal	1,583	1,038	Lead plating	406	400
Type metal	25,660	24,476	Weights and ballast	17,366	16,184
Total	973,134	944,905	Total	23,821	22,537
Pigments:			Other, unclassified uses	18,287	15,246
White lead	6,617	5,936			
Red lead and litharge	79,898	77,215	Grand total [2]	1,389,358	1,360,552

[1] Includes lead content of leaded zinc oxide and other pigments.
[2] Includes lead which went directly from scrap to fabricated products.

Table 13.—Lead consumption in the United States, by months

(Short tons)

Month	1969	1970	Month	1969	1970
January	118,080	118,444	August	112,189	110,486
February	105,585	110,497	September	123,941	114,215
March	117,508	120,832	October	131,891	115,419
April	115,948	117,797	November	112,521	103,401
May	117,272	117,547	December	117,749	114,889
June	115,780	116,137			
July	100,894	100,888	Total [1]	1,389,358	1,360,552

[1] Includes lead content of leaded zinc oxide and other pigments and lead which went directly from scrap to fabricated products.

Table 14.—Lead consumption in the United States in 1970, by class of products and types of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	173,491	83,366	45,310	14,133	316,300
Storage batteries	318,571	274,882			593,453
Pigments	97,558				97,558
Chemicals	278,843	285			279,128
Miscellaneous	9,754	12,546	143		22,443
Unclassified	13,939	896	411		15,246
Total	892,156	371,975	45,864	14,133	[1] 1,324,128

[1] Excludes 35,246 tons of lead that went directly from scrap to fabricated products, and 1,178 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

Table 15.—Lead consumption in the United States in 1970, by States [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	94,958	37,901	5,777	760	139,396
Colorado	1,146	3,135	64	---------	4,345
Connecticut	16,664	8,945	8	1,018	26,635
District of Columbia	136	---------	---------	---------	136
Florida	5,541	6,802	---------	---------	12,343
Georgia	44,985	17,121	1,887	---------	63,993
Illinois	75,277	38,138	7,185	1,847	122,447
Indiana	74,927	39,842	1,838	342	116,949
Kansas	11,089	10,095	58	215	21,457
Kentucky	3,040	7,726	1	---------	10,767
Maryland	1,176	12,918	37	---------	14,131
Massachusetts	5,081	722	15	135	5,953
Michigan	18,109	18,815	1,517	421	38,862
Missouri	36,172	10,606	189	525	47,492
Nebraska	3,680	627	44	947	5,298
New Jersey	132,984	18,703	10,165	678	162,530
New York	38,214	1,984	10,708	873	51,779
Ohio	8,575	3,357	3,013	883	15,828
Pennsylvania	59,589	40,573	746	2,600	103,508
Rhode Island	1,968	174	33	---------	2,175
Tennessee	201	13,319	205	130	13,855
Virginia	650	1,501	823	1,121	4,095
Washington	8,022	742	340	---------	9,104
West Virginia	19,233	3,826	---------	---------	23,059
Wisconsin	3,530	4,552	44	218	8,344
Alabama and Mississippi	1,442	4,233	---------	415	6,090
Arkansas and Oklahoma	4,718	2,685	80	---------	7,483
Hawaii and Oregon	1,545	4,444	---------	---------	5,989
Iowa and Minnesota	4,111	11,709	114	397	16,331
Louisiana and Texas	202,828	33,369	926	464	237,587
Montana and Idaho	1,344	---------	---------	---------	1,344
New Hampshire, Maine, Vermont, Delaware	7,681	10,341	47	144	18,213
North and South Carolina	3,501	3,070	---------	---------	6,571
Utah, Nevada, Arizona	39	---------	---------	---------	39
Total	892,156	371,975	45,864	14,133	1,324,128

[1] Excludes 35,246 tons of lead that went directly from scrap to fabricated products and 1,178 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

Table 16.—Production and shipments of lead pigments [1] and oxides in the United States

Product	1969				1970			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [2]			Short tons	Value [2]	
			Total	Average per ton			Total	Average per ton
White lead:								
Dry	8,551	7,858	$3,357,280	$427	6,497	7,287	$3,037,038	$417
In oil [3]	1,944	2,501	1,776,903	710	2,878	1,351	863,942	639
Total	10,495	10,359	5,134,183	496	9,375	8,638	3,900,980	452
Red lead	23,583	22,177	8,067,711	364	20,316	19,444	7,585,560	390
Litharge	123,395	135,719	44,396,471	327	132,529	146,343	49,206,528	336
Black oxide	244,586	-------	----------	------	247,862	-------	----------	------

[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 sources

(Short tons)

Product	1969				1970			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead	-------	-------	8,396	8,396	-------	-------	7,500	7,500
Red lead	-------	-------	21,378	21,378	-------	-------	18,416	18,416
Litharge	-------	-------	114,757	114,757	-------	-------	123,252	123,252
Black oxide	-------	-------	233,312	233,312	-------	-------	236,514	236,514
Leaded zinc oxide	367	204	-------	571	304	211	-------	515
Total	367	204	377,843	378,414	304	211	385,682	386,197

[1] Excludes lead in basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.

Table 18.—Distribution of white lead (dry and in oil) shipments,[1] by industries

(Short tons)

Industry	1966	1967	1968	1969	1970
Paints	8,260	6,968	6,681	5,969	4,460
Ceramics	130	96	124	67	26
Other	6,486	5,064	4,829	4,323	4,152
Total	14,876	12,128	11,634	10,359	8,638

[1] Excludes basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.

Table 19.—Distribution of red lead shipments, by industries

(Short tons)

Industry	1966	1967	1968	1969	1970
Paints	14,480	13,318	11,347	9,191	7,848
Storage batteries	W	W	W	9,302	W
Other	16,790	12,423	12,464	3,684	11,596
Total	31,270	25,741	23,811	22,177	19,444

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

Table 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1966	1967	1968	1969	1970
Ceramics	23,476	19,491	24,123	21,570	24,578
Insecticides	1,166	W	W	W	W
Oil refining	1,991	1,835	1,849	1,603	2,016
Rubber	2,296	1,928	1,986	1,794	1,663
Varnish	1,620	1,228	W	W	W
Other	79,754	75,500	103,220	110,752	118,086
Total	110,303	99,982	131,178	135,719	146,343

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	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
White lead	1,731	$661	1,105	$431
Red lead	5,517	1,365	6,909	1,827
Litharge	23,982	5,542	13,703	3,278
Other lead pigments	342	107	219	54
Other lead compounds	901	309	655	255
Total	32,473	7,984	22,591	5,845

Table 22.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1966	1967	1968	1969	1970
Refined pig lead	16,175	18,243	11,490	21,283	90,866
Lead in antimonial lead	6,396	5,119	3,852	4,448	6,988
Lead in base bullion	15,606	16,622	11,471	12,726	11,710
Lead in ore and matte	77,296	85,495	63,614	63,403	83,421
Total	115,473	125,479	90,427	101,860	192,985

Table 23.—Consumer stocks of lead in the United States, Dec. 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1966	44,490	34,704	10,071	1,041	90,306
1967	59,837	35,879	8,919	1,151	105,786
1968	43,933	r 25,009	9,184	774	r 78,900
1969	67,304	r 49,649	8,506	945	r 126,404
1970	82,823	42,420	7,344	915	133,502

r Revised.

Table 24.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London [1]

(Cents per pound)

Month	1969			1970		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	13.24	13.44	11.46	16.30	16.50	14.72
February	13.80	14.00	11.67	16.30	16.50	15.18
March	13.80	14.00	11.80	16.30	16.50	15.24
April	14.22	14.42	12.13	16.30	16.50	14.59
May	14.30	14.50	12.54	16.30	16.50	14.22
June	14.68	14.88	12.89	16.30	16.50	13.95
July	15.25	15.45	14.04	15.48	15.68	13.56
August	15.30	15.50	14.24	14.92	15.12	12.87
September	15.30	15.50	13.62	14.55	14.75	12.82
October	15.30	15.50	13.26	14.55	14.75	12.85
November	15.42	15.62	14.28	14.55	14.75	12.64
December	16.09	16.29	15.12	13.99	14.19	12.49
Average	14.73	14.93	13.09	15.49	15.69	13.76

[1] St. Louis: Metal Statistics, 1971. New York: Metal Statistics, 1971. London: Metals Week.
[2] Based on monthly rates of exchange by Federal Reserve Board.

Table 25.—U.S. exports of lead, by countries [1] [2]

Destination	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Unwrought lead and lead alloys:				
Belgium-Luxembourg	973	$835	2	$1
Canada	198	104	804	295
Chile	24	7	---	---
Dominican Republic	18	12	95	54
India	1	1	770	249
Italy	290	102	---	---
Japan	241	182	15	8
Korea, Republic of	83	90	39	14
Mexico	115	54	81	43
Netherlands	15	6	19	7
Pakistan	22	9	53	19
Philippines	98	45	87	49
Spain	---	---	1,791	519
Sweden	69	47	176	136
Taiwan	55	26	141	68
United Kingdom	79	53	211	64
Venezuela	33	29	375	134
Vietnam, South	28	8	29	10
Other	244	173	281	184
Total	2,586	1,783	4,969	1,854
Wrought lead and lead alloys:				
Belgium-Luxembourg	13	26	12	14
Brazil	65	32	5	5
Canada	212	198	316	344
Chile	12	9	110	63
Colombia	79	39	38	25
Dominican Republic	71	37	45	36
Italy	30	32	58	54
Japan	80	132	58	149
Korea, Republic of	46	41	62	28
Mexico	31	28	171	142
Netherlands	195	409	423	759
Pakistan	82	53	94	64
Philippines	43	26	27	30
Spain	27	15	7	11
Sweden	121	96	112	101
Taiwan	25	21	47	26
Turkey	1	(2)	366	240
United Kingdom	204	208	106	172
Venezuela	318	170	176	130
Vietnam, South	165	61	33	15
Other	562	497	512	495
Total	2,382	2,130	2,778	2,903
Scrap:				
Belgium-Luxembourg	189	29	702	127
Canada	492	68	781	180
Germany, West	259	45	250	33
Italy	---	---	983	216
Japan	---	---	192	93
Netherlands	252	62	314	63
South Africa, Republic of	---	---	110	22
Spain	122	36	---	---
United Kingdom	1,018	262	659	268
Venezuela	---	---	106	17
Other	8	3	117	37
Total	2,340	505	4,214	1,056

[1] Owing to changes in classifications in 1970, exports and reexports for 1969 have been changed to agree with new classifications.
[2] In addition foreign lead was reexported as follows: unwrought lead and lead alloys 1969, 29 tons ($10,183); 1970, 293 tons ($95,256). Wrought lead and lead alloys 1969, 1 ton ($2,127); 1970, 150 tons ($54,026).

Table 26.—U.S. imports [1] of lead, by countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Ore, flue dust, and matte (lead content):						
Australia	20,592	$3,772	20,335	$4,556	29,360	$6,468
Bolivia	5,718	994	3,605	724	3,041	561
Canada	36,815	6,733	48,606	10,299	41,337	9,223
Chile	490	89	-------	-------	10	3
Colombia	1	(2)	345	22	464	62
Honduras	9,272	1,782	12,988	2,606	15,054	2,539
Mexico	303	40	301	46	440	101
Peru	13,976	2,610	22,582	4,933	21,337	5,117
South Africa, Republic of	608	97	365	35	-------	-------
Other	r 61	r 13	125	22	1,363	261
Total	87,836	16,130	109,252	23,243	112,406	24,335
Base bullion (lead content):						
Australia	-------	-------	1,979	693	-------	-------
Canada	8	4	1	2	-------	-------
Mexico	-------	-------	13	4	170	40
United Kingdom	-------	-------	-------	-------	126	93
Total	8	4	1,993	699	296	133
Pigs and bars (lead content):						
Australia	46,919	9,851	60,791	14,417	51,705	13,902
Belgium-Luxembourg	18,649	4,343	1,315	465	680	396
Burma	-------	-------	150	36	341	132
Canada	60,161	14,637	44,457	11,409	63,753	19,107
Denmark	46	41	114	136	140	64
France	4,604	973	5,627	1,258	1,255	357
Germany, West	20,711	7,552	1,289	723	703	2,037
Mexico	56,516	12,062	57,451	13,973	38,368	10,156
Peru	75,105	18,896	57,249	15,687	52,473	16,292
South Africa, Republic of	8,298	2,201	12,558	3,706	12,984	4,164
Sweden	3,868	847	-------	-------	-------	-------
United Kingdom	22,919	5,546	8,664	3,752	2,928	1,508
Yugoslavia	19,775	4,155	27,862	6,272	18,765	4,930
Other	549	368	853	259	528	352
Total	338,120	81,472	278,380	72,093	244,623	73,397
Reclaimed scrap, etc. (lead content):						
Australia	2,280	986	36	15	3,638	1,098
Canada	2,834	528	4,866	1,222	2,075	661
Dominican Republic	292	31	236	29	-------	-------
Mexico	670	111	1,253	191	1,056	141
Netherlands Antilles	60	11	45	9	-------	-------
New Zealand	64	11	-------	-------	-------	-------
Panama	221	27	420	69	84	21
Other	60	10	106	23	4	(2)
Total	6,481	1,715	6,962	1,558	6,857	1,921
Grand total	432,445	99,321	396,587	97,593	364,182	99,786

r Revised.
[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 countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Ore, flue dust, and matte (lead content):						
Australia	12,640	$2,274	24,003	$5,004	6,726	$1,539
Bolivia	6,708	1,308	4,308	770	1,914	358
Canada	36,912	7,583	44,764	8,967	23,436	4,474
Chile	2,440	513	1,679	322	-------	-------
Colombia	113	17	-------	-------	301	19
Honduras	7,730	1,532	13,992	2,871	1,087	192
Mexico	321	54	555	95	121	23
Peru	28,999	5,545	21,794	4,023	8,228	1,595
South Africa, Republic of	836	133	413	43	-------	-------
Other	164	31	3,778	602	793	160
Total	96,863	18,990	115,286	22,697	42,606	8,360
Base bullion (lead content):						
Australia	-------	-------	1,979	693	876	238
Canada	8	4	1	2	-------	-------
Mexico	-------	-------	13	4	175	117
United Kingdom	-------	-------	-------	-------	126	93
Total	8	4	1,993	699	1.177	448
Pigs and bars (lead content):						
Australia	46,919	9,851	60,791	14,417	51,705	13,902
Belgium-Luxembourg	19,149	4,354	1,814	476	680	396
Burma	-------	-------	150	36	341	132
Canada	60,161	14,637	44,457	11,409	63,753	19,107
Denmark	46	41	108	136	140	64
France	4,604	973	5,627	1,258	1,255	357
Germany, West	19,711	7,333	1,289	723	703	2,037
Mexico	56,516	12,062	57,451	13,973	38,368	10,156
Peru	75,105	18,896	57,249	15,687	52,473	16,292
South Africa, Republic of	8,298	2,201	12,558	3,706	12,984	4,164
United Kingdom	22,919	5,546	8,664	3,752	2,928	1,508
Yugoslavia	19,775	4,155	27,862	6,272	18,765	4,930
Other	4,417	1,215	853	259	528	352
Total	337,620	81,264	278,873	72,104	244,623	73,397
Reclaimed scrap, etc. (lead content):						
Australia	30	14	79	27	352	116
Canada	2,834	528	4,515	1,147	1,394	495
Dominican Republic	292	31	236	29	-------	-------
Mexico	670	111	1,253	191	1,056	141
Netherlands Antilles	60	11	45	9	19	4
New Zealand	64	11	-------	-------	-------	-------
Panama	221	27	420	69	84	21
Spain	-------	-------	7	1	37	11
United Kingdom	-------	-------	28	18	23	7
Other	78	15	99	22	16	3
Total	4,249	748	6,682	1,513	2,981	798
Sheets, pipe, and shot:						
Belgium-Luxembourg	344	90	121	34	45	17
Canada	182	66	190	79	320	169
Germany, West	12	4	7	3	-------	-------
Netherlands	243	64	49	15	87	33
United Kingdom	112	32	30	10	35	13
Yugoslavia	-------	-------	121	33	26	9
Total	893	256	518	174	513	241
Grand total	439,633	101,262	403,352	97,187	291,900	83,244

[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.

Table 28.—U.S. imports for consumption of lead, by classes [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		
1968	97	$18,990	(2)	$4	338	$81,264	4	$748	1	$256	$273	$101,535
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

[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)
1968	1,204	566	$2,244
1969	2,134	667	3,822
1970	1,429	836	2,364

Table 30.—Lead: World mine production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada	360,025	330,781	394,547
Guatemala	520	314	1,198
Honduras	14,523	15,255	17,598
Mexico [2]	191,988	188,377	194,665
United States [3]	359,156	509,013	571,767
South America:			
Argentina	r 29,400	42,651	e 42,000
Bolivia	r 23,902	27,230	27,995
Brazil	29,782	30,416	30,350
Chile	1,091	917	885
Colombia	816	451	645
Peru [4]	170,333	170,354	170,859
Europe:			
Austria [3]	7,474	7,503	6,617
Bulgaria	103,500	100,500	e 130,000
Czechoslovakia	7,640	7,310	e 7,700
Finland	4,987	5,019	5,517
France	r 29,101	33,290	e 32,500
Germany, East e	r 11,000	r 11,000	10,800
Germany, West	57,867	43,335	44,650
Greece	r 9,995	9,551	10,171
Hungary e	1,100	1,100	1,100
Ireland	r 68,600	64,700	65,400
Italy	r 40,200	40,800	37,772
Norway	3,892	3,872	4,140
Poland	52,900	60,000	e 66,700
Portugal	r 2,521	1,986	1,613
Romania e	r 36,000	r 48,000	46,000
Spain	81,621	79,090	71,580
Sweden	r 79,402	88,200	e 88,000
U.S.S.R. e	460,000	r 485,000	485,000
United Kingdom	3,580	e 3,300	e 3,300
Yugoslavia	123,203	130,122	139,655
Africa:			
Algeria	5,700	8,700	8,700
Congo (Brazzaville) e	r 1,100	550	550
Morocco	79,787	77,832	80,538
South-West Africa [5]	r 69,382	72,588	76,843
Tunisia	r 17,600	25,800	22,400
Zambia [6]	24,133	25,350	29,517
Asia:			
Burma	r 10,903	9,586	8,912
China, mainland e	110,000	110,000	110,000
India	r 2,811	2,239	2,053
Indonesia	NA	NA	e 220
Iran e [7]	r 24,347	23,920	25,287
Japan [8]	69,306	69,953	70,996
Korea, North e	77,000	77,000	77,000
Korea, Republic of	r 17,301	18,163	17,655
Philippines	93	74	15
Thailand	2,998	2,094	1,488
Turkey e	r 7,700	7,900	12,000
Oceania: Australia	428,712	497,416	495,928
Total	r 3,314,992	r 3,568,602	3,750,826

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

[1] In addition to the countries listed, Pakistan, Uganda, and United Arab Republic 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, tellurium-lead bars, and bismuth-lead bars).

[5] Year ending June 30 of that stated.

[6] Smelter production.

[7] Year beginning March 21 of that stated.

[8] Content of concentrates.

Table 31.—Lead: World smelter production, by countries [1]

(Short tons)

Country	1968	1969	1970 p
North America:			
Canada (refined)	202,100	187,142	204,630
Guatemala [2]	220	248	83
Mexico (refined)	189,884	186,308	165,645
United States (refined) [3]	467,310	638,655	666,730
South America:			
Argentina	r 27,600	24,250	e 42,000
Bolivia (refined, including solder)	225	24	9
Brazil	17,821	20,635	21,259
Peru (refined)	r 95,221	r 85,478	79,340
Europe:			
Austria [4]	8,881	8,245	9,637
Belgium	r 105,100	107,100	103,000
Bulgaria [2]	r 102,200	104,800	108,000
Czechoslovakia [2]	r 19,715	22,206	e 19,800
France	110,154	118,972	e 132,000
Germany, East e	r 27,000	r 27,000	26,000
Germany, West	r 132,298	138,679	123,900
Greece (refined)	r 7,853	11,795	15,722
Hungary e [2]	1,100	1,100	1,100
Italy	63,442	68,701	59,842
Netherlands	18,943	16,308	19,415
Poland (refined) [2]	46,300	55,900	60,100
Portugal (refined)	r 1,353	1,245	626
Romania e	r 43,000	43,000	44,000
Spain	r 70,686	89,458	75,709
Sweden (refined)	r 46,200	46,400	44,800
U.S.S.R.	r 460,000	r 485,000	485,000
United Kingdom [5]	r 35,153	43,052	48,246
Yugoslavia (refined) [2]	r 116,825	117,899	107,364
Africa:			
Morocco	26,638	29,582	27,449
South-West Africa [6]	67,454	67,085	85,213
Tunisia [7]	15,459	17,782	25,134
Zambia	26,594	25,361	29,517
Asia:			
Burma [4]	r 10,588	10,985	10,697
China, mainland e	110,000	110,000	110,000
India	1,653	2,186	2,053
Iran [8]	r 202	e r 200	e 200
Japan (refined)	181,410	205,708	230,000
Korea, North e	60,000	60,000	60,000
Korea, Republic of	3,438	3,834	3,968
Turkey e	550	660	660
Oceania: Australia (refined and bullion)	r 326,330	378,215	388,624
Total	r 3,246,900	r 3,561,198	3,637,472

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 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 $287.6 million in 1970, 2 percent above the 1969 record. The quantity of lime produced however was about the same as in 1969. 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)

	1966	1967	1968	1969	1970
Number of plants	208	209	206	201	194
Sold or used by producers:					
Quicklime	13,195	13,449	14,440	15,479	15,248
Hydrated lime	2,669	2,656	2,364	2,864	3,126
Dead-burned dolomite	2,193	1,880	1,833	1,866	1,373
Total [2]	18,057	17,985	18,637	20,209	19,747
Value [3]	$239,588	$240,216	$249,639	$280,736	$286,155
Average value per ton	$13.27	$13.36	$13.39	$13.89	$14.49
Lime sold	11,451	11,461	12,054	13,113	12,718
Lime used	6,606	6,524	6,583	7,096	7,029
Exports [4]	60	52	69	51	54
Imports for consumption [4]	152	81	73	184	202

[1] Excludes regenerated lime. Excludes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] Selling value, f.o.b. plant, excluding cost of containers.
[4] Bureau of the Census.

DOMESTIC PRODUCTION

Lime producers sold or used 19.8 million tons, compared with 20.2 million tons in 1969, a decrease of 2 percent. Sales of lime declined 3 percent, but lime used by producers decreased only 1 percent. Figures include Puerto Rico.

Production of quicklime was 1 percent below that of 1969, hydrated lime production increased 11 percent, and production of refractory dolomite declined 26 percent. The number of plants decreased from 201 to 194.

Seven States, Ohio, Pennsylvania, Missouri, Texas, Michigan, Virginia, and Louisiana each producing more than 1 million tons, accounted for 65 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 New York and Louisiana; Bethlehem Steel Corp., with two plants in Pennsylvania and one in New York; Standard Lime & Refractories Co., with plants in Ohio, Pennsylvania, Illinois, and West Virginia; PPG Industries, Inc., with plants in Ohio and Texas; United States Gypsum Co., with two plants in Texas and one plant each in Ohio, Alabama, Louisiana, and Massachusetts; Pfizer, Inc., with plants in Ohio, Massachusetts, California, and Connecticut; The Dow Chemical Co., with plants in Michigan and Texas; and Olin Corp., with plants in Louisiana and Virginia. These 10 companies, operating 33 plants, accounted for 45 percent of the total lime production.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Lime sold or used by producers in the United States, by States and kinds [1]

(Thousand short tons and thousand dollars)

State	1969		1970			
	Total	Value	Hydrate	Quicklime	Total	Value
Alabama	747	$9,870	126	623	749	$10,286
Arizona	283	5,074	W	W	309	4,523
Arkansas	184	2,748	W	W	186	2,680
California	585	9,666	81	490	572	9,911
Colorado	127	2,449	--------	119	119	1,613
Florida	182	2,712	W	W	167	2,810
Hawaii	9	287	8	1	9	338
Kansas	W	W	--------	6	6	W
Louisiana	822	10,750	W	W	1,025	12,811
Massachusetts	199	3,718	W	W	W	W
Michigan	1,589	20,372	W	W	1,538	21,355
Montana	255	2,737	5	203	208	W
Nebraska	W	W	--------	27	27	W
New Mexico	W	W	37	--------	37	W
New York	1,055	10,224	W	W	W	W
Ohio	4,159	60,975	234	3,717	3,951	61,197
Oregon	115	2,337	W	W	96	1,777
Pennsylvania	2,008	28,952	322	1,564	1,887	29,279
Puerto Rico	41	1,505	40	1	41	W
Texas	1,633	22,107	782	892	1,673	24,427
Utah	191	3,947	W	W	186	3,756
Vermont	2	25	--------	--------	--------	--------
Virginia	1,072	13,653	70	977	1,046	14,090
West Virginia	269	3,648	W	W	262	3,757
Wisconsin	244	4,080	W	W	247	4,503
Wyoming	W	W	--------	22	22	W
Other States [2]	4,479	60,405	1,461	7,980	5,425	78,440
Total [3]	20,250	282,241	3,166	16,622	19,788	287,553

W Withheld to avoid disclosing individual company confidential data.

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Includes Connecticut, Idaho, Illinois, Indiana, Iowa, Maryland, Minnesota, Mississippi, Missouri, Nevada, New Jersey, 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 States and markets [1]

(Thousand short tons)

State	1969			1970		
	Plants	Sold	Used	Plants	Sold	Used
Arizona	6	W	W	7	185	124
California	15	225	360	15	230	342
Colorado	11	W	W	11	--------	119
Hawaii	1	W	W	1	8	1
Kansas	1	--------	W	1	--------	6
Montana	4	--------	255	4	--------	208
Nebraska	4	--------	W	4	--------	27
New Mexico	1	--------	W	1	--------	37
Ohio	23	2,548	1,611	20	2,315	1,636
Puerto Rico	1	41	--------	1	41	--------
Texas	15	866	768	13	934	739
Vermont	1	2	--------	--------	--------	--------
Wyoming	3	--------	W	3	--------	22
Other States [2]	116	9,472	4,102	114	9,046	3,768
Total	202	13,154	7,096	195	12,759	7,029

W Withheld to avoid disclosing individual company confidential data.

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Includes Alabama, Arkansas, Connecticut, Florida, Idaho, Illinois, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New York, North Dakota, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Utah, Virginia, Washington, West Virginia, Wisconsin, and States indicated by symbol W.

Table 4.—Lime sold or used by producers in the United States, by size of plant [1]

Size of plant	1969 Plants	1969 Thousand short tons	1969 Percent of total	1970 Plants	1970 Thousand short tons	1970 Percent of total
Less than 10,000	42	209	1	46	209	1
10,000 to less than 25,000	40	645	3	35	564	3
25,000 to less than 50,000	34	1,215	6	28	1,060	5
50,000 to less than 100,000	29	2,024	10	28	2,025	10
100,000 to less than 200,000	22	3,371	17	24	3,770	19
200,000 to less than 400,000 }	35	12,787	63	27	7,812	40
400,000 and over }				7	4,348	22
Total	202	[2] 20,250	100	195	19,788	100

[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Data may not add to total shown because of independent rounding.

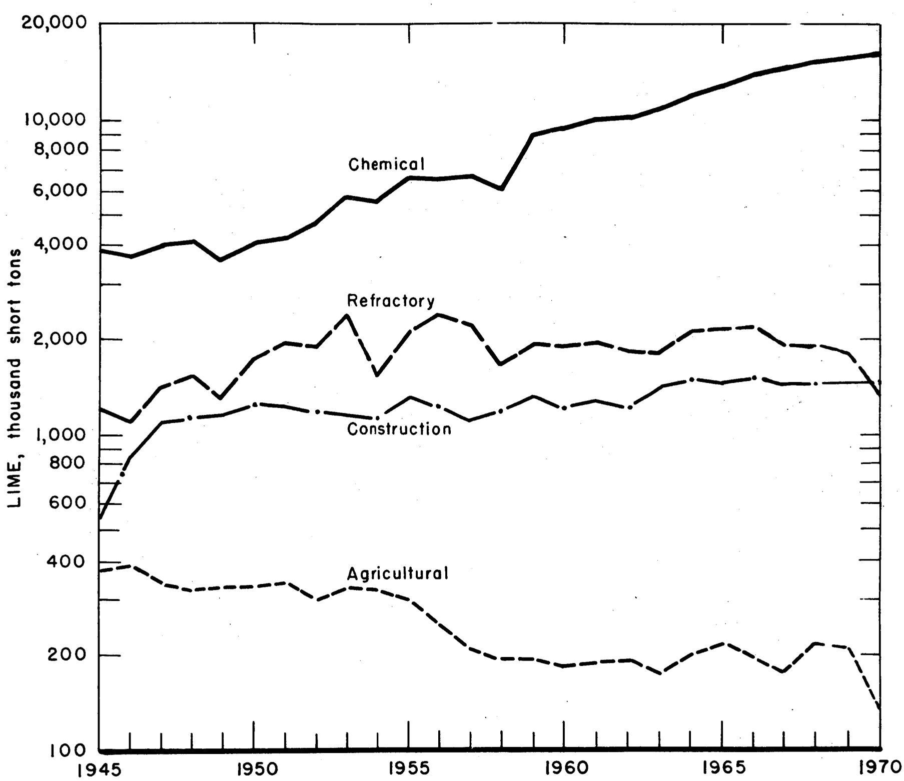

Figure 1.—Trends in major uses of lime.

Round Rock Lime Co. announced plans for a new vertical limekiln, to be constructed near Round Rock, Tex. When completed, the old plant at Round Rock will be closed.

United States Steel Corp. completed its new limekiln at Lorain, Ohio. Lime production started in December. The plant includes two 350-ton-per-day (tpd) vertical limekilns which use natural gas. The plant produces quicklime for use in the company's new $80 million basic-oxygen-furnace (BOF) complex.

The Flintkote Co. completed a new hydrating plant at City of Industry, Calif., 15 miles from Los Angeles. The plant receives quicklime from its Apex, Nev., plant and either processes it for sale, or hydrates and processes the hydrate for sale.

Plant expansions announced or started during the year included:

Huron Lime Co., Huron, Ohio—a third rotary kiln to raise capacity to 1,200 tpd. Cost is estimated at $2 million.

Pfizer, Inc., Gibsonburg, Ohio—a new rotary kiln to increase capacity an additional 130,000 tons per year (tpy).

St. Clair Lime Co., Marble City, Okla.—a new rotary kiln to raise capacity from 200 to 550 tpd.

The Flintkote Co., Apex, Nev.—a third rotary kiln to increase capacity an additional 300 tpd.

CF&I Steel Corp., Pueblo, Colo.—a new vertical kiln to increase capacity an additional 300 tpd.

Texas Lime Co., Cleburne, Tex.—a new 350-tpd kiln and two new 10-ton-per-hour hydrators.

Warner Co., Cedar Hollow, Pa.—a new 300-tpd rotary kiln. Cost is estimated at $2 million.

The Flintkote Co., Richmond, Calif.—a new hydrating plant to process quicklime from the company's Apex, Nev., plant.

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

(Thousand short tons and thousand dollars)

Use	1969			1970			
	Sold	Used	Total	Sold	Used	Total	Value
Agriculture	180	------	180	142	------	142	$2,339
Construction:							
Soil stabilization	783	W	W	888	------	888	16,136
Mason's lime	456	W	W	424	W	W	8,428
Finishing lime	278	W	W	196	------	196	3,582
Other uses	15	W	W	2	------	2	43
Total	1,532	W	W	1,510	W	W	28,189
Chemical and industrial:							
Steel, BOF	W	W	W	4,317	856	5,173	67,955
Alkalies	75	2,926	3,002	W	W	3,121	39,348
Water purification	1,112	W	W	1,217	10	1,227	17,195
Paper and pulp	970	W	W	918	85	1,003	14,734
Sugar refining	31	702	733	43	654	697	13,422
Steel, open-hearth	W	W	W	378	220	598	8,158
Copper ore concentration	193	316	509	228	350	578	7,612
Calcium carbide	491	274	765	W	W	561	6,871
Steel, electric	W	W	W	W	W	508	7,087
Aluminum and bauxite	183	W	W	W	W	381	5,099
Glass	390	------	390	327	------	327	4,428
Sewage	401	83	484	293	22	315	4,886
Other metallurgy	W	W	W	W	W	124	1,738
Petroleum refining	W	W	W	58	------	58	853
Tanning	W	W	W	36	------	36	658
Insecticides	W	------	W	34	------	34	549
Food	W	------	W	28	------	28	460
Magnesium	W	------	W	13	------	13	W
Sand-lime brick	20	------	20	10	------	10	152
Oil well drilling	W	------	W	6	------	6	87
Silica brick	4	------	4	4	------	4	68
Paint	W	------	W	3	------	3	46
Wire drawing	W	W	W	W	W	3	W
Coke	W	------	W	1	------	1	15
Other uses [2]	6,015	W	W	1,958	W	W	29,864
Total [3]	9,885	W	W	9,872	W	W	231,285
Refractory dolomite	1,524	343	1,866	1,235	138	1,373	25,740
Grand total [3 4]	13,154	7,096	20,250	12,759	7,029	19,788	287,553

W Withheld to avoid disclosing individual company confidential data.

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Includes other chemical uses, magnesium from sea water, petrochemicals, whiting, other ore concentration, other steel furnaces, magnesium metal, wire drawing, and rubber.

[3] Includes uses indicated by symbol W.

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

Table 6.—Destination of shipments of lime sold or used by producers in the United States in 1970, by States [1]

(Thousand short tons)

State	Quicklime	Hydrated lime	Total
Alabama	W	W	379
Arizona	W	W	298
Arkansas	W	W	174
California	645	122	767
Colorado	136	9	145
Delaware	W	W	16
Florida	278	42	320
Georgia	107	19	126
Illinois	1,005	146	1,151
Indiana	1,265	78	1,343
Iowa	97	22	119
Kansas	W	W	102
Kentucky	503	15	518
Louisiana	W	W	1,014
Maine	W	W	55
Maryland	412	20	432
Massachusetts	W	W	64
Michigan	1,687	82	1,769
Minnesota	171	14	185
Mississippi	129	7	136
Missouri	164	37	201
Montana	215	8	224
Nebraska	35	9	43
Nevada	W	W	51
New Hampshire	W	W	4
New Jersey	67	83	150
New Mexico	W	W	84
New York	1,034	116	1,149
North Carolina	89	29	119
Ohio	2,816	113	2,929
Oregon	112	20	132
Pennsylvania	1,710	229	1,939
Puerto Rico	1	40	41
Rhode Island	9	5	14
South Carolina	30	9	39
Tennessee	103	41	145
Texas	957	792	1,749
Utah	W	W	175
Virginia	293	31	325
Washington	95	15	110
West Virginia	352	33	385
Wisconsin	101	46	147
Wyoming	W	W	25
Exports:			
Canada	22	10	32
Other countries	31	12	44
Other States [2]	1,951	912	419
Total [3]	16,622	3,166	19,788

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Includes Alaska, Connecticut, District of Columbia, Hawaii, Idaho, North Dakota, Oklahoma, South Dakota, Vermont, and States indicated by symbol W.
[3] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Lime was consumed in every State, for a wide variety of uses. Leading consumers were the highly industrialized States Ohio, Pennsylvania, Michigan, Texas, Indiana, Illinois, New York, and Louisiana each of which consumed more than 1 million tons. Total consumption in these eight States accounted for 66 percent of the total.

The four principal uses for open market lime were chemical, 77 percent; construction, 12 percent; refractory, 10 percent; and agricultural, 1 percent.

Lime consumed by producers accounted for 36 percent of the total, compared with 35 percent in 1969. The new Lorain limekiln of United States Steel Corp. will increase this captive percentage in 1971.

The leading individual uses for total lime sold or used were: The BOF, alkalies, other chemical uses, refractories, water purification, and paper and pulp. Each of these uses required more than 1 million tons of lime.

Lime used in agriculture continued to decline, decreasing 21 percent from the 1969 level. Refractory dolomite use also continued its downward trend, decreasing 26 percent. Total chemical and industrial uses were about the same.

PRICES

The average value of lime sold or used in 1970 was $14.53 per ton, an increase of 4 percent over the 1969 value of $13.94.

Values for quicklime ranged $13.73 for chemical lime, to $14.77 for agricultural lime, to $16.77 for construction lime, and to $18.84 for refractory dolomite.

Values for hydrated lime ranged from $15.10 for chemical lime to $17.27 for agricultural lime, and $18.20 for construction lime.

All these values are f.o.b. plant of manufacture and do not include cost of containers. Prices quoted in trade journals are generally much higher and include cost of containers and delivery charges.

FOREIGN TRADE

Exports of lime increased 6 percent but were 22 percent below the 1968 record. Of the total exported, Canada received 67 percent, Mexico 12 percent, Surinam 7 percent, Guyana 5 percent, and British Bahamas 2 percent, the remaining 7 percent went to 38 countries, listed in order of quantities received: the Philippines, Panama, Venezuela, Bermuda, Japan, West Germany, British Honduras, Haiti, Nigeria, Honduras, Australia, Sweden, Greece, Trust Territories of the Pacific Islands, Angola, Italy, Trinidad, Jamaica, Brazil, Saudi Arabia, Belgium, Netherlands Antilles, Peru, Argentina, Republic of South Africa, Nicaragua, Leeward and Windward Islands, Costa Rica, France, Austria, Pakistan, Dominican Republic, Iran, New Zealand, Spain, Liberia, Colombia, and El Salvador.

Lime imports, mainly from Canada, increased 10 percent above the 1969 record, and exceeded 200,000 tons for the first time. Small quantities also were imported from France, the United Kingdom, West Germany, Japan, and Mexico.

Table 7.—U.S. exports of lime

Year	Short tons	Value (thousands)
1968	68,915	$1,437
1969	51,006	1,153
1970	53,876	1,391

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)
1966 r	203	$5	151,703	$1,772	151,906	$1,777
1967 r	545	12	79,983	961	80,528	973
1968 r	873	21	71,632	877	72,505	898
1969 r	39,270	542	144,471	1,911	183,741	2,453
1970	34,158	479	167,432	1,946	201,590	2,425

r Revised.

WORLD REVIEW

Canada.—Lime plants have been established near urban and industrial centers in Canada, mainly in the Provinces of Ontario and Quebec. During 1969, 23 plants were active, one in Newfoundland, four in Quebec, 11 in Ontario, three in Manitoba, and four in Alberta. Of the 90 kilns in operation, 19 were rotary, 68 were vertical, one was vibratory-grate, and two were rotary-grate. Production in 1969 was 1,635,000.

Companies active in Ontario included

Allied Chemical Canada, Ltd., Bonnechere Lime, Ltd., Canadian Gypsum Co., Ltd. Chemical Lime, Ltd., Cyanamid of Canada, Ltd., Domtar Chemicals, Ltd., and Reiss Lime Co. of Canada, Ltd.

Active companies in Quebec were Dominion Lime, Ltd., Domtar Chemicals, Ltd., Gulf Oil Canada, Ltd., and Quebec Sugar Refinery.

Poland.—Construction began on a 250,000-tpy lime plant at Tarnow, Opolski, Poland.

Table 9.—Quicklime and hydrated lime, including dead-burned dolomite: World production by countries

(Thousand short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada	1,440	1,635	1,626
Costa Rica [e]	9	9	9
Guatemala	19	19	24
Puerto Rico	39	41	41
United States (sold or used by producers)	18,637	20,209	19,747
South America:			
Brazil	1,669	[e r] 1,800	[e] 1,800
Colombia	[r] 1,009	1,100	1,100
Paraguay	20	21	23
Uruguay [e]	66	56	67
Europe: [2]			
Austria	[r] 756	806	817
Belgium	[r] 3,166	3,326	[e] 3,164
Bulgaria	1,069	1,002	[e] 1,000
Czechoslovakia	[r] 2,502	[e] 2,535	[e] 2,535
Denmark	185	[e] 210	[e] 210
Finland	231	235	254
France	4,411	4,615	[e] 4,650
Germany:			
East	2,848	2,770	[e] 2,755
West	11,722	11,758	11,813
Hungary	808	762	719
Ireland	69	58	65
Italy	[r] 5,401	6,388	[e] 6,400
Norway	246	234	[e] 240
Poland	2,528	2,456	3,875
Romania	[r] 1,881	2,114	[e] 2,200
Spain [e]	[r] 350	[r] 365	365
Sweden	871	[e] 1,025	844
Switzerland	162	165	160
U.S.S.R.	22,835	23,524	23,700
Yugoslavia	[r] 1,440	1,539	1,662
Africa:			
Ethiopia (including Eritrea)	25	20	18
South Africa, Republic of (sales)	[r] 1,174	1,034	1,189
Tanzania	8	12	----------
Tunisia	[r] 157	157	185
Uganda	22	----------	21
Zambia	79	[e] 77	105
Asia:			
Cyprus	[r] 104	110	120
India	313	336	[e] 350
Iran [e]	1,100	1,100	1,100
Japan	3,996	4,657	10,110
Kuwait	1	[e] 1	[e] 1
Lebanon	99	132	143
Mongolia [e]	44	44	44
Philippines	116	238	179
Saudi Arabia	12	17	24
Taiwan	[r] 131	121	141
Oceania:			
Australia [2]	237	[e] 230	[e] 230
Fiji Islands	[r] 3	4	[e] 4
Total	[r] 94,010	99,067	105,829

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Lime is produced in many other countries besides those listed. Congo (Kinshasa), Mexico, Nicaragua, Venezuela, and the United Kingdom are among the more important countries for which official data are unavailable.

[2] Year ended June 30 of year stated.

TECHNOLOGY

There was little or no improvement in the technology of lime making during the year. The impact of the BOF on dramatically increasing lime consumption leveled off.

A multicolumn vertical limekiln was marketed in the United States and Canada by Kennedy Van Saun Corp. Known as the "Schmid-Hofer" limekiln, it was developed in Austria in 1957.

The new Lorain plant of United States Steel Corp., designed and built by Dravo Corp., includes the two biggest vertical shaft kilns ever installed for a steel company in the United States. In the kilns, raw limestone is calcined by natural gas fed through seven burner beams. Each kiln has a capacity of 350 tons per day.

Magnesium

By E. Chin [1]

Production and shipments of magnesium metal increased in 1970, and deliveries of metal from the Government stockpile continued throughout the year. The domestic production capacity for magnesium increased substantially in 1970, and an oversupply of metal may result within 1 or 2 years. In the Great Salt Lake area of Utah, construction and other developmental activities aimed at the use of the lake's brines as a source of magnesium continued.

Legislation and Government Programs.—The General Services Administration (GSA) under authorization of Public Laws 90–604 and 91–321, continued the disposal of magnesium from the Government stockpile. A total of 14,572 short tons of magnesium was sold during 1970, leaving 99,646 short tons in the stockpile at yearend. On March 4, 1970, the Office of Emergency Preparedness removed magnesium from the list of strategic and critical materials, and the stockpile objective for magnesium was abolished.

Table 1.—Salient magnesium statistics

(Short tons)

	1966	1967	1968	1969	1970
United States:					
Production:					
Primary magnesium	79,794	97,406	98,375	r 99,887	112,007
Secondary magnesium	15,129	13,444	15,525	13,470	12,042
Shipments: Primary	96,443	100,743	103,671	r 117,695	118,693
Exports	15,448	13,173	19,457	27,372	35,720
Imports for consumption	3,959	9,721	4,808	4,316	3,295
Consumption	82,914	90,825	86,427	95,132	93,495
Price per pound cents	35.25	35.25	35.25	35.25	35.25
World: Primary production	179,894	208,575	212,305	221,748	p 243,250

p Preliminary. r Revised.

DOMESTIC PRODUCTION

U.S. production of primary magnesium rose 12 percent in 1970, to 112,007 short tons. Secondary magnesium recovery was estimated to be 12,000 tons for the year. The entire quantity of primary magnesium metal produced came from The Dow Chemical Company's electrolytic plants in Freeport and Velasco, Tex., and from American Magnesium Co.'s electrolytic plant in Snyder, Tex.

Oregon Metallurgical Corp. completed an expansion program at its Albany, Oreg., plant. This plant uses modified Alcan cells for electrolytic reduction of magnesium chloride generated at the plant as a byproduct of titanium production.

National Lead Co.'s three solar evaporation ponds in the Stanbury Basin of the Great Salt Lake produced over 600,000 tons of brine concentrate. This concentrate, which has a magnesium content of about 7.5 percent, will be further processed to produce anhydrous magnesium chloride for electrolytic reduction to magnesium metal. A reduction plant, being built on the southwestern shore of the lake, near Rowley and Grantsville, Tooele County, Utah, will have an annual capacity of 45,000 tons per year of magnesium metal. Plant startup is scheduled to begin late in 1971. The plant will also produce chlorine, calcium sulfate, potash salts, lithium, and other compounds.

[1] Chemist, Division of Nonferrous Metals.

Table 2.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

	1966	1967	1968	1969	1970
Kind of scrap:					
New scrap:					
Magnesium-base	6,462	5,062	7,006	4,767	4,564
Aluminum-base	4,127	4,266	5,050	5,712	4,698
Total	10,589	9,328	12,056	10,479	9,262
Old scrap:					
Magnesium-base	3,321	2,973	2,113	1,700	1,518
Aluminum-base	1,219	1,143	1,356	1,291	1,262
Total	4,540	4,116	3,469	2,991	2,780
Grand Total	15,129	13,444	15,525	12,470	12,042
Form of recovery:					
Magnesium alloy ingot [1]	5,202	3,760	2,502	3,231	2,006
Magnesium alloy castings (gross weight)	r 27	39	15	11	13
Magnesium alloy shapes	70	103	82	149	189
Aluminum alloys	r 6,333	6,157	9,900	8,378	7,088
Zinc and other alloys	17	18	18	r 13	24
Chemical and other dissipative uses	281	25	64	r 65	80
Cathodic protection	3,199	3,342	2,944	r 1,623	2,642
Total	15,129	13,444	15,525	13,470	12,042

r Revised.
[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

Great Salt Lake Minerals and Chemicals Corp. began concentration of lake brine at its 14,000-acre evaporation pond on the east shore of the Great Salt Lake near Ogden, Utah. In cooperation with the Dow Chemical Co., Great Salt Lake Minerals will process the bittern to produce anhydrous magnesium chloride for a new magnesium electrolytic plant to be built by Dow in Dallesport, Wash. The solar evaporation installation, largest of its kind in the world, will have initial annual capacities of 100,000 tons of anhydrous magnesium chloride, 240,000 tons of potassium sulfate, and 150,000 tons of sodium sulfate. Late in 1970, Dow Chemical announced a slowdown in the construction of the metal plant. The completion of the $20 million Dallesport project, originally scheduled to come onstream in the second half of 1971 with an initial capacity of 25,000 tons of magnesium metal per year, is now scheduled for mid–1972.

The Aluminum Company of America announced plans for constructing a plant at Addy, Wash., to produce magnesium from dolomite by the silicothermic process. The target date for operation is 1974 and the Bonneville Power Administration has contracted to furnish power by that date. The plant is estimated to cost $25 to $50 million and will employ between 300 and 400 people when on stream.

CONSUMPTION AND USES

Consumption of magnesium decreased 1.7 percent in 1970 to 93,495 tons. Distributive or sacrificial applications, in which magnesium is used for its chemical properties, accounted for 75.1 percent of the magnesium consumption. Structural products, such as castings and wrought products, accounted for the remainder. As in the previous year, the largest single use of magnesium was for aluminum alloys which accounted for 39.0 percent of the total consumption in 1970. Magnesium used for die castings increased 20.3 percent to 9,002 tons.

Table 3.—Consumption of primary magnesium in the United States, by uses

(Short tons)

	1966	1967	1968	1969	1970
For structural products:					
Castings:					
Sand	3,961	3,848	3,740	2,562	1,735
Die [1]	4,980	8,366	7,337	7,484	9,002
Permanent mold	632	555	607	404	260
Wrought products:					
Sheet and plate	6,075	(2)	(2)	(2)	(2)
Extrusions (structural shapes, tubing) [3]	7,100	10,517	11,280	13,110	12,250
Total	22,748	23,286	22,964	23,560	23,247
For distributive or sacrificial purposes:					
Powder	(4)	(4)	(4)	(4)	5,646
Aluminum alloys	30,862	31,244	34,484	37,375	36,543
Zinc alloys	100	53	52	54	35
Other alloys	1,975	2,370	(4)	(4)	(4)
Scavenger and deoxidizer	195	(4)	(4)	(4)	(4)
Chemical	4,604	5,214	(4)	(4)	8,385
Cathodic protection (anodes)	4,670	4,855	5,714	6,087	5,778
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	8,429	6,704	6,209	7,363	6,300
Nodular iron	(4)	(4)	2,480	2,374	4,720
Other [5]	r 9,331	r 17,099	14,524	r 18,319	2,841
Total	r 60,166	r 67,539	63,463	r 71,572	70,248
Grand total	r 82,914	r 90,825	86,427	r 95,132	93,495

r Revised.
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, debismuthizing lead, and miscellaneous uses.

PRICES

As it has been 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 throughout the year. However, The Dow Chemical Co. announced that the price of pig and ingot will be increased to 36.25 and 37.00 cents per pound effective January 1, 1971. Magnesium alloy prices remained the same throughout the year.

Depending upon the state of preservation of the metal available from the national stockpile, GSA accepted bids for primary magnesium ranging from 30.015 to 33.000 cents per pound, f.o.b. storage locations. The average price of metal sold by GSA during the year was 31.894 cents per pound.

STOCKS

Producer and consumer stocks of primary magnesium totaled 9,195 tons as of December 31, 1970. Yearend stocks of primary magnesium alloy ingot were 3,501 short tons. Stocks a year earlier were 9,126 short tons of primary metal and 3,446 short tons of alloy ingot.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1970

(Short tons)

Scrap item	Stocks Jan. 1 r	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	188	2,357	302	1,854	2,156	389
Solid wrought scrap [1]	1,213	4,831	5,272	----------	5,272	772
Total	1,401	7,188	5,574	1,854	7,428	1,161

r Revised.
1 Includes borings, turnings, drosses, etc.

FOREIGN TRADE

U.S. exports of primary magnesium rose from 4,467 short tons in 1960 to 34,185 tons in 1970. Except for the 1966–67 period, the trend since 1960 has been upward. West Germany was the largest customer for U.S. magnesium, accounting for 56 percent of the total exported in 1970. Imports by Brazil, Japan, and Mexico increased over the previous year and collectively accounted for 22 percent of the total primary metal exported. Exports to Canada decreased about 41 percent, from 2,345 short tons in 1969 to 1,389 tons in 1970.

Imports for consumption of magnesium (metallic and scrap) continued the downward trend established in 1968. Imports in 1970 dropped 16 percent from the previous year. Canada, by far the largest of U.S. sources, contributed 69 percent of the total metal imported. West Germany, the Republic of South Africa, Belgium-Luxembourg, the Netherlands, Hong Kong, the United Kingdom, and Italy accounted for 25 percent of the total U.S. imports; the remaining 6 percent was contributed by 10 other nations.

Table 5.—U.S. exports of magnesium, by classes and countries

Destination	1969				1970			
	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)
Argentina	141	$79	3	$5	211	$127	16	$26
Australia	867	478	87	272	982	563	56	112
Austria	------	------	------	------	198	111	------	------
Belgium-Luxembourg	234	166	23	34	771	441	9	17
Brazil	2,663	1,498	------	------	5,495	3,113	(1)	(1)
Canada	2,345	1,421	476	945	1,389	852	216	388
Colombia	27	28	57	70	(1)	1	13	18
France	130	93	14	35	383	405	14	28
Germany, West	15,954	8,982	3	21	19,144	10,774	13	33
Ghana	------	------	------	------	------	------	130	66
India	106	71	(1)	1	124	89	80	60
Indonesia	10	5	3	2	(1)	(1)	27	43
Israel	21	17	103	169	32	19	50	69
Italy	222	131	5	13	378	216	70	47
Japan	227	160	105	263	1,127	872	299	359
Mexico	305	190	195	195	1,164	907	189	207
Netherlands	1,267	876	152	625	316	178	169	725
New Zealand	68	40	3	5	60	34	1	2
Norway	84	48	3	8	757	456	1	4
Philippines	2	2	42	24	------	------	2	2
South Africa, Republic of	46	26	(1)	(1)	163	94	------	------
Spain	441	251	2	4	481	270	58	37
Surinam	54	33	------	------	25	15	------	------
Sweden	44	23	4	20	------	------	25	44
Switzerland	2	3	12	21	225	127	12	21
United Kingdom	545	338	20	41	309	176	19	43
Venezuela	190	156	7	7	249	162	40	36
Yugoslavia	------	------	(1)	4	122	68	------	------
Other	37	22	21	40	80	50	38	35
Total	26,032	15,137	1,340	2,824	34,185	20,120	1,547	2,422

[1] Less than ½ unit.

Under the provisions of the "Kennedy round" trade agreements, another series of tariff reductions became effective on January 1, 1970. The import duty on nonalloyed unwrought magnesium dropped to 28 percent from the 32 percent ad valorem rate of the previous year; the duty on unwrought alloys was lowered from 12.8 cents per pound on magnesium content plus 6 percent ad valorem to 11 cents per pound plus 5.5 percent ad valorem; and the duty on wrought magnesium was reduced from 10.5 cents per pound on magnesium content plus 5.5 percent ad valorem to 9.4 cents per pound plus 4.5 percent ad valorem.

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)	Exports: Semifabricated forms, n.e.c. — Short tons	Value (thousands)
1968	18,364	$10,719	1,093	$2,330
1969	26,032	15,137	1,340	2,824
1970	34,185	20,120	1,547	2,422

Year	Imports: Metallic 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)
1968	4,077	$2,203	656	$1,228	r 75	r $825
1969	3,515	1,913	467	1,175	r 334	r 1,168
1970	2,948	1,566	122	300	225	637

r Revised to include manufactures of articles of magnesium.

WORLD REVIEW

World production of magnesium rose about 10 percent in 1970 and totaled 243,250 short tons. The United States produced 46 percent of the estimated world total, followed by the U.S.S.R., 23 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). Societé d'Electrochimie, d'Electrométallurgie et des Aciéries Electriques d'Ugine (35 percent), Société des Produits Azotés (SPA) - (30 percent).	7,000	do	Marignac.
Italy	Societa 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,	40,000	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 Corporation of America	[1] 12,000	Electrolytic	Henderson, Nev.
	Oregon Metallurgical Corp	[1] 2,500	do	Albany, Oreg.

NA Not available.
[1] Captive use.

France.—Société Générale du Magnesium is undertaking further expansion of its plant at Marignac. Installation of a sixth electrothermic reduction furnace using the magnetherm process for the reduction of dolomite with ferrosilicon is scheduled for completion in April 1971. The new furnace will raise plant capacity to 9,000 tons per year. Plans for a further increase in capacity to 16,000 tons per year are being considered.

Greece.—The Greek Government has issued details of a $200 million investment agreement with Stavros Niarchos. In addition to a proposed steel plant, the agreement includes a magnesium metal plant with an annual capacity of 30,000 tons.

India.—The Central Government and the Tamilnadu State authorities are discussing the feasibility of a joint project for a magnesium pilot plant. This proposed plant will have an initial annual capacity of 250 to 300 metric tons and will use an electrolytic process developed by the Central Electrochemical Research Institute at Karaikudi. Little progress has been made on the plans by the Central Government to establish a 250-ton-per-year magnesium plant, which will use a process developed by the National Metallurgical Laboratory of Jamshedpur.

Japan.—Mitsubishi Chemical Industries Co., Ltd., is planning to build a small electrolytic magnesium plant with an initial capacity of 5,000 tons per year. The Dow Chemical Co., which will be a partner in the venture, will provide magnesium chloride feed for the plant in addition to supplying process know-how under a licensing agreement.

Norway.—Norsk Hydro Elektrisk A/S continued expansion of its magnesium production facilities at Heroya, which was expected to raise its capacity to 47,000 tons per year by the fall of 1972. An additional expansion of 8,000 tons per year was also planned.

West Germany.—Norsk Hydro announced that its joint venture with Salzdetfurth A.G. to build a 30,000-ton-per-year magnesium plant in Germany has been indefinitely postponed. However, Norsk Hydro and Salzdetfurth are continuing to study the feasibility of a magnesium plant in Germany.

Yugoslavia.—The location of Yugoslavia's first primary magnesium plant has been changed from the original site at Kraljevo to nearby Jajce. The 4,400-ton-per-year silico-thermic reduction facility, scheduled to come on stream in 1973, is a joint project of Magnohrom of Kraljero and Electrobosna of Jajce. The last-minute switch was made on the basis of the proximity of far larger reserves of dolomite and ferrosilicon. There are also two large power stations in the mountainous Jajce location.

Table 7.—Primary magnesium: World production, by countries

(Short tons)

Country	1968	1969	1970 p
Canada	9,928	10,637	9,583
China, mainland e	r 1,100	1,100	1,100
France	4,938	4,866	e 5,000
Italy	7,273	7,385	7,165
Japan	6,236	10,340	11,395
Norway	r 34,487	34,333	e 39,000
U.S.S.R.e	r 46,000	50,000	55,000
United Kingdom	3,968	p 3,200	e 3,000
United States	98,375	99,887	112,007
Total	r 212,305	221,748	243,250

e Estimate. p Preliminary. r Revised.

TECHNOLOGY

A technique was developed by the Harvill Aircraft Die Casting Corp. to check the soundness of aircraft diecastings. This process, called flotation inspection, depends on the preparation of a test solution of a desired specific gravity. If a casting remains submerged in the test solution, it can be considered sound, but if it rises and floats on top of the solution, it is unacceptable due to porosity.[2]

Magnesium Elektron, Ltd., developed magnesium alloys which display a paste-like property over a comparatively wide temperature range, and which could lead to a new high-speed technique for producing thick-sectioned, light-weight components for use in aircraft, automobiles, and other equipment. The unique property of remaining in a paste-like state permits placing a measured amount of molten alloy in the bottom half of a mold and closing the die at forging speed. After a few seconds, the die can be opened and the part ejected.[3]

Tests conducted by Hamilton Die Cast, Inc., for The Dow Chemical Co. indicate that the Acurad die-casting process should be extremely effective on most types of heavy-wall magnesium parts such as trans-

[2] Harvill, H. L. Flotation Inspection of Aluminum and Magnesium Castings. Foundry, v. 98, No. 2, February 1970, pp. 136–137.

[3] Metallurgia. New Press-Cast Process for Magnesium. V. 82, No. 490, August 1970, p. 54.

mission cases, oil filter bases, air-cooled engine blocks, and chain saw pistons. The production of high-integrity military castings, castings requiring good machined surface finishes, and pressure-tight castings also are proposed candidates for the Acurad process.[4]

An improved cathodic protection system to prevent corrosion damage to steel gas service risers has been developed by Kaiser Magnesium, Tulsa, Oklahoma. The system is a self-contained unit consisting of a high-purity magnesium anode permanently bonded to a steel riser pipe.[5]

ITT Research Institute will conduct a research program to identify optimum combinations of elements such as magnesium and cerium in ductile iron and to obtain information on the properties of the products as cast and annealed. Analysis of the properties induced by various combinations of elements will permit production of specific compositions, optimization of desired properties, and will indicate which combinations of elements will result in superior products.[6]

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[4] Nelson, C. W. Diecasting Magnesium with Acurad. Foundry, v. 98, No. 10, October 1970, pp. 136–140.

[5] American Metal Market. Kaiser Magnesium Develops Improved Cathodic Protection System. V. 77, No. 226, Nov. 27, 1970, p. 7.

[6] American Metal Market. Effect of Magnesium, Cerium on Ductile Iron to be Probed. V. 77, No. 209, Oct. 30, 1970, p. 10.

Magnesium Compounds

By E. Chin [1]

The increase in world production of magnesia from sea water continued to exert competitive pressure on producers of magnesite. A new magnesia-from-sea-water plant become operational at Dungarvan, County Waterford, Ireland. Sea water magnesia plants were under construction at Syracuse, Sicily, and at Arad, Israel. An expansion program to double magnesia production at the sea water magnesia plant at Sant' Antioco, Sardinia, was initiated. Also, a Mexican company, which utilizes brine feed from a dry lake, announced that it plans to increase the capacity of its brine magnesia plant at Laguna del Rey, Coahuila.

Table 1.—Salient magnesium compounds statistics
(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Caustic-calcined and specified magnesias: [1]					
Shipments:					
Quantity	99	114	135	154	198
Value	$9,686	$11,250	$12,226	$14,698	$18,581
Exports: [2]					
Value	$1,627	$2,095	$2,301	$2,687	$3,200
Imports for consumption: [2]					
Value	$743	$585	$758	$983	$702
Refractory magnesia:					
Sold and used by producers:					
Quantity	852	688	661	737	802
Value	$52,290	$43,148	$44,535	$51,843	$60,333
Exports:					
Value	$6,208	$5,889	$4,706	$4,973	$9,133
Imports:					
Value	$8,139	$5,171	$6,179	$5,913	$7,357
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	2,193	1,880	1,833	1,866	1,373
Value	$39,725	$34,083	$31,627	$33,580	$25,740
World: Crude magnesite production:					
Quantity	11,106	11,248	11,781	12,670	13,847

[1] Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2] Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

In 1970, Basic, Inc., produced crude magnesite and brucite from its Gabbs, Nev., property. Crude olivine was produced in North Carolina and Washington. Production decreased about 3 percent in 1970.

Most of the dead-burned dolomite produced came from Illinois, Louisiana, Pennsylvania, and Ohio. Smaller amounts were produced in Alabama, California, Colorado, Mississippi, Missouri, Pennsylvania, Utah, and West Virginia.

Output of refractory magnesia from well brines, sea water, and dolomite increased in 1970, and Michigan supplied more than any of the other producing States, which included California, Florida, Mississippi, New Jersey, and Texas. The only production of refractory magnesia from magnesite was in Nevada.

Producers sold 447,722 tons of refractory magnesia in 1970 and consumed 354,040 tons in their own plants, for a total pro-

[1] Chemist, Division of Nonferrous Metals.

duction of 801,762 tons valued at $60.3 million compared with 737,238 tons valued at $51.8 million in 1969. The value of refractory magnesia consumption was derived by using the reported unit value of shipments.

Production of hydrous magnesium sulfate decreased 2 percent in 1970, while production of magnesium trisilicate increased. Small quantities of magnesium nitrate, magnesium phosphate, magnesium acetate and stearate, and anhydrous magnesium sulfate also were produced.

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
1966	2,193	$39,725
1967	1,880	34,083
1968	1,833	31,627
1969	1,866	33,580
1970	1,373	25,740

CONSUMPTION AND USES

Consumption of refractory magnesia, both single-burned and double-burned, increased 9 percent to 801,762 tons in 1970. Consumption of caustic-calcined magnesia, excluding that used in the production of refractory magnesia, increased 28 percent to 197,899 tons.

Most of the magnesium hydroxide was consumed in the production of other magnesium compounds and magnesium metal. However, 87,051 tons was shipped to other industries, including wood pulp mills.

Consumption of hydrous magnesium sulfate decreased in 1970 by 2 percent, and that of magnesium trisilicate increased. Consumption of anhydrous magnesium chloride, principally for the production of magnesium metal, increased 25 percent. Consumption of hydrous magnesium chloride decreased about 14 percent.

Table 3.—Magnesium compounds shipped and used in the United States

Year and product	Plants	Shipped and used	
		Short tons	Value (thousands)
1969			
Refractory magnesia [1]	10	737,238	$51,843
Caustic-calcined [2] and specified (U.S.P. and technical) magnesias	r 9	154,303	14,698
Magnesium hydroxide (100 percent $Mg(OH)_2$) [2]	r 6	r 88,628	r 3,540
Magnesium chlorides [3]	7	r 409,670	r 28,307
Precipitated magnesium carbonate [2]	5	7,800	NA
1970			
Refractory magnesia [1]	10	801,762	60,333
Caustic-calcined [2] and specified (U.S.P. and technical) magnesias	11	197,899	18,581
Magnesium hydroxide (100 percent $Mg(OH)_2$) [2]	6	87,051	3,655
Magnesium chlorides [3]	8	513,029	36,002
Precipitated magnesium carbonate [2]	6	6,779	NA

r Revised. NA Not available.
1 Includes both single-burned and double-burned.
2 Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.
3 Production for 1969, 564,844; 1970, 841,370; includes magnesium chloride used in production of magnesium metal.

Table 4.—Domestic consumption of caustic-calcined magnesia and specified magnesias, by uses

(Percent)

Use	1969	1970
Chemical processing	10	13
Fertilizer	7	7
85-percent MgO insulation	1	1
Oxychloride and oxysulfate cements	10	10
Pulp and paper	11	8
Rayon	6	4
Rubber	8	7
Other: Electrical, medicinal, flux, ceramic, glass, sugar, animal feed, fuel additive, water treatment, and uranium processing	47	50

PRICES

Prices for magnesia, calcined, technical, heavy, 90 percent and 93 percent (bags, carlot, f.o.b. Luning, Nev.) showed no change from the 1969 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 at $0.24 per pound (bags, carlot, freight equalized), compared with $0.23 to $0.24 in 1969.

Prices for magnesium carbonate, technical (bags, carlot, freight equalized) increased from $0.14 to $0.16 per pound, and for truckload quantities from $0.14–$0.145 to $0.18–$0.185 per pound. For magnesium hydroxide, NF, powder (drums, carlot, and truckload, works) the price range was $0.21 to $0.295 per pound, compared with $0.21 to $0.265 in 1969. No price changes were noted for other magnesium compounds, which were quoted as follows: Magnesium bromide, 80-pound drums, f.o.b. works, $1.60 per pound; magnesium chloride, anhydrous, 92 percent, flake or pebble, drums, carlot, works, $0.1275 per pound; magnesium chloride, hydrous, 99 percent, flake, bags, carlot, works, $60.00 per ton; magnesium gluconate, 100-pound drums, f.o.b. works, $1.42 per pound; and magnesium lauryl sulfate, tanks, freight allowed, $0.18 per pound.

FOREIGN TRADE

Exports of dead-burned magnesite and magnesia in 1970 totaled 88,848 short tons, an increase of 58 percent over exports in 1969. The gain was due largely to increased exports to Canada, Italy, and Mexico. The increase in exports in 1970 reversed the decline in exports of dead-burned magnesite and magnesia, which had existed for the previous 5 years. Exports of magnesite, including crude, caustic-calcined, lump or ground, increased 16 percent to 10,089 tons in 1970. Deliveries to Canada, Costa Rica, 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 decreased 25 percent, to 11,476 tons in 1970. Imports of dead-burned and grain magnesia and periclase containing a maximum of 4 percent lime increased 9 percent, to 94,675 tons. Imports for the same class of material containing over 4 percent lime increased from 10,780 tons in 1969 to 33,518 tons in 1970. Total imports increased 32 percent over those of 1969 to 128,193 tons.

Under the "Kennedy round" tariff agreement, tariffs on a number of magnesium compounds were further reduced as the following tabulation shows:

Item	1969	1970
Magnesite:		
Crude	$4.20 per ton	$3.67 per ton
Caustic calcined	$8.40 per ton	$7.35 per ton
Magnesium carbonate:		
Precipitated	0.25¢ per pound	0.24¢ per pound
Not precipitated	6.5 percent ad valorem	5.5 percent ad valorem
Magnesium chloride:		
Anhydrous	0.8¢ per pound	0.7¢ per pound
Other	0.33¢ per pound	0.29¢ per pound
Magnesium oxide:		
Calcined magnesia	1.6¢ per pound	1.4¢ per pound
Magnesium sulfate:		
Epsom salts	0.3¢ per pound	0.26¢ per pound

Table 5.—U.S. exports of magnesium and magnesia, by countries

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude, caustic-calcined, lump or ground			
	1969		1970		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	902	$36	553	$77	39	$15	78	$38
Australia	------	------	25	7	390	212	521	295
Belgium-Luxembourg	------	------	------	------	69	30	78	31
Brazil	3	1	7	4	4	2	58	26
Canada	28,458	2,528	38,217	4,103	3,259	243	1,524	303
Chile	1,147	95	1,602	146	133	35	92	21
Colombia	220	18	16	9	84	21	33	20
Costa Rica	817	163	------	------	275	23	772	72
Denmark	2	1	1	1	51	29	54	31
El Salvador	399	82	8	2	------	------	440	37
Finland	------	------	------	------	27	14	86	42
France	2	1	------	------	145	49	234	105
Germany, West	114	62	140	59	1,028	614	797	446
Honduras	------	------	------	------	151	19	70	10
Israel	1	(1)	------	------	36	17	17	8
Italy	21	3	5,175	538	278	118	2,027	355
Japan	9	1	77	38	427	188	103	81
Mexico	11,298	845	30,777	2,921	237	36	705	69
Netherlands	439	27	30	4	80	34	167	85
New Zealand	------	------	25	16	87	55	94	60
Peru	1,653	106	2,471	227	------	------	1	(1)
Philippines	3	1	45	7	56	9	30	15
South Africa, Republic of	83	54	121	76	150	66	195	80
Spain	4,704	310	5,879	495	105	44	152	68
Sweden	148	97	47	31	362	254	223	165
Switzerland	------	------	42	4	112	24	60	19
United Kingdom	141	74	74	38	992	481	1,062	612
Venezuela	5,435	443	3,468	322	34	6	236	28
Other	85	25	48	8	121	49	180	78
Total	56,084	4,973	88,848	9,133	8,732	2,687	10,089	3,200

[1] Less than ½ unit.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Crude magnesite:				
Canada	----------	----------	17	(1)
Japan	----------	----------	4	(1)
Venezuela	18	(1)	----------	----------
Total	r 18	(1)	21	(1)
Lump or ground caustic-calcined magnesia:				
Australia	2,454	$244	1,399	$136
Austria	562	21	551	20
Belgium-Luxembourg	10	1	437	33
Canada	5	(1)	----------	----------
Greece	3,472	242	2,673	189
India	7,535	397	5,509	280
Israel	16	2	----------	----------
Italy	545	41	----------	----------
Japan	----------	----------	319	12
Netherlands	109	7	210	14
Turkey	362	21	166	9
Yugoslavia	168	7	212	9
Total	15,238	983	11,476	702
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4 percent lime:				
Austria	2,405	153	2,638	174
Belgium-Luxembourg	----------	----------	23	2
Bulgaria	----------	----------	717	97
Canada	2	6	5	11
Germany, West	3	(1)	25	2
Greece	r 67,202	r 4,989	78,942	6,319
Japan	14,722	647	6,638	380
Turkey	----------	----------	5,667	365
United Kingdom	(1)	4	20	7
Yugoslavia	2,221	114	----------	----------
Total	r 86,555	r 5,913	94,675	7,357
Containing over 4 percent lime:				
Austria	----------	----------	6,411	284
Canada	4,141	239	3,309	183
Greece	----------	----------	1,086	39
United Kingdom	----------	----------	(1)	2
Yugoslavia	6,639	329	22,712	1,167
Total	10,780	568	33,518	1,675
Grand total	r 97,335	6,481	128,193	9,032

r Revised.
1 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 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)
1968	535	$183	1,269	$222	480	$92	44,261	$644	2,799	$185
1969	103	47	836	157	368	70	43,685	605	3,727	372
1970	521	200	808	192	------	------	34,939	617	3,608	327

1 Not specifically provided for; includes magnesium silicofluoride or fluosilicate and calcined magnesia.

WORLD REVIEW

Greece.—In midyear, Sté. Financière de Grèce S.A. (Skalisteris Group) started up its new magnesite ore beneficiation plant at Paraskevorema on the island of Euboea. The plant was designed to produce between 300 and 400 tons of dressed magnesite per day.

Ireland.—The country's first plant for the production of magnesia from sea water was dedicated at Dungarvan, County Waterford. Operated by the Quigley Magnesite Division of Pfizer Inc., this facility will produce magnesia from sea water at a rate of 75,000 tons per year. The dolomite required for the operation is quarried, crushed, and sized at Bennettsbridge in County Kilkenny, 50 miles north of Dungarvan, and transported to the site by rail. It is then converted into dolomitic lime in a 300-foot-long rotary kiln and combined with sea water to precipitate magnesium hydroxide. The magnesium hydroxide is calcined to produce refractory magnesia with a 93- to 95-percent purity.

Israel.—The Israeli Government approved the construction of a $13 million magnesium oxide plant in Arad, near the Dead Sea. The new plant will utilize byproduct magnesium chloride from Dead Sea Works, Ltd., to produce magnesia. The plant is scheduled to begin operation in 1972 and reportedly will produce 46,000 tons of magnesia and 82,000 tons of hydrochloric acid annually.

Italy.—Compagnia Generale del Magnesio SpA is building a sea water magnesia plant near Syracuse, Sicily. This plant will have a capacity of 50,000 tons of magnesia annually and will cost approximately $14 million.

Sardamag SpA was doubling the production capacity of its sea water magnesia plant at Sant' Antioco, on the south coast of Sardinia. The expansion program, which will increase capacity from 60,000 to 120,000 tons of magnesia per year, will be completed during 1971 and will involve the expenditure of an estimated $14.4 million.

Mexico.—Quimica del Rey S.A., a wholly owned subsidiary of Industrias Peñoles S.A., plans to increase the capacity of its brine magnesia plant at Laguna del Rey, Coahuila, from 30,000 to 50,000 tons. The plant processes brine feed from a nearby

Table 8.—Magnesite: World production, by countries [1]
(Short tons)

Country	1968	1969	1970 [p]
North America: United States	W	W	W
South America: Brazil	151,920	[e] 200,000	[e] 260,000
Europe:			
Austria	1,704,923	1,772,979	1,773,992
Czechoslovakia	[r] 2,369,967	[e] 2,400,000	[e] 3,300,000
Greece	486,119	639,340	788,152
Italy	5,516	4,410	----------
Poland [e]	50,000	50,000	60,000
Spain [2]	250,224	220,462	NA
U.S.S.R. [e]	3,300,000	3,400,000	3,400,000
Yugoslavia	441,272	526,262	564,222
Africa:			
Kenya	75	554	4
South Africa, Republic of	65,915	53,044	92,874
Sudan	7,165	550	110
Tanzania	[r] 1,544	1,651	854
Asia:			
China, mainland [e]	1,000,000	1,100,000	1,100,000
India	278,965	325,741	384,664
Iran [e]	7,200	7,200	7,200
Korea, North [e]	1,500,000	1,700,000	1,800,000
Pakistan	1,798	NA	NA
Turkey	[r] 131,111	241,442	313,946
Oceania:			
Australia	25,923	25,953	NA
New Zealand	887	882	534
Total	[r] 11,780,524	12,670,470	13,846,552

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

dry lake containing sodium and magnesium salts. The expansion of the Laguna del Rey complex, which will also increase production of salt cake and sodium sulfate, will cost an estimated $9 million.

Sea water magnesia plants of the world by country, company, and capacity are listed as follows:

Country	Location	Company	Capacity (short tons MgO)
Canada	Aquathuna, Newfoundland	Lundrigan's, Ltd	30,000
Ireland	Dungarvan, Co. Waterford	Pfizer, Inc	75,000
Italy	Sant' Antioco, Sardinia	Sardamag SpA	60,000
Japan	Ube, Yamaguchi	Ube Chemical Industries Co	300,000
	Onahama and Minamata	Shin-Nihon Chemical Ind. Co. (Shin-Nihon	
	Toyama	Kinzoku Kagaku)	170,000
	Hotsu	Hokuriku Seien K.K	35,000
	Naoetsu	Nihon Kasui Kako	50,000
Mexico	Ciudad Madero, Tampico	Quimica del Mar, S.A	50,000
Norway	Heröya, OsloFjord	Norsk Hydro-Elektrisk Kvaelstofaktieselskab A/S	80,000
United Kingdom	Hartlepool, Dur	Steetley Magnesite Co., Ltd	250,000
U.S.S.R	NA	NA	100,000
United States	Cape May, N.J	Harbison Walker Refractories	90,000
	Port St. Joe, Fla	Basic, Inc	60,000
	Pascagoula, Miss	H.K. Porter Co., Inc	40,000
	Freeport, Tex	The Dow Chemical Co	250,000
	Moss Landing, Calif	Kaiser Aluminum and Chemical Corp	130,000
Total			1,770,000

NA Not available.

TECHNOLOGY

Ferrite-dielectric composites were prepared by a hot-pressing technique using substrates of MgO-$MgAl_2O_4$ mixtures with thermal expansions closely matched to these of the ferrites.[2] Thermal conductivity and dielectric data indicate that the mixtures in this system have properties essentially equivalent to alumina. The advantage of the present mixtures lies in the ability to vary their thermal expansion coefficients over a wide range to suit matching problems associated with composition fabrication.

A new, 60-percent magnesium oxide class, basic brick for high-temperature refractory applications was developed by General Refractories Co.[3] The brick is a polyphosphate bonded refractory that has a hot strength twice that of high-fired, direct-bonded brick. Other properties of the brick include high density, low porosity, and excellent hot load and thermal shock resistance.

A new type of refractory grain was developed by prereacting high-purity MgO and low-silica chrome ore concentrates.[4] The resulting dense grain contains 60 percent MgO. High-fired bricks made from prereacted grain belong in the general class of direct-bonded refractories and had low apparent porosities and low silicon contents.

Chemical Construction Co. (Chemico) and Basic Chemicals of Cleveland developed a process to absorb SO_2 on magnesia.[5] The magnesium sulfate produced will be treated, and the magnesia recovered will be recycled. Chemico is building a prototype unit for Boston Edison's Nystic Station No. 6.

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[2] Paladino, A. E., and C. R. Snider. Ferrite-Dielectric Composites Utilizing MgO-$MgAl_2O_4$ Mixtures to Achieve Thermal Expansion Matched Substrates. Am. Ceramic Soc. Bull., v. 49, No. 3, March 1970, pp. 280–285.

[3] American Metal Market. Magnesium Oxide Brick Has High Hot Strength. V. 77, No. 102, May 1970, p. 11.

[4] Neely, J. E., W. H. Boyer, and C. A. Martinek, Jr. Sintered Magnesia-Chrome Grains for New Types of Refractories. Am. Ceramic Soc. Bull. v. 49, No. 8, August 1970, pp. 710–713.

[5] Chemical and Engineering News. Boston Electric is the First to Install Chemical Construction Co.'s SO_2 Recovery Process. V. 48, No. 28, July 1970, p. 19.

Manganese

By Gilbert L. DeHuff [1]

The Nation's only mine producing manganese ore, concentrate, or nodules, containing 35 percent or more manganese, closed down completely at the end of the year. Domestic shipments were less than those of the previous year. Ferromanganese prices continued to rise and imports were only slightly down from those of 1969. Ferromanganese exports increased appreciably, but were still small compared with imports. Quoted prices for metallurgical ore rose in September as a result of increases in ocean freight rates, but the actual price of the ore itself appeared to be unchanged.

Legislation and Government Programs.—On August 14, the Director of the Office of Emergency Preparedness made public his report thereby concluding that office's investigation of ferroalloy imports, which had been initiated in 1968 under the authority of Section 232 of the Trade Expansion Act of 1962. The report found that manganese, chromium, and silicon ferroalloys and refined metals are not being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security.

On July 10, enactment of Public Laws 91-322, 323, and 331 gave the Administrator of the General Services Administration (GSA) authority to dispose of 111,900 short dry tons of type A chemical-grade ore, 65,800 tons of type B chemical-grade ore, and 173,800 tons of natural battery-grade ore held in the national or supplemental stockpiles. GSA's outstanding Solicitation of Offers for Metallurgical-Grade Manganese, PMDS-ORES-85, was superseded by PMDS-ORES-129, offering for sale by negotiation a "buying list" of 98 metallurgical-grade manganese ore items totaling approximately 1,852,041 short dry tons. The items, mostly of domestic origin, were in the national, supplemental, or Defense Production Act stockpiles at storage depots in various parts of the country. GSA's disposal program, however, continued to limit deliveries to 300,000 short tons per fiscal year, divided evenly among quarters. Sales of metallurgical ore in 1970 totaled 47,977 short tons. In addition, 1,001 short tons of synthetic manganese dioxide were sold by GSA during the year.

Manganese stockpile inventory changes for the year were as follows: Metallurgical ore, stockpile grade, decreased 343,540 short tons to 8,419,673 tons; metallurgical ore, nonstockpile grade, decreased 15,977 tons to 1,407,018 tons; synthetic dioxide decreased 1,637 tons to 21,916 tons; medium carbon ferromanganese increased 10,261 tons to 28,921 tons; and silicomanganese increased 11,243 tons to 23,574 tons. Part of the metallurgical ore released from stocks was used by conversion contractors on outstanding contracts to make the medium carbon ferromanganese and the silicomanganese represented by the increases in those stocks. Another part went for payments to the contractors on those contracts and for freight involved. A further part of the ore withdrawals represented deliveries under both new and outstanding sales contracts.

DOMESTIC PRODUCTION

The Nancy-Tower mine of Goret and Aguilar, Inc., produced metallurgical manganese ore in the Luis Lopez district, Socorro County, N. Mex., until October when mining came to an end. Shipments continued to be made from stocks till the end of the year when all operations ceased. The ore was concentrated to an average 48-percent manganese content at the firm's mill

[1] Physical scientist, Division of Ferrous Metals.

at Socorro before shipment. This was the only remaining mine in the United States producing manganese ore containing 35 percent or more manganese. The Anaconda Co. shipped some metallurgical oxide nodules that were made some years ago from Montana carbonate ore, but no manganese ore, concentrate, or nodules, of any type or grade were produced in Montana in 1970. There were no shipments nor was there any production of domestic natural battery-grade ore.

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. Manganiferous zinc residuum was produced from New Jersey zinc ores.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1966	1967	1968	1969	1970
Manganese ore (35 percent or more Mn):					
Production (shipments):					
Metallurgical	W	W	10,536	5,630	4,737
Battery	W	W	842	-----------	-----------
Total	14,406	12,585	11,378	5,630	4,737
Imports general	2,553,704	2,058,691	1,827,626	1,959,661	1,735,055
Consumption	2,370,516	2,382,984	2,228,412	2,181,333	2,363,937
Manganiferous ore (5 to 35 percent Mn):					
Production (shipments)	324,926	289,160	244,590	430,637	368,302
Ferromanganese:					
Production	946,210	940,927	879,962	852,019	835,463
Exports	545	1,861	3,710	1,759	21,747
Imports for consumption	251,972	216,279	203,212	307,891	290,946
Consumption	1,048,429	982,130	1,016,559	1,071,042	1,000,611

W Withheld to avoid disclosing individual company confidential data.

Table 2.—Manganese and manganiferous ore shipped [1] in the United States, by States

(Short tons)

Type and state	1969		1970	
	Gross weight	Manganese content	Gross weight	Manganese content
Manganese ore (35 percent or more Mn, natural):				
Montana	775	404	512	272
New Mexico	4,855	2,331	4,225	2,040
Total	5,630	2,735	4,737	2,312
Manganiferous ore:				
Ferruginous manganese ore (10 to 35 percent Mn, natural):				
Minnesota	381,435	54,510	321,436	44,927
New Mexico	49,146	5,465	46,166	4,856
Utah	-----------	-----------	700	196
Total	430,581	59,975	368,302	49,979
Manganiferous iron ore (5 to 10 percent Mn, natural):				
Minnesota	56	4	-----------	-----------
Total manganiferous ore	430,637	59,979	368,302	49,979
Value manganese and manganiferous ore	$3,454,254	-----------	$2,839,863	-----------

[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 13.1 pounds per short ton of raw steel produced. Of this total, 11.5 pounds was ferromanganese; 1.3 pounds, silicomanganese; 0.05 pounds, spiegeleisen; and 0.2 pounds, manganese metal. The comparable 1969 total, on the same basis, was 13.0 pounds with ferromanganese at 11.4, silicomanganese at 1.3, spiegeleisen at 0.05, and metal at 0.25.

Producers of manganese ferroalloys and electrolytic manganese metal had pollution control and power shortage problems with which to contend, and the General Motors strike lasting from September 14 to October 1 adversely affected demand. Woodward Corp., a Division of the Mead Corp., produced high-carbon and medium-carbon ferromanganese, and silicomanganese, at the Roane Electric Furnace plant, Rockwood, Tenn., which had formerly belonged to Tennessee Products & Chemical Corp. The plant has been leased and operated by Union Carbide Corp. since 1964 until acquired by Woodward in the latter part of 1969.

Table 3.—Consumption and stocks of manganese ore [1] in the United States

(Short tons)

	Consumption 1969	Consumption 1970	Stocks Dec. 31, 1970 [2] (including bonded warehouses)
By use:			
Manganese alloys and metal	2,000,735	2,099,426	1,424,197
Pig iron and steel	50,157	107,733	69,487
Dry cells, chemicals and miscellaneous	130,441	156,778	274,398
Total	2,181,333	2,363,937	[3] 1,768,082
By origin:			
Domestic	22,300	25,472	20,674
Foreign	2,159,033	2,338,465	1,747,408
Total	2,181,333	2,363,937	[3] 1,768,082

[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 1970

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Silicomanganese	Spiegeleisen	Manganese metal [1]
Steel:					
Carbon	713,681	91,550	87,845	11,169	4,837
Stainless and heat resisting	1,830	4,931	8,371	W	6,689
Alloy (exclude stainless and tool)	108,043	27,539	26,852	1,679	1,960
Tool	839	122	W	---------	W
Cast irons	8,471	2,343	7,154	7,309	11
Superalloys	437	44	W	---------	363
Alloys (exclude alloy steels and superalloys)	5,387	1,172	1,838	---------	9,410
Miscellaneous and unspecified	32,423	1,799	6,440	111	1,212
Total	871,111	129,500	138,500	20,268	24,482
Stocks December 31 [2]	244,412	33,474	40,269	10,355	9,172

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.

Table 5.—Ferromanganese produced in the United States and metalliferous materials [1] consumed in its manufacture

Year	Ferromanganese produced			Materials consumed		
	Gross weight (short tons)	Manganese content		Manganese ore (35 percent or more Mn natural) [2]		Manganese ore used per ton of ferromanganese[3] made (short tons)
		Percent	Short tons	Foreign (short tons)	Domestic (short tons)	
1966	946,210	78.7	744,359	2,133,925	30,043	2.2
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

[1] Excluding scrap and other secondary materials.
[2] Includes ore used in producing silicomanganese and metal.
[3] Includes ore used in producing silicomanganese.

Electrolytic Manganese and Manganese Metal.—It can be assumed that virtually all the manganese metal consumed, produced, and imported in the United States was electrolytic metal. Producers were Kerr-McGee Chemical Corp. (until October 1 operating under the name of American Potash & Chemical Corp.), Hamilton (Aberdeen), Miss.; Foote Mineral Co., Knoxville and New Johnsonville, Tenn.; and Union Carbide Corp., Marietta, Ohio.

Ferromanganese.—U.S. Steel Corp. and Bethlehem Steel Co. were the only producers using blast furnaces to make ferromanganese. U.S. Steel converted the No. 1 blast furnace at its National works from pig iron to ferromanganese production and added air and water pollution control equipment. The company continued to produce the alloy at Clairton, Pa., also in the Pittsburgh district. Bethlehem's production continued at Johnstown, Pa. U.S. shipments of ferromanganese totaled 807,000 short tons compared with 837,000 tons in 1969.

Silicomanganese.—Production of silicomanganese in the United States was 193,000 short tons, compared with 223,000 tons in 1969. Shipments from furnaces were 173,000 tons, compared with 218,000 tons in 1969. The ratio of consumption of silicomanganese to consumption of ferromanganese was 14 percent, essentially the same as in 1969.

Spiegeleisen.—The New Jersey Zinc Co. continued to produce spiegeleisen solely by electric furnaces at Palmerton, Pa.

Pig Iron.—In producing pig iron, 744,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural) were consumed. Domestic sources supplied 594,000 tons, of which 255,000 tons were manganiferous iron ore containing 5 to 10 percent manganese, and 339,000 tons were ferruginous manganese ore containing 10 to 35 percent manganese. Foreign sources supplied 150,000 tons, of which 42,000 tons were manganiferous iron ore, and 108,000 tons contained more than 35 percent manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide, but 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 specifications P–81–R for chemical-grade ore.

A new dry-cell battery plant was under construction at Marysville, Mo., for Union Carbide Corp., and one was planned by Gould Inc. for completion early in 1971 at Woodruff, S. C. ESB Inc. placed a new Ray-O-Vac manganese-alkaline battery plant in operation at Fennimore, Wis., and was building another dry-cell plant at Appleton, Wis., expected to go into production in late 1971. Both of these plants are highly automated and air conditioned. The demand for manganese-alkaline batteries continued to grow at a higher rate than that for standard dry cells.

PRICES

Manganese Ore.—All manganese ore prices are negotiated, and are dependent in part on the characteristics and quantity of ore offered, delivery terms, and fluctuating shipping rates. The American Metal Market quotation for ore containing 46 to 48 percent manganese continued from the latter part of 1969 into September 1970 at 49 to 53 cents, nominal, per long ton unit, c.i.f. eastern seaboard and Gulf ports. An increase at that time to 56 to 59 cents, nominal, same basis, reflected increased freight rates. This quotation carried on into 1971. The American Metal Market quotation for ore containing 48 to 50 percent manganese was 4 cents higher throughout the year.

Manganese Alloys.—The price of standard high-carbon ferromanganese containing 74 to 76 percent manganese increased $5, effective January 2, to $169.50 per long ton of alloy, f.o.b. producer plant. An increase of $10 per long ton became effective July 1, and a further $5 increase October 1 brought the price to $184.50. This price held to the end of the year. Similar increases were made at the same times for standard ferromanganese having 78 percent minimum manganese content so that the price for this grade was $5.50 higher throughout the year, ending the year at $190 per long ton. Metals Week's quotation for imported standard ferromanganese containing 74 to 76 percent manganese held at $160 to $164 per long ton, delivered in Pittsburgh or Chicago, until July when it increased to $165 to $170, then to $185 to $190 in late September. At the end of December it was dropped to $180.

Manganese Metal.—The price of standard electrolytic manganese metal was 31.25 cents per pound, f.o.b. producer plant, throughout the year. In December an increase of 2 cents per pound was announced, effective January 2, 1971.

FOREIGN TRADE

Ferromanganese exports were 21,747 short tons valued at $4,355,525, compared with 1,759 tons valued at $482,684 in 1969. West Germany took the largest quantity, 7,862 tons; followed by Romania, 4,366 tons; Venezuela, 2,790 tons; the United Kingdom, 1,795 tons; Sweden, 1,105 tons; Mexico, 948 tons; Canada, 866 tons; Colombia, 711 tons; Finland, 550 tons; and lesser quantities in decreasing order to Brazil, the Dominican Republic, Peru, Jamaica, the Philippines, Ghana, the Republic of South Africa, Argentina, South Vietnam, France, Singapore, Bolivia, and Panama. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" totaled 2,971 tons valued at $2,042,469 in 1970 and 2,470 tons valued at $1,410,437 in 1969. Exports of ore and concentrate containing more than 10 percent manganese totaled 20,294 tons at a value of $2,461,176, compared with 19,796 tons at $1,589,424 in 1969. These were believed to consist almost entirely of imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

Airco Alloys and Carbide Division, Air Reduction Co., contracted to sell the Romanian state trading organization, Metal-import, 61,000 tons of ferroalloys, including standard ferromanganese, medium-carbon ferromanganese, and silicomanganese. Deliveries of 7,000 tons were agreed for 1970; the remaining 54,000 tons of ferroalloys were to be delivered over the following 4 years at prices described as "highly competitive". Although Airco has made spot sales to other East European countries, these will be the company's first sales to Romania.

The average grade of imported manganese ore was 48.8 percent manganese in 1970, compared with 50.6 percent in 1969 and 47.5 percent in 1968. More than half of the total continued to come from Brazil and Gabon. There were no imports of manganiferous ores containing more than 10 but less than 35 percent manganese.

Silicomanganese imports for consumption totaled 14,539 short tons containing 9,624 tons of manganese. Sources and tonnage (gross weight) were as follows: Norway, 12,371; France, 659; the Republic of South Africa, 654; Canada, 577; and Mexico, 279. Imports for consumption classified as unwrought manganese metal, except alloys, and waste and scrap of such metal, totaled 1,276 short tons, compared with 1,371 tons in 1969. Of the quantity in 1970, the Re-

Table 6.—U.S. imports of manganese ore (35 percent or more Mn), by countries

Country	General imports [1] (short tons)						Imports for consumption [2] (short tons)					
	1969			1970			1969			1970		
	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)
Angola [3]	29,762	14,356	$419	70,276	33,535	$1,364	29,762	14,356	$419	70,276	33,535	$1,364
Australia	154,774	75,887	3,105	67,613	32,774	1,301	154,774	75,887	3,105	67,613	32,774	1,301
Brazil	693,802	353,557	13,509	610,949	292,420	11,879	670,316	342,284	13,069	610,949	292,420	11,879
British West Africa [4]	101	38	2	-----	-----	-----	101	38	2	-----	-----	-----
Canada	444	213	13	16,415	7,829	450	444	213	13	16,415	7,829	450
Congo (Kinshasa) [5]	r 197,167	r 108,975	r 4,443	67,312	33,768	1,140	r 197,167	r 108,975	r 4,443	67,312	33,768	1,140
Gabon [6]	r 526,813	r 264,558	r 10,535	480,342	241,615	8,841	r 526,813	r 264,558	r 10,535	480,342	241,615	8,841
Ghana	95,202	46,835	1,946	74,738	36,171	1,831	95,202	46,835	1,946	74,738	36,171	1,831
Guyana [7]	17,196	6,707	353	-----	-----	-----	17,196	6,707	353	-----	-----	-----
India	65,040	30,508	1,081	80,793	37,023	1,391	65,040	30,508	1,081	80,793	37,023	1,391
Ivory Coast	7,194	3,218	119	9,343	3,644	81	7,194	3,218	119	9,343	3,644	81
Japan	39	16	5	49	18	6	39	16	5	49	18	6
Malaysia	-----	-----	-----	49	24	1	-----	-----	-----	49	24	1
Mexico	5,249	2,376	229	35,505	16,988	968	5,249	2,376	229	35,505	16,988	968
Morocco	23,939	12,799	1,372	35,794	19,940	2,306	23,939	12,799	1,372	35,794	19,940	2,306
Philippines	4,744	2,540	147	-----	-----	-----	4,744	2,540	147	-----	-----	-----
South Africa, Republic of	59,228	29,018	904	139,067	66,452	1,809	59,228	29,018	904	139,067	66,452	1,809
South Africa, n.e.c. [8]	-----	-----	-----	10	7	(9)	-----	-----	-----	10	7	(9)
Turkey	-----	-----	-----	3,360	1,546	75	-----	-----	-----	3,360	1,546	75
Venezuela [10]	216	104	4	-----	-----	-----	216	104	4	-----	-----	-----
Western Africa, n.e.c. [11]	r 78,751	r 39,276	r 1,390	36,922	19,693	703	r 78,751	r 39,276	r 1,390	36,922	19,693	703
Western Portuguese Africa, n.e.c	-----	-----	-----	6,518	3,259	117	-----	-----	-----	6,518	3,259	117
Total	r 1,959,661	r 990,981	r 39,576	1,735,055	846,706	34,263	r 1,936,175	r 979,708	r 39,136	1,735,055	846,706	34,263

r Revised.
[1] Comprises ore received in the United States; part went into consumption during the year and the remainder entered bonded warehouses.
[2] Comprises ore received during the year for immediate consumption and ore withdrawn from bonded warehouses.
[3] Part or all in 1970 is believed to have originated in Gabon or Congo (Kinshasa).
[4] Probably from Ghana or Guyana.
[5] In 1969, actual imports originating in Congo (Kinshasa) were approximately 118,000 tons (gross weight); see footnote 6.
[6] In addition for 1969: Gabon imports reported as Congo (Kinshasa) were approximately r 80,000 tons (gross weight); those reported as Western Africa, n.e.c. were approximately r 79,000 tons (gross weight). 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.
[7] All reported from Trinidad and Tobago (country of transshipment). In addition, Guyana imports reported as Venezuela (country of transshipment) appear to have been 216 tons (gross weight) in 1969.
[8] Probably Botswana.
[9] Less than ½ unit.
[10] Apparently no imports originated in Venezuela; see footnote 7.
[11] Actually from Gabon.

Table 7.—U.S. imports for consumption of ferromanganese, by countries

Country	1969 Gross weight (short tons)	1969 Mn content (short tons)	1969 Value (thousands)	1970 Gross weight (short tons)	1970 Mn content (short tons)	1970 Value (thousands)
Belgium-Luxembourg	4,464	3,365	$445	551	423	$60
Canada	4,483	3,514	557	357	288	90
Chile	390	341	65	613	536	96
France	64,421	49,476	5,571	100,036	77,745	10,285
Germany, West	r 39,802	r 30,409	r 4,539	8,342	6,499	1,022
India	42,188	32,241	3,118	35,597	27,128	3,255
Italy	r 2,208	1,782	442	1,111	896	199
Japan	6,436	5,063	1,153	5,556	4,373	913
Mozambique	-------	-------	-------	12,340	9,648	1,485
Netherlands	-------	-------	-------	2,065	1,611	194
Norway	2,339	1,830	217	3,291	2,577	351
South Africa, Republic of	r 121,331	r 94,811	r 12,589	119,292	93,759	13,161
Sweden	14,341	12,031	2,916	1,795	1,496	452
Western Africa, n.e.c. [1]	r 5,488	r 4,281	r 669	-------	-------	-------
Total	r 307,891	r 239,144	r 32,281	290,946	226,979	31,563

r Revised.
[1] Probably originated in Republic of South Africa.

public of South Africa supplied 1,180 tons and Japan supplied 96 tons. Small quantities of high unit value, measured in pounds, came from the United Kingdom and Italy.

Imports for consumption classified as "managanese compounds, other" totaled 3,209 tons in 1970, compared with 2,160 tons in 1969. The sources, gross weights, and values per pound in 1970 were as follows: Japan, 2,752 tons (14.7 cents); the United Kingdom, 429 tons (7.0 cents); Belgium-Luxembourg, 21 tons (7.6 cents); the Republic of South Africa, 5 tons (5.0 cents); West Germany, 1.5 tons ($1.83); and Austria, 0.5 tons (32.7 cents). The imports from Japan appear to have consisted largely, if not entirely, of synthetic manganese dioxide.

Tariff.—Suspension of the duty on manganese ore from most nations was extended for another 3 years (through June 30, 1973) by Public Law 91–306. Ore from the U.S.S.R., mainland China, and certain other specified Communist countries, continued to be subject to a tariff of 1 cent per pound of contained manganese.

WORLD REVIEW

Angola.—Manganese ore produced in 1970 had a manganese content ranging from 30 to 52 percent manganese. As in 1969, production was from several small mines of Companhia do Manganês de Angola. Exports of 22,600 and 30,300 short tons in 1970 and 1969, respectively, were reported to have gone primarily to Japan. No manganiferous ore was produced in either of the two years.

Argentina.—Manganese ore produced in 1969 averaged 35 percent manganese, whereas the manganiferous ore produced had an average manganese content of 22 percent. Rhodochrosite exports in 1969 totaled 24 short tons valued at $68,433. Of this quantity, 2 tons went to the United States. Argentine imports of manganese ores and concentrates were 22,000 short tons in 1969, compared with 60,000 tons in 1968.

Australia.—Groote Eylandt Mining Co., a Broken Hill Proprietary Co. Ltd. subsidiary, proceeded with the expansion program announced in December 1968. The largest item involved is a new A$8 million concentrator, expected to be in operation in the latter half of 1971. A new wharf, increased stockpile capacity at the wharf, an extension to the power plant, a 90-ton-capacity road train, and other new equipment and facilities are included in the program. Although Groote Eylandt now accounts for the major part of Australian manganese ore production, ore exports of the two Western Australia producers—Bell Brothers and Longreach—had reached a value of A$3.25 million per year. Trucks

Table 8.—Manganese ore: World production by countries [1]
(Short tons)

Country	Percent Mn e	1968	1969	1970 p
North America:				
Mexico [2]	35+	65,420	158,252	301,939
United States	35+	11,378	5,630	4,737
South America:				
Argentina	30–40	r 25,954	24,095	e 24,000
Bolivia (exports)	35+	----------	----------	93
Brazil	38–50	1,852,000	2,166,000	2,126,000
Chile	41–47	26,283	26,124	29,457
Guyana	36–42	144,138	----------	----------
Peru	30+	7,885	r 13,228	2,119
Europe:				
Bulgaria	30+	45,000	43,000	e 44,000
Greece	50	r 7,434	r 7,125	7,190
Hungary	30–	172,000	172,000	186,028
Italy	30–	56,020	58,385	55,216
Portugal	38–44	r 10,654	7,637	6,083
Spain	30+	14,248	25,302	11,504
U.S.S.R. [3]	NA	7,236,000	7,221,000	e 7,700,000
Yugoslavia	30+	r 15,582	13,593	16,298
Africa:				
Angola	30+	10,086	32,044	25,000
Botswana	30+	r 11,021	24,769	45,020
Congo (Kinshasa)	42+	354,735	343,291	382,446
Gabon	50–53	r 1,382,958	r 1,502,000	1,601,700
Ghana [4]	48+	455,617	r 366,800	446,837
Ivory Coast	32–47	128,685	140,036	25,419
Morocco	35–53	176,602	143,935	123,873
South Africa, Republic of	30+	2,173,438	2,429,600	2,953,609
Sudan	36–44	5,500	940	1,279
United Arab Republic	30–	4,361	4,400	NA
Zambia	35+	r 27,999	r 28,284	e 33,000
Asia:				
China, mainland e	30+	990,000	1,100,000	1,100,000
India [5]	NA	1,766,000	r 1,637,000	1,820,000
Indonesia	35–49	r 2,400	7,100	2,200
Iran [6]	35+	r 28,000	39,000	e 40,000
Japan	30–43	344,247	r 331,587	298,701
Korea, Republic of	35+	4,653	3,199	3,749
Malaysia	30–40	49,737	11,392	----------
Philippines	30–52	72,800	22,048	5,645
Thailand	40+	45,270	32,872	26,307
Turkey	30–50	r 27,842	r 15,090	10,465
Oceania:				
Australia	46	r 819,692	r 1,016,286	886,080
Fiji	30–50	r 9,750	22,917	27,054
New Hebrides	31–43	r 46,824	----------	16,926
Total		r 18,628,213	r 19,195,961	20,389,974

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. Colombia has produced ore of unspecified grade as follows (short tons): 1968, 551; 1969, 606; 1970, 511. Low grade ore output, not included in the table, has been reported as follows (short tons): Argentina (about 22 percent Mn), 1968, r 11,210; 1969, 16,151, 1970, e 17,000; Czechoslovakia (about 17 percent Mn), 1968, 95,000; 1969, 93,000; 1970, e 94,000; Romania (about 22 percent Mn), about 140,000 tons in each year; Republic of South Africa (15 to 30 percent Mn), 1968, 502,080; 1969, 484,041; 1970, 412,264; Sweden (about 12 percent Mn), 1968, 12,921; 1969, 9,700; 1970, NA.
[2] Estimated on the basis of reported contained manganese.
[3] Grade unreported. Source: The National Economy of the U.S.S.R., Central Statistical Administration (Moscow).
[4] Dry weight.
[5] Indian output not reported by grade, but of total exports of 1,310,769 tons in 1968 and 1,331,349 tons in 1969, 61 percent and 57 percent respectively graded less than 35 percent manganese.
[6] Iranian calendar year beginning March 21; all figures are mine run ore.

and trailers of 100-ton capacity are used to transport the ore from the mines at Woody Woody, in the Pilbara district, to Port Hedland for shipment to Japan.

Brazil.—Production of mine run manganese ore in 1970 by Indústria e Comércio de Minerios S.A. (ICOMI) totaled 2,205,000 short tons, averaging less than 40 percent manganese. The company's washed ore product was 1,577,000 tons, averaging approximately 48 percent manganese. Production at the Urucum mine in Mato Grosso was 93,600 tons averaging 46.42 percent manganese, and the Meridional mine in Minas Gerais produced 108,000 tons with a manganese content, averaging 38.33 percent.

Brazilian exports of manganese ore in 1968 totaled 1,239,000 short tons. Of this quantity, 44 percent went to the United

States, 11 percent to the United Kingdom, 9 percent to Norway, 7 percent to France, 7 percent to Japan, 6 percent to the Netherlands, and the balance, in descending order, to West Germany, Argentina, Belgium, Spain, Canada, Uruguay (probably point of transshipment to an ultimate destination elsewhere), and Mexico.

Cuba.—The Charco Redondo manganese mine, Oriente Province, was reportedly producing metallurgical-grade manganese ore for local consumption at the rate of a few thousand tons per year.[2]

France.—United States Steel Corp. acquired a 27-percent interest in France's largest ferromanganese producer, Ste. des Aciéries de Paris et d'Outreau, which announced plans to build a new ferromanganese plant in the harbor area of Boulogne. The French company's two present ferromanganese plants produce approximately 300,000 tons of blast furnace ferromanganese per year.

Gabon.—Facilities of Gabon's only manganese ore producer, Cie. Minière de l'Ogooúe (COMILOG), were being expanded for the fourth time in 3 years. By 1972, annual sales of 2.46 million short tons should be supported, representing an increase of nearly 40 percent over the 1970 level. United States Steel Corp. continues to hold a 49-percent interest in COMILOG. Production of battery-and chemical-grade ore was 26,000 short tons in 1970, compared with 16,500 tons in 1969.

Ghana.—Parliament was informed March 12 by the Minister of Finance and Economic Development that the Nsuta-Wassaw manganese mine of African Manganese Co., wholly owned subsidiary of Union Carbide Corp., is to be closed within 5 years upon exhaustion of its oxide ore reserve. Union Carbide Corp. started producing dry-cell batteries at its new plant in 1969.

Indonesia.—The new $2,700,000 dry-cell battery plant of P.T. Union Carbide Indonesia went into production. This replaced an old facility which had been out of operation for some time.

Iran.—ESB Inc. completed construction of a new Ray-O-Vac dry-cell battery plant at Qazvin. Production was expected to begin in 1971. The company's existing plant at Teheran was expanded in 1969 to almost four times its original size. In 1970, Union Carbide Corp. purchased a majority interest in an Iranian dry-cell battery producer. Modification and expansion of existing plant facilities was expected to be completed before mid-1972 by the operating company, now known as Union Carbide Iran S.A.

Italy.—Manganese ore produced in 1970 averaged 27 percent manganese, compared with 28 percent in 1969.

Ivory Coast.—Closing of the country's only operating manganese mine, the Mokta mine at Grand Lahou, was announced March 11 in the semiofficial newspaper, Fraternite-Matin. The low quality of the ore together with poor market prices had made the operation unprofitable. Exports of 92,000 short tons in 1970 included an appreciable quantity from stocks. Exports were 78,000 tons in 1969 and 131,000 tons in 1968. Spain, the United States, and West Germany have been the principal recipients. Of the 1969 exports, 63,000 tons averaged 45 to 47 percent manganese. The remaining 15,000 tons consisted of fines having a manganese content of 33 percent. On December 4, Union Carbide Cote d'Ivoire S.A. opened a $3 million plant for the production of dry-cell batteries.

Japan.—A number of large electric ferroalloy furnaces, complete with pollution-control equipment, were under construction or planned in the course of a general trend toward replacement of old, smaller furnaces. Those for ferromanganese being built in 1970 included a 40,000-KVA plant at Kawasaki Steel's subsidiary, Mizushima Ferroalloy, and one of 20,000-KVA at Kobe Steel's Kakogawa Works. A 44,000-KVA ferromanganese plant at the Niigata Works of Nippon Kokan was scheduled for completion in April 1971, and a 40,000-KVA silicomanganese plant in August at Tokushima for Nippon Steel's subsidiary, Nippon Denko. The Kakogawa plant charges its hot product direct to the plant's basic oxygen steel furnaces.[3] Japanese production of dioxide ore or concentrate in 1970 was 2,066 short tons, averaging 68.3 percent manganese dioxide; metallurgical concentrate produced averaged 29.1 percent manganese. Production of ferromanganese was 490,000 tons; electrolytic managanese metal, 10,410 tons; and synthetic manganese dioxide, 45,540 tons. A very large part of the synthetic

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[2] Delinois, Serge L. Is Cuba Winning Battle To Develop Mining Industry? Eng. and Min. J., v. 171, No. 5, May 1970, pp. 86–94.

[3] American Metal Market. V. 78, No. 35, Feb. 22, 1971, pp. 1, 3.

dioxide was produced for export.

Korea, Republic of.—The manganese ore produced in 1970 and in 1969 was of an average 40 percent manganese grade.

Mexico.—Cia. Minera Autlán began shipment of nodules containing 36 percent manganese to Bethlehem Steel Co. from its new loading facilities at Ciudad Madero (Tampico). Ships can load at a rate of 1,650 to 2,000 short tons per hour.

Morocco.—All manganese ore produced in 1970 was chemical-grade concentrate, averaging 84 percent manganese dioxide. Exports of chemical grade totaled 118,000 short tons, of which the United States took 35,000 tons, and France and the Netherlands the larger part of the remainder. In addition, 7,000 tons of metallurgical sinter were exported, obviously from stocks. Most of this went to Czechoslovakia. Reserves of ore at the Imini mine, the country's only remaining significant producer of manganese ore, were reported to be sufficient for 15- to 20-year operation at the current rate. Reserves at the Tiouine mine, where a beneficiation plant was being built by the Hungarian organization NIKEX, were estimated at 400,000 short tons of ore containing 30 to 48 percent manganese plus 100,000 tons of waste material considered worth processing. As encouragement to the mining industry, the Government reduced the ad valorem export tax on certain ores, including all manganese ores, from 5 percent to 0.5 percent.

New Hebrides.—The manganese deposits at Forari on Efate (or Vaté) Island are stratiform and lenticular concentrations of manganese oxide, with todorokite as the principal discrete mineral. They occur generally as one or two layers conformable with the underlying tuffs and overlying red clays and soils at a depth of a few feet to 20 feet below surface. The upper layer is the richer of the two layers. It averages 9 inches in thickness, contains most of the minable ore, and has a manganese content of 39 to 45 percent. The poorer lower layer has a maximum manganese content of 30 to 35 percent with patchy development of manganese oxide. A similarity between these deposits and those of Oriente Province in Cuba was noted.[4] The first outloading of ore since the reopening of the mine was placed on ship in July at Forari. Whereas the previous operators, Cie. Française des Phosphate de l'Oceanie, washed and agglomerated the ore, the plans of the present operators, Le Manganese de Vaté, encompass only washing.[5] The concentrate produced in 1970 averaged 43 percent manganese. Exports totaled 29,000 short tons of concentrate, and 2,100 tons of agglomerate that apparently had been left in stocks.

Nigeria.—Relatively small bodies of manganese oxides resulting from the supergene alteration of a spessartite-quartzite (gondite) lens in a hitherto unmapped metasedimentary belt in northern Nigeria were described. This and other unexplored metasedimentary belts of this part of the country are similar to those carrying manganese ores further west in Ghana, Upper Volta, and the Ivory Coast, except that these are much younger in age.[6]

Norway.—Production of both ferromanganese and silicomanganese was adversely affected by a continuing power shortage and by an explosion April 1 that severely damaged Elkem's Porsgrunn plant.

Pakistan.—Reserves of manganese ore were estimated by the country's Geological Survey to total more than 565,000 short tons of ore. Grade was not stated. West Pakistan produced 159 tons in 1969.

Peru.—Manganese ore produced in 1970 averaged 33.0 percent manganese.

Philippines.—There was no low-grade manganese ore produced in 1970. The manganese ore produced had an average grade of 52 percent manganese. No ferromanganese or silicomanganese was produced. Union Carbide Corp. was completing construction of its second dry-cell battery plant in the Philippines. Located on the island of Cebu, the plant will be owned and operated by Union Carbide Philippines, Inc. Union Carbide's other Philippine plant is in Manila where it has operated for more than 15 years.

Portugal.—Production of manganese ore in 1969 averaged 43.6 percent manganese. In addition, approximately 60,000 short tons of manganiferous iron ore was produced analyzing 46.5 percent iron and 8 percent manganese.

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[4] Warden, A. J. Genesis of the Forari Manganese Deposit, New Hebrides. Inst. Min. & Met. Bull. (London), No. 759, February 1970, pp. B 30–41.

[5] Pacific Islands Monthly (Sydney, Australia). V. 41, No. 8, August 1970, pp. 126–127.

[6] Wright, J. B. and P. McCurry. First Occurrence of Manganese Ores in Northern Nigeria Econ. Geol., v. 65, No. 2, March–April 1970, pp. 103–106.

Romania.—Beginning in 1970, Metalimport contracted to import manganese and other ferroalloys from the United States (AIRCO) over a 5 year period.

South Africa, Republic of.—Production of metallurgical ore of the various grades in 1970 was as follows, in short tons: 30 to 40 percent manganese, 1,837,000; 40 to 45 percent, 120,000; 45 to 48 percent, 125,000; and over 48 percent, 732,000. Local sales were, respectively, 443,000, 24,000, 81,000, and 229,000 tons. Of the chemical ore produced, 128,000 tons contained 35 to 65 percent manganese dioxide, 12,000 tons contained 65 to 75 percent manganese dioxide. No chemical ore of 75–to–85 grade was produced. Local sales for the two lower grades were 88,000 and 2,700 tons, respectively. Production of ferruginous manganese ore, containing 15 to 30 percent manganese and 20 to 35 percent iron, amounted to 412,000 tons. Exports were 98,000 tons and local sales 7,500 tons. Total exports of metallurgical ore were 2,237,000 tons; for chemical grade ore they were 8,800 tons. Effective April 1, the government-owned South African Railways reduced rail rates for manganese ores from the mines in northern Cape Province to the ports of Durban and Port Elizabeth. An acute shortage of railway cars and lines became apparent in 1969 and continued into 1970. This was coupled with, and probably was in part a contributing factor to, deteriorating ship-loading rates at the ports in spite of increased mechanization. Capital expenditures of the Assocated Manganese Mines of South Africa Ltd. included funds for extension of the rail line under construction from Hotazel to the company's Black Rock Mine. The company's subsidiary, Ferroalloys Ltd., in which U.S. Steel Corp. has a 31–percent interest, operated its ferromanganese and ferrochromium plant at capacity in 1970.

Electrolytic Metal Corp. (Pty) Ltd. (EMCOR), owned 70 percent by Technimetals (Pty) Ltd. which is a wholly owned subsidiary of General Mining and Finance Corp. Ltd., was expanding production capacity 30 percent at its Krugersdorp plant to 13,450 short tons per year. Continued success in lowering production costs and declaration of the first dividend were reported. Production of electrolytic manganese metal was 9,900 tons in 1969. The increased output combined with higher prices halted a series of losses so that a satisfactory profit was realized for the fiscal year ending June 30, 1969.

Marble Lime & Associated Industries Ltd., another affiliate of General Mining and Finance, completed a new manganese dioxide grinding and drying plant at Zeerust.

Thailand.—Production of battery-grade manganese ore (75 percent manganese dioxide) was 7,100 short tons in 1970, with most or all of the ore apparently from the mining operations of Thai Rocks and Minerals Ltd., Lamphun Province in northern Thailand. The run-of-mine ore at that property, consisting almost entirely of pyrolusite, ranges in grade from an average of 40 to 50 percent manganese dioxide to as high as 80 percent manganese dioxide. The ore is broken out with paving breakers, trucked to the sorting area, washed in concrete mixers, and dried in the open air. It is then screened into four size fractions: Coarse, which is hand sorted; jig feed; shaking-table feed; and fines. The fines are washed and the various products are blended to obtain the shipping grade of 75 percent manganese dioxide, which brings $75 per metric ton f.o.b. Bangkok. The operation employs 500 people in two shifts and a staff of 20. A shortage of rail cars in the country poses a problem in moving the ore to market.[7] Metallurgical-grade ore produced in Thailand in 1970 amounted to 19,000 tons, containing 46 to 50 percent manganese; exports were 8,300 tons. Exports of battery-grade ore were only 400 tons. Japan has been the principal destination for Thai metallurgical ore, but it appears that the market is being lost to lower-cost Australian ore.

U.S.S.R.—Gornyi Zhurnal, the Soviet Mining Journal, reported on the status of both the Chiatura and Nikopol' mining districts. Run-of-mine ore at Chiatura in Georgia now exceeds 6 million tons per year. Washing has produced a concentrate ranging from 48 to 52 percent manganese. This has accounted for most of the Soviet exports of ore. The first stage of a new flotation plant was completed in 1968, receiving slurries from the gravity sections of other concentrators. When the plant is finally completed, output will be approximately 600,000 short tons per year of concentrate in the form of fines having a

[7] Beall, John V. Thailand. Min. Eng., v. 22, No. 7, July 1970, pp. 100–105.

manganese content of 37 to 38 percent. Exports of Georgian ore began in 1879 and the deposits are expected to last another century. At Nikopol' in the Dneper basin of the Ukraine the run-of-mine ore averages 30 percent manganese. The deposit is mined by two organizations, Nikopolmarganetz and Ordzhonikidsemarganetz, from 31 underground mines and 17 open pits, feeding eight beneficiation plants. The grade of the concentrates has been improving and is currently 40.58 percent manganese for the first mentioned organization and 42.95 percent for the other. The underground mines are being automated, and the open pits are in course of modernization and mechanization. Most of the Nikopol' ore is used domestically.[8]

United Kingdom.—Kodak Ltd. planned to begin production of manganese sulfate at the Kirby (Liverpool) plant of its chemical division. The output will satisfy domestic demand, roughly 550 short tons per year, for use in the production of fertilizers; the larger part of expected annual production of approximately 1,650 tons will be exported to Europe. Plans called for doubling capacity later. The company's U.S. affiliate, Tennessee Eastman Co., and mainland China have been the principal sources of supply of manganese sulfate for the United Kingdom. There has been no domestic production since 1966–67 when S. G. Bailey, Stroud, Kent, ended its small operation upon being unable to compete with Chinese pricing.

TECHNOLOGY

Study of major unit operations in a Bureau of Mines laboratory suggested that a reductive roast-ammoniacal leach process would be impractical for recovering manganese from calcareous deep-sea nodules. However, 90 percent or more of the nickel, cobalt, and copper contained in the nodules was extracted with an oxygenated ammonia-ammonium carbonate solution. Indications were that subsequent processing to obtain marketable nickel, cobalt, and copper products would be costly. The tests were conducted on nodules from the surface of the Blake Plateau off the Georgia coast at a depth of approximately 3,000 feet. A representative portion of pulverized nodules gave the following analysis, in percent: manganese 17; calcium, 13; iron, 11; silicon, 1.7; nickel, 0.6; cobalt, 0.3; and copper, 0.1. Because of high calcite content, acid leaching processes would not be economical. In testing siliceous nodules from the Pacific Ocean, four different sulfur-recycling acidic methods were tried: (1) atmospheric-pressure leaching, using sulfur dioxide dissolved in water, (2) high-temperature leaching, using sulfur dioxide and dilute sulfuric acid, (3) water leaching of the material after baking with sulfuric acid, and (4) water leaching of the material after roasting in sulfur dioxide and air. The latter proved to be the most promising of the four methods. Good extractions of manganese, nickel, cobalt, and copper were obtained with moderate consumption of sulfur dioxide, sulfuric acid, hydrogen sulfide, and ammonia. These siliceous nodules came from the ocean floor off the Baja California coast at a depth of approximately 12,000 feet. A dried sample analyzed, in percent as follows: manganese, 25; iron, 10; silicon, 7; calcium, 2; magnesium, 2; aluminum, 2; nickel, 1; copper, 0.5; zinc, 0.2; and cobalt, 0.1. In the case of both the Atlantic and the Pacific nodules, their constituents were of a cryptocrystalline nature, intimately associated with one another.[9]

In continuing research toward an economical process for extracting both manganese and iron from Cuyuna Range (Minn.) manganiferous ores, the Bureau of Mines investigated in the laboratory a procedure whereby: (1) The nonmagnetic iron minerals are converted to magnetite, and the manganic minerals are converted to manganous oxide, by low-temperature gaseous reduction; (2) the manganese then is extracted by leaching with sulfuric acid; and (3) the iron is recovered from the leach residue by magnetic separation. The four tested ores came from the Hillcrest, South Alstead, Sultana, and Hopkins mines, and had the following respective percentage analyses: manganese, 6.4, 9.4,

[8] Industrial Minerals (London). No. 29, February 1970, p. 51.
Mining Magazine (London). V. 122, No. 3, March 1970, p. 237.
American Metal Market. V. 77, No. 97, May 21, 1970, p. 15.

[9] Brooks, P. T., and D. A. Martin. Processing Manganiferous Sea Nodules. BuMines Rept. of Inv. 7473, 1971, 19 pp.

7.8, and 5.5; iron, 45.8, 39.9, 36.3, and 36.0; and silica, 8.2, 12.8, 27.1, and 33.5. The results gave high manganese recoveries in solution for all four of the ores tested. In addition, the Hillcrest and South Alstead ores yielded iron concentrates of acceptable blast furnace quality; the iron concentrate from the Sultana ore was to be considered marginal. Although manganese recoveries from the Hopkins ore averaged 88 percent, and iron recoveries of more than 90 percent were obtained in some instances, the iron concentrate obtained was of poor quality with silica content in the 15- to 20-percent range. For all four ores, this procedure obtained much better manganese recoveries than did previously reported research using the "metallizing roast," or that using a roast-leach method wherein magnetic separation of the iron preceded acid leaching of the manganese. The latter method registered poorly in the comparisons, whereas the "metallizing roast" did better for the iron by delivering better iron recoveries than either of the other two and having an appreciably better grade of iron concentrate.[10]

Interest continued in the substitution of manganese for nickel in stainless steels. Armco Steel Corp. developed a new austenitic stainless steel, designated 18-2 Mn, which contained 12 to 13 percent manganese, 18 percent chromium, and only 1.5 to 2 percent nickel. It was reported to have almost double the strength of costlier standard grades, as well as excellent cold working characteristics. It has found use for high-strength, corrosion-resistant fasteners, wire screens, cloth, and cables.[11] In Japan, Nisshin Steel Works Co., Ltd., Tokyo, developed a new stainless steel in which all of the nickel is replaced by manganese and copper. Designated NHS104, its composition is 15-½ percent chromium, 10 percent manganese, 3 percent copper, and the balance iron. It can be produced with conventional equipment, and will be lower in price than type 304 stainless. It is being used in the manufacture of sinks, bathtubs, and kitchen utensils.[12]

Lupgi Gesellschaften, a subsidiary of Metallgesellschaft AG, Frankfurt, West Germany, joined with Deepsea Ventures Inc., Gloucester Point, Va., in the latter's continuing exploration and test mining of deep sea floors. During 1970, Deepsea Ventures successfully completed testing of its prototype ocean mining rig at depths of 3,000 feet on the Blake Plateau, and was scaling up its metallurgical testing from "mini-pilot plant" to pilot plant level. Plans called for developing a complete system for removing nodules from ocean floor depths of 15,000 to 18,000 feet with subsequent extraction of nickel, copper, manganese, and cobalt by means of a sophisticated metallurgical process. If the results of the mining and metallurgical tests continue to be favorable, the company envisages commercial production by an international consortium by 1976 or 1977. Other organizations were active during the year in investigating the possibilities for development of the deep-sea nodules. Both Japan and the U.S.S.R. reported recovery of nodules from depths exceeding 10,000 feet. The Japanese operation, 250 miles northwest of Tahiti, recovered 2 tons of nodules using a flexible cable bucket line having approximately 300 buckets of 65-pound capacity each. Numerous patents were granted for methods for recovering manganese nodules from the deep ocean floors.

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[10] Jacobs, H. D. Magnetic Roasting and Leaching for Upgrading Minnesota Manganiferous Iron Ores. BuMines Rept. of Inv. 7411, 1970, 13 pp.

[11] Materials Engineering. V. 71, No. 2, February 1970, p. 20.

[12] Iron Age. V. 206, No. 25, Dec. 17, 1970, p. 50.

Mercury

By V. Anthony Cammarota, Jr.[1]

Consumption, production, and imports of mercury in the United States during 1970 were lower than the previous year. In the first quarter consumption continued at the 1969 rate, but at yearend declines were noted for almost all uses. Much of the decline in usage was attributed to the slowed pace of the U.S. economy and the problem of mercury pollution. The use of mercury compounds in the pulp and paper industry declined significantly. Mine production in 1970 was down about 8 percent to 27,303 flasks.[2] Secondary production also was lower, primarily because of lower sales of surplus mercury from the General Services Administration (GSA) stockpiles. Imports declined sharply to 21,972 flasks but exports increased substantially.

Pollution of the environment by mercury became a major consideration in 1970. The U.S. Department of Agriculture (USDA) cancelled the registration of 48 mercury compounds used as agricultural and commercial biocides. Because of the potential hazard, USDA is reviewing all biocidal uses of mercury.

The price of mercury (New York) dropped continuously during the year, to $350–$360 at yearend. Lack of buying interest on the part of domestic consumers contributed to soft prices.

Of the major world mercury producers, only Canada, which became the chief foreign supplier to the United States, and Mexico increased production significantly during 1970.

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. No contracts were executed during 1970.

In early 1970 Congress refused approval of legislation which would have allowed the sale of 73,605 flasks of mercury in excess of the stockpile objective of 126,500 flasks. As of December 31, 1970, total stockpile accumulations from all programs stood at 200,105 flasks.

Releases by the GSA of surplus mercury stocks continued into 1970, but bidding was cancelled in September because of un-

[1] Physical scientist, Division of Nonferrous Metals.

[2] Flask as used throughout this chapter refers to the 76-pound flask.

Table 1.–Salient mercury statistics

	1966	1967	1968	1969	1970
United States:					
Producing mines	130	122	87	109	79
Production flasks	22,008	23,784	28,874	29,640	27,303
Value thousands	$9,722	$11,639	$15,464	$14,969	$11,134
Exports flasks	357	2,627	7,496	507	4,653
Reexports do	476	475	103	108	50
Imports:					
For consumption do	31,364	24,348	23,246	31,924	21,972
General do	34,757	23,899	23,956	30,848	21,672
Stocks Dec. 31 do	20,076	18,277	22,907	22,692	16,376
Consumption do	71,509	69,517	75,422	77,372	61,503
Price: New York, average per flask	$441.72	$489.36	$535.56	$505.04	$407.77
World:					
Production flasks	264,994	232,073	259,694	290,043	284,497
Price: London, average per flask	$447.68	$499.36	$546.80	$536.41	$411.45

favorable market conditions. Total releases were 703 flasks, 701 of which were commercial sales. The stock remaining to be sold at the end of 1970 was about 13,500 flasks. In January mercury was sold for an average price of $486.42; in June the average selling price was $411.00.

The depletion allowance for mercury remained at 22 percent for domestic deposits and 14 percent for foreign deposits.

DOMESTIC PRODUCTION

Because of low prices and soft demand, the number of operating mines in 1970 decreased to 79 from 110 in 1969. Many of the mines that became inactive were small producers who found it uneconomical to produce mercury at prevailing prices during the year. Some exploration and development work continued, however. Some of the large producing mines that ceased operations during 1970 included the Juniper, El Capitan, and Gambonini in California, and the Quinn River, Goldbanks, and B & B in Nevada. The number of mines reporting outputs of 1,000 flasks or more increased by one over 1969. Properties producing 500 to 999 flasks increased from three to five. The number reporting 100 to 499 flasks decreased to 10 from 15 in 1969. Of the total production, 75 percent came from producers of 1,000 flasks or more, 11 percent from producers of 500 to 999 flasks, and 10 percent from producers of 100 to 499 flasks. Principal mines in 1970 were as follows:

State	County	Mine
	Properties Producing 1,000 Flasks or More	
Alaska	Aniak District	Red Devil.
California	Lake	Abbott.
Do	San Luis Obispo	Buena Vista.
Do	Sonoma	Culver-Baer.
Do	Santa Barbara	Gibraltar.
Do	Santa Clara	Guadalupe.
Do	Sonoma	Mt. Jackson.
Do	Santa Clara	New Almaden.
Do	San Benito	New Idria.
Idaho	Washington	Idaho-Almaden.
Nevada	Humboldt	Quinn River (Cordero).
Do	do	Ruja.
	Properties Producing 500 to 999 Flasks	
Alaska	Kuskokwim River Region	Cinnabar Creek.
California	Trinity	Altoona.
Do	Marin	Gambonini.
Do	Napa	Manhattan-One Shot.
Nevada	Esmeralda	B & B.
	Properties Producing 100 to 499 Flasks	
Alaska	Kuskokwim River Region	White Mountain.
California	Napa	Aetna.
Do	Marin	Chileno Valley.
Do	Napa	Corona.
Do	San Luis Obispo	Klau.
Do	Santa Clara	Old Guadalupe.
Nevada	Lander	Basic McCoy.
Do	Pershing	Goldbank.
Oregon	Douglas	Elkhead.
Texas	Brewster	Study Butte.

California continued to be the major producing State, contributing 68 percent of the prime virgin mercury compared with 62 percent in 1969. Although 21 fewer mines were operating in the State in 1970, total output was maintained by increased production from the Abbott, Aetna, Altoona, Culver-Baer, Manhattan-One Shot, New Almaden, and Old Guadalupe mines. Operation of new furnace at the New Almaden mine site increased mercury capacity by approximately 200 flasks per month.

Nevada produced 18 percent of the total mercury with 11 fewer mines than in 1969. The shutdown of the famous Quinn River (Cordero) mine was permanent with regard to underground mining, but the company is weighing the possibility of strip mining. The Ruja mine, which adjoins the Quinn River mine, is now the State's largest producer.

The Idaho-Almaden mine in Idaho continued production at the 1969 level. Four mines were active in Alaska. The Red Devil mine, reopened by Alaska Mines and Minerals, Inc., has contracted to sell to Japan all concentrates from its 100-ton-per-day flotation mill during the first year of operation. The Elkhead mine accounted for the bulk of the increased output from Oregon. No production was reported from Arizona and only minor quantities from Arkansas and Washington.

The St. Joe Minerals Corp. recovered byproduct mercury from zinc concentrates at its smelter in Monaca, Pa. Most of the zinc concentrate comes from the company's mines in New York. Mercury recovery in 1969 was 280 flasks.

Secondary production of mercury decreased by 41 percent. While much of this decline was due to a lower rate of release from Government stockpiles, slack demand during the year generated less scrap. Dental amalgams, scrap batteries, various types of sludges, and discarded mercury-containing instruments were sources of secondary mercury.

Table 2.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1] (thousands)
1969			
California	72	18,480	$9,333
Idaho	1	1,012	511
Nevada	24	8,165	4,124
Oregon	4	43	22
Alaska, Arizona, New York, Texas	8	r 1,940	r 979
Total	109	r 29,640	r 14,969
1970			
California	51	18,593	7,582
Idaho	1	1,038	423
Nevada	13	4,916	2,005
Oregon	5	274	112
Alaska, Arkansas, New York, Texas, Washington	9	2,482	1,012
Total	79	27,303	11,134

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
1966	321,080	21,993	5.2
1967	439,753	23,767	4.1
1968	434,193	28,857	5.1
1969	432,591	28,552	5.0
1970	424,595	26,802	4.8

[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]
1966	16,400
1967	22,150
1968	34,380
1969	13,650
1970	8,051

[1] Includes GSA releases.

CONSUMPTION AND USES

Consumption decreased to 61,503 flasks, the lowest level since 1961. All categories except amalgamation and mildew proofing for paint showed decreases. The largest use of mercury was for electrical apparatus, which accounted for 26 percent of the total, followed by electrolytic preparation of chlorine and caustic soda with 24 percent.

In 1970 an estimated 9.7 million tons of chlorine was produced, with 27.6 percent coming from mercury cells. Although chlorine production increased by about 3 percent over 1969, mercury consumption as processing loss in the mercury cells decreased about 27 percent. Consumption of mercury per ton of chlorine produced was 0.43 pound in 1970, compared with the usual level of 0.5 to 0.6 pound during the previous 8 years. Reasons cited for the decrease were improved plant operating procedures which resulted in lower mercury losses. The Department of the Interior had set a limit of 8 ounces of mercury per day in water effluent from each plant. This action resulted in 50 major mercury users, primarily chlorine and caustic soda plants, reducing their mercury discharge by 85 percent. No new mercury-cell plants are planned in the United States, and three have closed or announced plans to do so.

Several industries have curtailed or eliminated the use of mercury in their processes. The American Paper Institute stated that the paper industry no longer uses mercury compounds for in-process slime control. Methyl mercury compounds can no longer be used for seed treating. Compounds subject to USDA registration accounted for about 21 percent of the total mercury used in 1970. Homestake Mining Co., Lead, S. Dak., discontinued the mercury amalgamation process for gold recovery at yearend.

Table 5.—Mercury consumed in the United States, by uses

(Flasks)

Use	1966 [1]	1967 [1]	1968 [1]	1969	1970
Agriculture	2,374	3,732	3,430	2,689	1,811
Amalgamation	248	219	267	195	219
Catalysts	1,932	2,489	1,914	2,958	2,238
Dental preparations	2,133	2,386	3,079	r 2,880	2,286
Electrical apparatus	17,638	16,223	19,630	r 18,490	15,952
Electrolytic preparation of chlorine and caustic soda	11,541	14,306	17,453	20,720	15,011
General laboratory use	2,217	1,940	1,989	r 1,936	1,806
Industrial and control instruments	7,294	7,459	7,978	r 6,655	4,832
Paint:					
Antifouling	140	152	392	244	198
Mildew proofing	8,789	7,026	10,174	9,486	10,149
Paper and pulp manufacture	612	446	417	558	226
Pharmaceuticals	232	283	424	r 712	690
Other [2]	16,359	12,856	8,275	r 9,134	5,858
Total known uses	71,509	69,517	75,422	76,657	61,276
Total uses unknown	------	------	------	r 715	227
Grand total	71,509	69,517	75,422	r 77,372	61,503

r Revised.

[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 1970

(Flasks)

	Primary	Redistilled	Secondary	Total
Agriculture [1]	1,811	------	------	1,811
Amalgamation	206	3	10	219
Catalysts	1,916	225	97	2,238
Dental preparations	166	1,372	748	2,286
Electrical apparatus	11,432	3,469	1,051	15,952
Electrolytic preparation of chlorine and caustic soda	14,749	------	262	15,011
General laboratory use	689	495	622	1,806
Industrial and control instruments	2,124	2,353	355	4,832
Paint:				
Antifouling	193	5	------	198
Mildew proofing	10,149	------	------	10,149
Paper and pulp manufacture	223	------	3	226
Pharmaceuticals	280	362	48	690
Other	5,668	12	178	5,858
Total known uses	49,606	8,296	3,374	61,276
Total uses unknown	15	69	143	227
Grand total	49,621	8,365	3,517	61,503

[1] Includes fungicides and bactericides for industrial purposes.

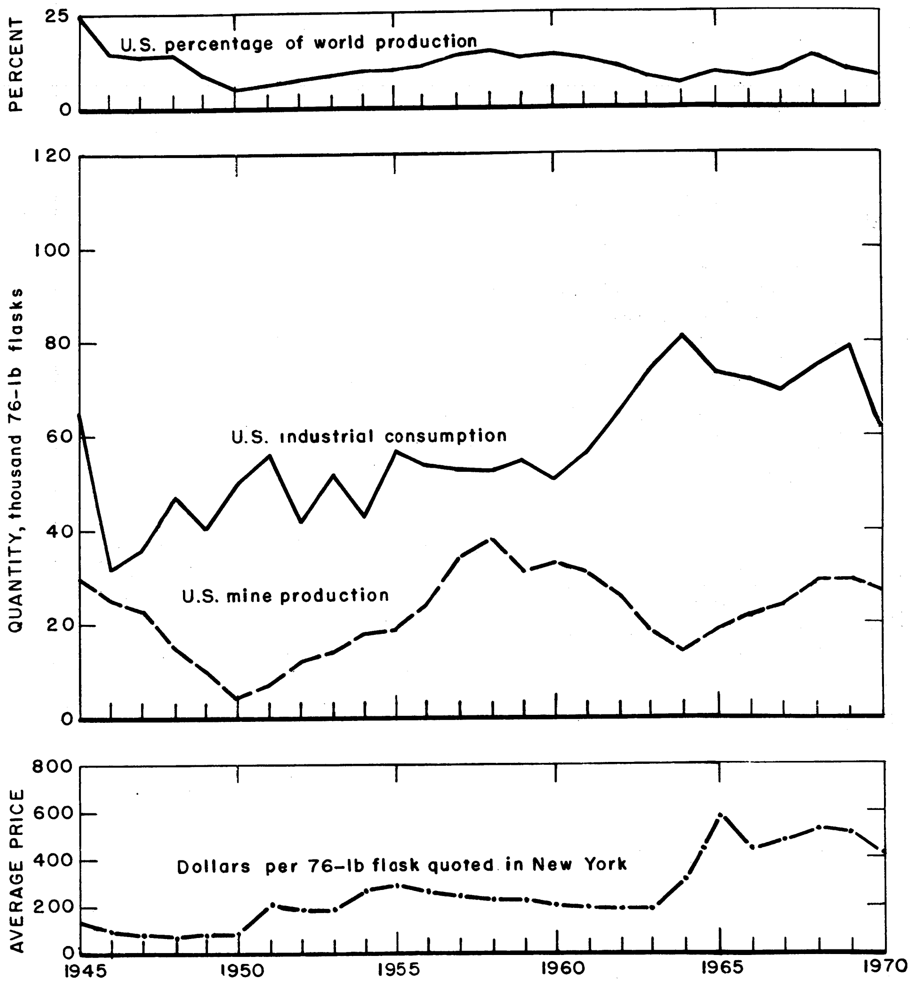

Figure 1.—Trends in production, consumption, and price of mercury.

Table 7.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1966	1,976	18,100	20,076
1967	757	17,520	18,277
1968	1,059	21,848	22,907
1969 r	2,920	19,772	22,692
1970	3,861	12,515	16,376

r Revised.

PRICES

Mercury prices declined during 1970, averaging $407.77 per flask on the New York market. With the exception of several price rallies during the year, monthly averages slid from $482.50 in January to $354.50 in December. Bearish factors were the Senate hearings on the effects of mercury on man and the environment and the cancellation of registration of 48 mercury biocides. The monthly average on the London market kept pace with New York prices and showed an annual average of $411.45 per flask.

Table 8.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1969		1970	
	New York [1]	London [2]	New York [1]	London [2]
January	$528.18	$532.29	$482.50	$494.25
February	537.26	533.28	462.47	460.13
March	520.48	533.34	459.76	463.97
April	500.95	533.67	467.23	464.03
May	516.24	532.19	442.00	439.27
June	495.00	532.87	411.14	414.33
July	499.32	533.05	409.09	413.09
August	485.24	531.92	358.48	370.34
September	491.10	524.47	351.05	355.65
October	483.91	526.32	341.59	346.17
November	506.89	560.13	353.42	359.38
December	495.95	563.36	354.50	358.46
Average	505.04	536.41	407.77	411.45

[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 jumped sharply to 4,653 flasks from 507 flasks in 1969. Over half the exports went to Japan, and much of this originated from the Red Devil mine in Alaska. Other large buyers included Australia, Canada, and Pakistan. Reexports remained small at 50 flasks.

Imports for consumption decreased by 31 percent, to 21,972 flasks. Canada supplied 81 percent and Spain 9 percent. Italy and Mexico supplied much less than in 1969, while no imports were reported from Yugoslavia. Sweden and Switzerland supplied minor quantities. No mercury ore was imported, and trade in mercury compounds was insignificant.

Mercury waste and scrap from Canada were included in the import figures. Based on dollar values, the scrap contained about 150 flasks.

The U.S. rate of duty on mercury imports dropped from $12.92 per flask during the year to $11.40 per flask as of January 1, 1971, in accordance with provisions of the General Agreement on Tariffs and Trade.

Table 9.—U.S. exports and reexports of mercury

Year	Exports		Reexports	
	Flasks	Value (thousands)	Flasks	Value (thousands)
1968	7,496	$3,951	103	$54
1969	507	294	108	57
1970	4,653	2,133	50	19

Table 10.—U.S. imports for consumption [1] of mercury, by countries

Country	1968		1969		1970	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Argentina	142	$69	------	------	------	------
Bolivia	20	10	11	$6	------	------
Canada	5,626	2,829	15,546	7,455	17,872	$7,140
Chile	40	19	------	------	------	------
Germany, West	------	------	------	------	(2)	(2)
Ghana	------	------	107	4	------	------
Italy	252	119	5,041	2,520	1,101	560
Mexico	1,928	877	7,398	3,409	920	419
Peru	1,161	463	------	------	14	6
Spain	12,900	6,218	2,602	1,216	2,002	945
Sweden	6	2	------	------	12	4
Switzerland	------	------	------	------	1	1
United Kingdom	------	------	388	186	50	26
Yugoslavia	1,171	558	831	411	------	------
Total	23,246	11,164	31,924	15,207	21,972	9,101

[1] In 1968, general imports were 23,956 flasks ($11,505,001); Italy supplied 551 flasks ($260,846) and Mexico 2,339 flasks ($1,076,267). 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).

[2] Less than ½ unit.

WORLD REVIEW

Canada.—Output from the Pinchi Lake mercury deposit operated by Cominco Ltd. increased about 15 percent over 1969. Seventy-four percent of the production was exported to the United States. The ore grade increased from 4.3 pounds of mercury per ton of ore in 1969 to 4.8 pounds per ton in 1970. Empire Mercury Corp., Ltd., continued drilling in the Bralorne District, Lilloet area, British Columbia. Reserves of some 700,000 tons grading 1.1 pounds per ton have been outlined, and recent drilling indicates 3.2 pounds per ton in another area.

China, mainland.—No production statistics are available, but some export figures for 1968 and 1969 can be derived from reports of the recipient countries. The largest buyers of Chinese mercury in 1968 included the United Kingdom, France, Poland, West Germany, and Japan. Exports to these countries decreased sharply in 1969, and Italy became an importer.

Czechoslovakia.—The crude zinc ore from the Rudnany enterprise near Spisska Nova Ves was treated by flotation to remove the copper and mercury sulfides. The concentrate contained 1.8 to 2 percent mercury, which was recovered in the flue gas condensate, redistilled, and bottled at the rate of 20 flasks per day.

Finland.—The large Finnish base metal producer, Outokumpu Oy, started to recover byproduct mercury from zinc roaster gases at its new Kokkola electrolytic zinc refinery. Production capacity is almost 600 flasks per year, which is approximately Finland's annual consumption. The process has the advantage of being applicable to the treatment of a large variety of mercury-containing gases, thereby making it attractive in regard to environmental pollution.

Indonesia.—A Japanese survey team failed to discover any promising mercury deposits in the Tegoro district, southeast

Table 11.—Mercury: World production, by countries

(Flasks)

Country [1]	1968	1969	1970 [p]
Bolivia (exports)	134	68	12
Canada	[r] 5,700	21,200	24,400
Chile	513	286	[e] 380
China, mainland [e]	20,000	20,000	20,000
Colombia	362	344	[e] 350
Czechoslovakia	116	435	[e] 2,000
Ireland	-------	420	[2] 1,604
Italy	[r] 53,317	48,733	44,382
Japan	5,084	6,543	5,907
Mexico [3]	17,202	22,539	30,269
Peru	[r] 3,132	3,365	[e] 3,400
Philippines	3,544	3,478	4,648
Spain	[r] 56,943	64,862	47,689
Tunisia	309	244	100
Turkey	[r] 4,670	6,556	8,592
U.S.S.R. [e]	45,000	47,000	48,000
United States	28,874	29,640	27,303
Yugoslavia	14,794	14,330	15,461
Total [4]	[r] 259,694	290,043	284,497

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Romania recorded production of mercury through 1967 at which time production was terminated; estimates for 1968 and 1969 which appeared in previous editions of the Minerals Yearbook therefore are in error.
[2] Sales only.
[3] Official figures as reported by Statistical Office, Secretary of Industry and Commerce, Mexico; overall production of mercury believed to be much higher.
[4] Total is of listed figures only.

of Kuching, Sarawak (Malaysia) and the Japan Mining Association said it will suspend exploration in the area.

Ireland.—Gortdrum Mines Ltd. in County Tipperary planned to recover 1,440 flasks of mercury during 1970 as a byproduct at its copper and silver mine. In the first 7 months, 6,000 tons of concentrate yielded 742 flasks. The mercury content is so low in the ore that it has not been assayed, but estimates for mercury recovery during the life of the mine range from 9,000 to 12,000 flasks.

Italy.—Production fell for the second consecutive year to 44,382 flasks, and exports were off by 55 percent in 1970 to 15,487 flasks. Società Mineraria Monte Amiata held metal off the market to firm up falling world prices, with the result that sizable inventories of as much as 40,000 flasks may have been built up. Monte Amiata reported labor strikes at its mercury mines and refineries near Siena, but production was not affected. Italy's other producer, Stabilimento Minerario del Siele, maintained normal operations. The average grade of Italian ore was 10 pounds of mercury per ton. Italy's biggest customer in 1970 was again East Germany, followed by the United Kingdom, Japan, and the Netherlands. Exports to West Germany and the United States decreased sharply from 1969 levels.

Japan.—Japan consumes between 35,000 and 44,000 flasks of mercury annually, of which more than 80 percent is imported, mostly from Mexico, Italy, Spain, and Yugoslavia. Two Japanese companies reportedly purchased 2,450 flasks of Philippine mercury offered for sale by Palawan Quicksilver Mines, Inc. The Nomura Mining Co. produces about 3,500 flasks annually from Alaskan concentrate and hopes to produce about 500 flasks annually from domestic ore.

Mexico.—A greater proportion of mercury is entering legal channels in response to action by the Government of Mexico to reduce smuggling. At the beginning of 1968, production and export taxes were halved, and in August 1968, new control regulations were promulgated. Nevertheless, trade sources estimate that as much as half of the total production is not reported. One reason for illegal production and smuggling is the Mexican income tax, which puts many medium-sized producers in a tax bracket above 40 percent. It is estimated that at least a thousand localities are worked, regularly or sporadically, for mercury; many are in wild, inaccessible areas where law enforcement is difficult.

Philippines.—Output in 1970 increased 34 percent over 1969 with improvements in the furnaces and grinding units of Palawan Quicksilver Mines, Inc. Reserves were

Table 12.—Italy, Spain and Yugoslavia: Mercury exports, by countries

(Flasks)

Destination	From Italy			From Spain			From Yugoslavia		
	1968	1969	1970 [1]	1968	1969	1970 [2]	1968	1969	1970
Australia	1,044	203	NA	71	203	------	------	------	------
Belgium-Luxembourg	174	116	NA	100	1,276	2,321	------	------	------
Bulgaria	174	145	NA	30	174	------	------	------	------
Canada	------	------	NA	400	261	667	------	------	------
Czechoslovakia	116	------	NA	4,253	3,481	348	290	------	290
France	1,508	1,421	NA	3,151	1,915	3,365	------	360	150
Germany:									
East	3,017	6,411	4,351	1,001	377	1,799	------	------	------
West	3,916	4,902	1,108	11,709	13,866	13,083	2,077	1,980	978
Greece	174	232	NA	------	------	------	------	------	------
Hungary	1,508	841	NA	901	986	377	------	------	------
India	1,828	2,843	NA	------	------	1,611	72	------	------
Japan	6,150	4,409	2,274	5,284	783	5,047	------	------	------
Korea, North	870	------	------	------	------	------	------	------	------
Netherlands	1,102	145	1,729	801	1,160	145	------	------	------
Poland	1,915	1,799	NA	------	1,740	1,276	290	------	------
Portugal	------	------	NA	172	638	667	------	------	------
Romania	1,160	------	NA	400	2,437	493	------	------	------
South Africa, Republic of	203	------	NA	460	261	290	------	40	------
Sweden	87	------	NA	2,052	1,189	377	200	330	180
Switzerland	174	29	NA	20	58	667	210	600	250
United Arab Republic	------	------	NA	------	29	------	3,301	3,301	750
United Kingdom	7,136	5,889	3,266	1,621	7,716	290	------	------	------
United States	2,756	4,119	1,099	10,336	2,901	------	5,646	5,546	2,454
U.S.S.R	------	------	NA	------	145	1,189	2,030	2,611	1,450
Other countries and undistributed	291	552	[1] 1,660	213	350	[2] 8,688	56	7	153
Total	35,303	34,056	15,487	42,975	41,946	[2] 42,700	14,172	14,775	6,655

NA Not available.

[1] Source gives only a partial distribution of total; many potential recipient countries are not listed separately. The total for all such countries is listed under "Other countries and undistributed."

[2] Exports for last 3 months of the year totaled 6,903 76-pound flasks; data on destination of these exports are not available and the total for these months has been included under "Other countries and undistributed." Figures given for individual countries are for the first 9 months only.

estimated at 40,000 flasks, with additional resources of 500,000 tons of ore containing about 2.8 pounds per ton.

Spain.—Production decreased to 47,689 flasks from 64,862 flasks in 1969. Cutbacks were dictated by market considerations rather than any technical problems or ore shortage. One of the four Herreschoff eight-hearth furnaces at Almadén was shut down for alteration. New condenser lines were built to improve recovery, and automatic furnace temperature controls were installed. Ore reserves are not given other than that they are adequate for 90 to 100 years at the present rate of extraction. Ore grade averages 60 pounds per ton but is said to be as high as 1,400 pounds per ton in places. Some old waste dumps were reprocessed during the year, accounting for the average ore grade of 40 pounds per ton during 1970. Minas de Almadén has announced plans to increase mercury output by 50 percent in the next 2 years, but the mercury market situation may alter these plans. Prospecting continues for new mercury deposits in Leon and Asturias.

Turkey.—Production increased substantially, reflecting the startup of the Konya Sizma mine. The increase will probably continue with the expected activation of the new Turk Civa A.S. mine. Etibank's Halikoys mine supplied about one-third of the output. Average grade of ore mined contained 4.8 pounds of mercury per ton.

Yugoslavia.—Prospecting at the Idria mine has been successful, enabling a further increase from the present production of 15,461 flasks obtained in the new rotary furnaces from ore grading 3.6 pounds per ton. The new Ljubevce mine will provide sufficient ore reserves for increased production and operation of a fourth rotary smelting furnace.

WORLD RESERVES

Updating 1962 reserve data, provided by the U.S. Geological Survey,[3] with estimated reserve figures available in 1970, resulted in the assessment of world mercury reserves minable at $410 per flask that are shown in table 13. Data for the U.S.S.R. and China are inadequate and reserves in Spain may be significantly higher than indicated. About 54 percent of the mercury reserve is in Spain and Italy.

Table 13.—Assessment of world mercury reserves recoverable at the 1970 average price

Country or area	Estimate (thousand flasks)
North America:	
United States	380
Canada	320
Mexico	370
South America	40
Europe:	
Italy	240
Spain	2,600
U.S.S.R.	300
Yugoslavia	460
Other	10
Africa	30
Asia:	
China, mainland	400
Japan	20
Philippines	40
Turkey	100
Total	5,310

TECHNOLOGY

Research continued on techniques for determining trace mercury often associated with base-metal deposits. Samples of rock, soil, or plants are digested with sulfuric acid and then treated with potassium permanganate solution to oxidize and release the mercury in elemental form. After amalgamation on copper foil, it is heated in a flow of carbon dioxide, and the amount of mercury is determined from a mercury detector. The method offers good sensitivity down to 10 parts per billion (ppb).[4]

The need for monitoring liquid and gas-

[3] Bailey, E. H., and R. M. Smith. Mercury—Its Occurrence and Economic Trends. Geol. Survey Cir. 496, 1964, 11 pp.

[4] Barakso, J. J., and C. Tarnocai. A Mercury Determination Method and Its Use for Exploration in British Columbia. Can. Min. Met. Bull., v. 63, No. 696, April 1970, pp. 501–505.

eous plant discharges has spurred the development of analytical techniques capable of detecting mercury in the low ppb range. One instrument was described that can analyze air or water samples continuously, and almost instantaneously measure and record mercury in the 0 to 10 ppb range. A Swedish firm claims it can determine in 2 minutes mercury content in gases and liquids in the low ppb range and even distinguish between metallic and ionic mercury.[5] A relatively inexpensive system for determination of mercury in organic or inorganic solids and solutions, or air, facilitates routine checks for mercury contamination.[6] A patent has been filed for an iodide electrode method, making possible direct measurement of as little as 2 ppb mercuric ion in water.[7]

Procedures to recover mercury from waste streams for pollution abatement received much attention. One method involves conversion of organic mercury into the inorganic form, then reduction with sodium borohydride to precipitate metallic mercury.[8] Another system, licensed from Osaka Soda Co. of Japan that used the process at five chlor-alkali plants, removes mercury from waste waters, slurries, and gases.[9] The system can cut mercury in waste water to below 5 ppb and recover a substantial amount for reuse. Other processes for recovering mercury from hydrogen streams of chlor-alkali plants,[10] and from waste effluent in a manner similar to a fixed-bed filter/ion exchanger[11] have been described. A novel Japanese approach for removing organic mercury compounds from wastewater utilizes bacteria which convert the mercury compounds to a volatile gas that is trapped in an activated carbon filter.[12]

A report was issued by the Bureau of Mines Reno (Nev.) Metallurgy Research Center describing the process for recovering mercury from ores by electrolytic oxidation.[13] Continuation of the work on a pilot plant scale indicates that extraction of mercury ranges from 82 to 95 percent. The process has the added advantage of avoiding the formation of hazardous vapors associated with conventional retorting of ores.

At the College Park (Md.) Metallurgy Research Center, applications of amalgam techniques were studied for refining aluminum-base scrap. Electrolytic recovery of the least noble component of amalgams containing lead, tin, zinc, and copper has been readily accomplished. Also, an analytical program is underway to determine mercury content based on the combination of chemically loaded papers and X-ray spectrography-neutron activation. An interesting possibility from this work is the separation of methyl mercury and inorganic mercury by pH adjustment prior to passage of the solution through the resin.

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[5] Metal Bulletin. No. 5532, Sept. 15, 1970, p. 20.

[6] Chemical and Engineering News. V. 48, No. 44, Oct. 19, 1970, p. 87.

[7] Work cited in footnote 6.

[8] Chemical Week. V. 107, No. 25, Dec. 16, 1970, p. 59.

[9] Work cited in footnote 8.

[10] Chemistry and Industry. No. 52, Dec. 26, 1970, p. 1634.

[11] Chemical Engineering. V. 77, No. 21, Oct. 5, 1970, p. 47.

[12] Air and Water News. V. 4, No. 37, Sept. 14, 1970, p. 4.

[13] Scheiner, B. J., R. E. Lindstrom, D. E. Shanks, and T. A. Henrie. Electrolytic Oxidation of Cinnabar Ores for Mercury Recovery. BuMines Tech. Prog. Rept. No. 26, June 1970, 11 pp.

Mica

By Benjamin Petkof [1]

There was no reported sheet mica production in the United States during 1970. Scrap and flake production declined in both quantity and value from the previous year. Ground mica, produced from scrap and flake, also declined in quantity and value. Exports of all classes of mica increased. Imports of muscovite scrap and flake and phlogopite increased significantly.

Table 1.—Salient mica statistics

	1966	1967	1968	1969	1970
United States:					
Sold or used by producers:					
Sheet mica ---------- thousand pounds --	4	20	15	W	-------
Value ---------- thousands --	$1	W	W	$3	-------
Scrap and flake mica ---- thousand short tons --	113	119	125	133	119
Value ---------- thousands --	$3,732	$2,876	$3,014	$2,893	$2,527
Ground mica ---------- thousand short tons --	103	97	111	125	115
Value ---------- thousands --	$6,247	$5,756	$7,072	$8,058	$7,350
Consumption, block and film ---- thousand pounds --	2,813	1,972	1,628	1,498	1,299
Value ---------- thousands --	$3,642	$2,757	$2,591	$2,595	$2,058
Consumption, splittings ---------- thousand pounds --	7,100	6,188	4,785	5,077	5,214
Value ---------- thousands --	$3,221	$2,759	$2,010	$2,196	$2,254
Exports ---------- thousand short tons --	6	7	14	6	9
Imports for consumption ---------- do ----	7	4	5	5	6
World: Production ---------- thousand pounds --	323,411	317,381	346,513	351,655	347,426

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Sheet Mica.—No domestic sheet mica production was reported during the year. This marks the termination of an old domestic minerals industry that began with the production of sheet for use as windows, lamp chimneys, and lampshades at the beginning of the nineteenth century. It is unlikely that there will be any future production of sheet mica because of the high labor cost involved in production.

Scrap and Flake Mica.—The output of scrap and flake mica declined 11 percent in quantity and 13 percent in value. North Carolina was again the major producer of scrap and flake, accounting for more than half of the total domestic supply. Ten States accounted for the remaining production.

Ground Mica.—Sales of ground mica declined 8 percent in quantity and 9 percent in value from 1969. Dry-ground mica accounted for 91 percent of total sales. Reports were received from 20 companies operating 22 plants; 18 were dry grinding plants and four wet-grinding plants.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica [1]	
	Uncut punch and circle mica		Uncut mica larger than punch and circle		Total sheet mica			
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value
1966	4,500	$905	------	------	4,500	$905	113,133	$3,732,242
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:								
North Carolina	------	------	------	------	------	------	64,136	1,456,763
Pennsylvania	------	------	------	------	------	------	1,200	60,000
Other [2]	------	------	------	------	------	------	53,507	1,010,687
Total	------	------	------	------	------	------	118,843	2,527,450

W Withheld to avoid disclosing individual company confidential data.
[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, Colorado, Connecticut, Georgia, New Hampshire, New Mexico, South Carolina, and South Dakota.

Table 3.—Ground mica sold by producers in the United States by methods of grinding [1]

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value [2] (thousands)
1966	87,361	$4,110	16,089	$2,137	103,450	$6,247
1967	82,849	3,842	14,204	1,915	97,053	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	104,743	5,666	10,350	1,683	115,093	7,350

[1] Domestic and some imported scrap.
[2] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Sheet Mica.—Consumption of sheet mica, consisting of block, film, and splittings, declined only slightly from 6.6 million pounds in 1969 to 6.5 million pounds in 1970.

About 1.2 million pounds of block mica was consumed for the production of vacuum tubes, capacitors, and various other electrical and nonelectrical products. Vacuum tubes required 51 percent; capacitors accounted for 16 percent of total consumption. Lower than stained quality was in greatest demand, accounting for 62 percent of total consumption; stained, 35 percent; and good stained or better, the remainder.

Muscovite block and film was consumed by 17 companies in eight States. North Carolina, with four consuming plants, and New Jersey and New York, with three each, consumed 60 percent of the domestically fabricated block and film mica. The consumption of phlogopite block declined 24 percent to 60,780 pounds.

Total consumption of mica splittings increased almost 3 percent over that of 1969. India and the Malagasy Republic supplied the bulk of the splittings consumed. Splittings were fabricated into various built-up mica products by 13 companies in nine States. Six companies, two in New York, two in Pennsylvania, and one each in Massachusetts and New Hampshire, consumed about 4.1 million pounds of splittings or almost 79 percent of the total consumption.

Table 4.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States in 1970

(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	1,004	3,499	2,638	7,141	4,400	-------	4,400	11,541
Stained	43,875	359,120	29,603	432,598	2,031	94	2,125	434,723
Lower than Stained [1]	146,082	264,335	140,234	550,651	13,618	207,904	221,522	772,173
Total	190,961	626,954	172,475	990,390	20,049	207,998	228,047	1,218,437
Film:								
First quality	3,693	-------	-------	3,693	-------	-------	-------	3,693
Second quality	12,575	-------	-------	12,575	-------	350	350	12,925
Other quality	3,575	-------	-------	3,575	-------	-------	-------	3,575
Total	19,843	-------	-------	19,843	-------	350	350	20,193
Block and film:								
Good Stained or better [2]	17,272	3,499	2,638	23,409	4,400	350	4,750	28,159
Stained [3]	47,450	359,120	29,603	436,173	2,031	94	2,125	438,298
Lower than Stained	146,082	264,335	140,234	550,651	13,618	207,904	221,522	772,173
Total	210,804	626,954	172,475	1,010,233	20,049	208,348	228,397	1,238,630
Phlogopite: Block (all qualities)	-------	-------	4,350	---------	-------	56,430	-------	60,780

[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 1970, by qualities and grades

(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	4,355	826	473	964	-------	6,618
Stained	8,977	56,316	50,444	282,336	12,769	410,842
Lower than stained	24,438	106,964	71,838	259,963	216,904	680,107
Total	37,770	164,106	122,755	543,263	229,673	1,097,567
Nonruby:						
Good Stained or better	2,063	510	2,150	200	-------	4,923
Stained	2,946	7,922	3,900	9,313	-------	24,081
Lower than stained	26,016	13,340	1,750	1,750	49,010	91,866
Total	31,025	21,772	7,800	11,263	49,010	120,870
Film:						
Ruby:						
First quality	718	425	300	400	-------	1,843
Second quality	6,097	2,378	3,100	450	-------	12,025
Other quality	------	-------	-------	-------	3,575	3,575
Total	6,815	2,803	3,400	850	3,575	17,443
Nonruby:						
First quality	------	-------	1,000	850	-------	1,850
Second quality	------	-------	900	-------	-------	900
Other quality	------	-------	-------	-------	-------	---------
Total	------	-------	1,900	850	-------	2,750

[1] Figures for block mica include all smaller than No. 6 grade and "punch" mica.

Table 6.—Consumption of stocks of mica splittings in the United States, by sources
(Thousand pounds and thousand dollars)

	India		Malagasy		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1966	6,749	$3,005	351	$216	7,100	$3,221
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	5,214	2,254
Stocks Dec. 31:						
1966	3,669	NA	206	NA	3,875	NA
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

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. During the period 1965–68 the output of this material had been declining, but began to increase in 1969. Output in 1970 was up 8 percent in quantity and 10 percent in value over the previous year. The form in greatest demand was segment plate (30 percent), followed by tape (22 percent), and molding plate (21 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 Schenectady, N.Y.; and Acim Paper Corp. at New Hyde Park, N.Y. Mica paper was made from the delaminated mica using paper-making techniques. According to the National electrical Manufacturers Association, net domestic sales of mica-paper products declined from $5.0 million in 1969 to $4.7 million in 1970.

Table 7.—Built-up mica [1] sold or used in the United States, by products
(Thousand pounds and thousand dollars)

Product	1969		1970	
	Quantity	Value	Quantity	Value
Molding plate	947	$2,706	1,005	$3,024
Segment plate	1,376	2,453	1,389	2,863
Heater plate	[2] 407	123	43	94
Flexible (cold)	403	856	605	1,187
Tape	1,208	4,529	1,051	3,796
Other	(2)	1,034	589	1,898
Total [3]	4,341	11,701	4,682	12,862

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] "Other" combined with Heater Plate for 1969 to avoid disclosing individual company confidential data.
[3] Data may not add to totals shown because of independent rounding.

Table 8.—Ground mica sold by producers in the United States, by uses

Use	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	41,095	$1,198	28,409	$947
Wallpaper	600	79	506	84
Rubber	7,348	885	6,673	793
Paint	29,081	2,818	25,382	2,458
Plastics	684	133	570	109
Welding rods	W	W	W	W
Joint cement	30,031	2,106	34,834	2,183
Other uses [1]	16,017	838	18,719	775
Total [2]	124,856	8,058	115,093	7,350

W Withheld to avoid disclosing individual company confidential data, included with "Other uses."
[1] Includes mica used for molded electric insulation, house insulation, Christmas tree snow, annealing, well drilling, other purposes, and uses indicated by symbol W.
[2] Data may not add to totals shown because of independent rounding.

STOCKS

At yearend there were about 3.2 million pounds of sheet mica in fabrications' stocks. Of this quantity, nearly four-fifths was splittings and one-fifth was 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

At the beginning of 1970, the Engineering and Mining Journal published prices for domestic sheet mica that were unchanged from those of the previous year. However, these published prices are no longer meaningful because of the termination of domestic sheet mica production. The price of first quality mica from the Malagasy Republic ranged from $0.50 per pound for material under 1 square inch to $3.25 per pound for that averaging 10 to 14 square inches.

Yearend prices quoted in the Oil, Paint and Drug Reporter were unchanged from those of the previous year and are shown in table 9.

Table 9.—Price of dry- or wet-ground mica in the United States in 1970 [1]

	Cents per pound
Dry-ground:	
Joint cement	3¾
Plastic, 100 mesh	3¾
Roofing, 20 to 80 mesh	2–3
Wet-ground:[2]	
Biotite	7½
Biotite, less than carlots [3]	8½
Paint or lacquer, 325 mesh	8½
Paint or lacquer, 325 mesh, less than carlots [3]	9½
Rubber	8½
Rubber, less than carlots [3]	9½
Wallpaper	9½

[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. 198, No. 26, Dec. 28, 1970.

FOREIGN TRADE

All classes of mica exports increased slightly more than 50 percent in both quantity and value over that of the previous year. More than half of the total exports were shipped to Canada, Jamaica, and Japan. Reported 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.

All forms of sheet mica imports declined during the year indicating possible diminishing demand for sheet mica by domestic consumers. However, imports of muscovite scrap material almost doubled, and imports of phlogopite almost tripled. Imports of the remaining classes of mica also declined.

Table 10.—U.S. exports of mica and manufactures of mica, by countries

Destination	Mica, including block, film and splittings, waste and scrap and ground mica		Manufactured	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Arabia, n.e.c	97,000	$8	245	(1)
Algeria	90,000	5	----------	----------
Argentina	87,057	10	12,089	$26
Australia	40,110	5	22,266	46
Bahamas	20,000	20	5,423	7
Belgium-Luxembourg	30,200	3	934	3
Brazil	201,250	50	53,729	142
Canada	5,354,311	346	235,041	814
Chile	25,000	2	863	6
Colombia	95,234	16	9,476	25
Ecuador	81,000	8	----------	----------
Egypt	75,850	6	----------	----------
Finland	----------	----------	7,896	38
France	594,000	34	3,216	20
Germany, West	309,393	58	17,108	30
Hong Kong	----------	----------	17,730	53
Indonesia	91,900	7	----------	----------
Iran	36,450	5	48	1
Italy	347,407	21	26,472	101
Jamaica	2,107,985	264	4,967	21
Japan	2,676,701	82	66,796	81
Mexico	106,240	13	572,111	1,517
Netherlands	367,886	42	10,173	40
Peru	161,100	10	3,588	6
Philippines	64,900	7	172	1
Singapore	40,000	4	----------	----------
South Africa, Republic of	168,000	8	8,448	19
Spain	151,950	10	9,820	32
Sweden	----------	----------	47,896	70
Switzerland	52,530	50	----------	----------
Taiwan	98,474	3	2,138	14
Trinidad and Tobago	30,000	4	380	2
United Kingdom	2,730,426	254	97,462	141
Venezuela	884,807	45	4,394	10
Other countries	242,446	22	19,904	44
Total	17,459,607	1,422	1,260,780	3,310

[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
1968	27,489	$2,766	1,491	$1,539	3,157	$77	5,293	$3,373
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	126	4,530	2,549

Table 12.—U.S. imports for consumption of mica, by kinds and countries

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)
1968	93,069	$5	3,064,096	$72	1,128,661	$1,041	186,426	$298	175,526	$200
1969	135,207	10	2,942,643	64	1,253,092	1,204	133,274	285	215,141	206
1970:										
Argentina	---	---	---	---	---	---	---	---	6,063	3
Brazil	275,575	8	341,713	9	551,401	566	34,514	57	87,213	35
Ceylon	---	---	247,640	4	---	---	---	---	2,240	(2)
Germany, West	---	---	---	---	13,228	14	---	---	2,950	11
Haiti	---	---	---	---	---	---	---	---	1,917	3
Hong Kong	---	---	---	---	---	---	---	---	256	21
India	---	---	4,545,815	95	99,850	87	2,700	12	1,536	30
Malagasy Republic	105,044	5	212,160	9	12,037	16	---	---	41,890	41
Mexico	---	---	---	---	520	(2)	---	---	---	---
Nepal	---	---	---	---	---	---	1,400	7	220	19
South Africa, Republic of	---	---	320,000	6	2,000	2	4,914	2	---	---
Tanzania	---	---	---	---	690	2	4,877	16	222	4
United Kingdom	---	---	---	---	1,408	3	576	11	43	4
Total	380,619	13	5,667,328	123	681,134	690	48,981	105	144,550	171

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)
1968	4,808,447	$1,339	97,997	$233	98,594	$1,444	120,339	$191
1969	5,093,992	1,139	84,939	136	90,984	1,372	109,743	165
1970:								
Belgium-Luxembourg	---	---	---	---	---	---	13,077	33
Brazil	21,164	19	11,291	15	1,737	22	2,636	9
Haiti	---	---	220	2	---	---	---	---
Hong Kong	1,000	2	---	---	---	---	---	---
India	4,042,078	1,171	15,955	33	60,551	724	42,867	64
Israel	---	---	---	---	119	1	---	---
Japan	---	---	---	---	215	1	---	---
Kenya	---	---	---	---	53	(2)	---	---
Korea, Republic of	---	---	---	---	170	2	2	(2)
Leeward and Windward Islands	---	---	72	(2)	100	(2)	---	---
Malagasy Republic	178,839	114	---	---	4,287	18	---	---
Mexico	---	---	2,500	(2)	2,242	72	645	4
Nepal	---	---	1,900	13	1,447	30	---	---
South Africa, Republic of	---	---	---	---	---	---	26,142	30
United Kingdom	1,751	4	---	---	1,146	18	288	3
Total	4,244,832	1,310	31,938	63	72,067	888	85,657	143

See footnotes at end of table.

Table 12.—U.S. imports for consumption of mica, by kinds and countries—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)
1968	45,860	$77	113,616	$13	8,039	$76
1969	71,457	97	55,115	5	13,898	146
1970:						
Belgium-Luxembourg	57,772	47	-----	-----	6,042	15
Canada	4,652	17	4,480	1	-----	-----
Germany, West	9,539	16	-----	-----	16	1
India	600	2	-----	-----	1,034	3
Japan	3,696	4	-----	-----	510	1
Korea, Republic of	-----	-----	-----	-----	2	1
Netherlands	-----	-----	-----	-----	91	5
Taiwan	-----	-----	-----	-----	59	1
United Kingdom	2,999	4	-----	-----	4,710	27
Total	79,258	90	4,480	1	12,464	54

[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.
[2] Less than ½ unit.

WORLD REVIEW

World mica production declined only slightly from that of the previous year. India and the Malagasy Republic were the major producers of muscovite and phlogopite mica, respectively. The United States was the largest producer of scrap and flake mica.

India.—Crude mica production increased only slightly from 29,527 tons (revised) in 1968 to 29,834 tons in 1969. Value increased 3 percent from $21.9 million in 1968 to $22.6 million in 1969. Forty-one percent consisted of block, film and splittings; an additional 43 percent, scrap; and the remainder processed mica primarily in the form of ground mica.[2]

According to the Bihar Mica Exporters Association, the 40-percent ad valorem export duty imposed by the Indian Government on many grades of mica, has led some foreign buyers to substitute alternate materials for natural mica and has caused a decline in mica production. During 1969, exports of some grades of splittings increased by 50 percent when the Indian Government reduced the export duty on these grades from 40 to 20 percent ad valorem.[3]

[2] Bureau of Mines. Mineral Trade Notes. V. 67, No. 10, October 1970, pp. 32–33.
[3] Industrial Minerals (London). No. 29, February 1970, pp. 43–44.

Table 13.—Mica: World production, by countries
(Thousand pounds)

Country [1]	1968	1969	1970 [p]
Argentina:			
Sheet	[r] 45	262	[e] 300
Waste, scrap, etc	[r] 1,768	1,263	1,300
Bolivia	-------	-------	13
Brazil [2]	3,677	3,922	[e] 4,000
Colombia	57	37	57
France	3,360	[e] 3,000	[e] 3,000
India:[2]			
Block	3,816	3,944	3,732
Splittings [3]	[r] 13,834	14,976	10,340
Scrap and other	31,275	27,500	53,539
Malagasy Republic (phlogopite):			
Block	172	137	86
Splittings	1,598	2,218	1,935
Scrap	227	251	42
Mexico	1,625	1,310	1,235
Mozambique (including scrap)	642	772	[e] 770
Norway (including scrap) [2]	10,613	8,393	9,493
Portugal	4,665	2,573	[e] 2,600
South Africa, Republic of:			
Sheet	20	220	23
Scrap	17,456	13,997	16,647
Tanzania:			
Sheet	[2] 159	213	99
Scrap	[2] 527	253	28
United States:			
Sheet	15	W	-------
Scrap and flake	250,646	266,115	237,686
Yugoslavia	[r] 316	299	501
Total	[r] 346,513	351,655	347,426

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, China (mainland), 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 as follows: 1968, 189,000 pounds; 1969, 237,000 pounds; 1970, 231,000 pounds.

TECHNOLOGY

A recent report summarized the activities of the Bureau of Mines in developing a process to produce commercial-grade mica concentrates with a high recovery of contained mica. Laboratory work and continuous process development work was conducted on the weathered mica pegmatite areas of Alabama, Georgia, and North Carolina to establish the feasibility of flotation methods to recover commerical-grade mica concentrates. An acid-cationic method for recovery of coarse mica and a alkaline-anionic-cationic method for recovery of fine mica were developed. Research indicated that both methods may be effectively used separately or together for flotation of mica from weathered pegmatite areas.[4]

Research studies of the elastic behavior of muscovite showed that some specimens were elastically isotropic in the basal plane while others were anisotropic. These anisotropic crystals, when examined by X-ray topographic techniques, were found to have a corrugated structure of the basal plane. When measurments were made on corrugation-free samples, no noticeable anisotropy of the elastic behavior in the basal plane was observable.[5]

[4] Browning, J. S. Mica Process Development. Trans., SME. AIME, v. 247, September 1970, pp. 269–273.
[5] Caslavsky, J. L., and K. Vedom. Muscovites With Isotropic and Anistropic Elasticity in the Basal Plane. Amer. Miner., v. 55, No. 9–10, September–October 1970, pp. 1633–1638.

Molybdenum

By Andrew Kuklis [1]

Free world molybdenum production capacity rose significantly in 1970, but demand for molybdenum weakened; hence by yearend a condition of oversupply and rising inventories developed in the industry.

Demand for molybdenum was exceptionally strong for the first part of the year when the steel mills of industrialized countries were operating at near-capacity levels. As the year progressed, steel production declined in response to weakness in the free world economy. Consumption of molybdenum declined proportionally because of lower production of molybdenum-bearing alloys and stainless steel. This condition coincided with increased output of molybdenum in the United States, Canada, and Chile.

Despite an apparent oversupply, record expenditures were obligated for new mines and expansion of present operations. These were in various stages of construction at yearend.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Concentrate:					
Production	90,532	90,097	93,447	99,807	111,352
Shipments	91,670	81,596	93,245	103,009	110,381
Value	$144,327	$133,604	$151,000	$173,819	$190,077
Consumption	75,476	58,967	75,647	73,275	76,101
Imports for consumption	5	1,179	1	(1)	25
Stocks, Dec. 31: Mine and plant	3,433	9,919	12,208	8,398	9,715
Primary products:					
Production	74,392	54,922	69,675	68,526	75,480
Shipments	78,811	57,231	63,761	77,726	76,095
Consumption	52,324	49,506	49,271	51,622	45,337
Stocks, Dec. 31: Producers	5,945	7,156	18,170	17,844	25,904
Free world: Production	124,988	126,273	128,071	142,639	163,648

[1] Less than ½ unit.

Legislation and Government Programs.—In July, a bill was enacted by Congress (Public Law 91–333) authorizing the General Services Administration (GSA) to dispose of approximately 3.5 million pounds of molybdenum held in the national stockpile. Specific rules and regulations were provided in the bill for disposition of material.

During the year, GSA sold 4.8 million pounds of molybdenum to the molybdenum industry. Table 2 shows molybdenum material in Government inventories on December 31, 1970, totaling 47.1 pounds of molybdenum. Approximately 5.8 million pounds of stored molybdenum in concentrate was classified as sold but unshipped.

Table 2.—Molybdenum material in Government inventories on December 31, 1970

(Thousand pounds molybdenum)

Type material	Stockpile objective	National (strategic) stockpile
Concentrate	17,115	28,499
Ferromolybdenum	7,500	7,501
Molybdic oxide	10,600	11,123
Total	35,215	47,123

[1] Mining engineer, Division of Ferrous Metals.

DOMESTIC PRODUCTION

Domestic output of molybdenum established new record highs in production and shipments in 1970. Mine production of molybdenum in concentrate exceeded the 100-million-pound mark for the first time in history. Higher production from both primary and coproduct sources accounted for the record output. In the past 20 years, annual production of molybdenum has nearly tripled, increasing from 38.9 million pounds in 1951 to over 111 million pounds in 1970.

During 1970, the domestic molybdenum industry enjoyed continuous operations, as no serious labor problems interrupted production schedules. Large investments were obligated for new mines and expansion of present operating facilities.

Of the total molybdenum output, over 68 percent was produced from primary molybdenum sources and the balance was recovered as a coproduct of copper, tungsten, and uranium.

Output of molybdenum from primary sources increased over 8 percent compared with the 1969 figure. However, primary molybdenum production's share of total domestic output decreased from 71 percent in 1969 to 68 percent in 1970. This trend is expected to continue until the mid-1970's when the Henderson mine of American Metal Climax, Inc. (AMAX) is placed in operation.

Output of molybdenum at coproduct plants rose over 19 percent compared with the 1969 figure, owing principally to the entry of two new producers during the year; namely, Duval Sierrita Corp. and The Anaconda Co. Of the 15 traditional coproduct producing plants, 10 reported an increase in output; the remainder had lower production. Most coproduct producers shipped molybdenum concentrate rather than converting it to oxide before shipment. The molybdenite content of copper ores treated ranged from about 0.02 percent to 0.06 percent, and recovery ranged from a low of 40 percent at some mills to as much as 80 percent at others.

Kennecott Copper Corp. was the leading producer of coproduct molybdenum followed by Duval Corp. and Magma Copper Co. According to the annual report of Kennecott Copper Corp., the company's four domestic mines produced nearly 17 million pounds of molybdenum, compared with 15.9 million pounds in 1969. Increased output was principally due to a higher production rate of copper ore.

Pima Mining Co. initiated an expansion of its mining and milling facilities from 40,000 tons to 53,000 tons per day at an estimated capital cost of $16.5 million. The project was scheduled for completion in late 1971. Molybdenum production is expected to reach 2 million pounds annually.

Molybdenum Corporation of America (Molycorp) stated in their annual report that the Questa mine produced 10.1 million pounds of molybdenum in 1970, slightly lower than reported for 1969. The decline in output was due to lower-than-anticipated ore grade. At yearend, ore reserves totaled 150 million tons with an average grade of 0.173 percent molybdenite.

With the authorization of $44.2 million in 1970, a total of over $103 million now has been obligated for development of the Henderson project, the new AMAX molybdenum mine. Development work at the Henderson molybdenum deposit to date includes completion of mine-site grading and sinking of the Henderson No. 1 shaft, which reached the planned depth of 2,410 feet in 1969. Construction of the Henderson No. 2 shaft and concentrator began in 1970, and the contractor, Harrison Western Corp., reported making good progress in sinking the 28-foot-diameter shaft.

The estimated cost of developing the Henderson deposit is approximately $250 million. With the output of this mine, AMAX's capacity is expected to exceed 100 million pounds of molybdenum per year.

A $165 million copper-molybdenum mine was placed in operation near Tucson, Ariz., by Duval Sierrita Corp. The investment was jointly financed by the Federal Government and the Duval Corp. in the interest of national security and under authorization of the Office of Emergency Preparedness. The open pit mine and concentrator have a designed capacity of 80,000 tons of ore per day, and the mill is expected to produce 13 million pounds of molybdenum annually. Ore reserves developed were reported at 414 million tons with an average copper content of 0.35 percent and an average molybdenite content of 0.036 percent.

The Anaconda Co. Twin Buttes open pit copper mine, placed in operation in late 1969, began producing molybdenum concentrates at midyear. The plant was designed to process over a million tons of copper-molybdenum ore annually, from which 1 million pounds of molybdenum will be recovered. Ore reserves are reported at 292 million tons, averaging 0.60 percent copper and 0.03 percent molybdenite.

Table 3.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	1969	1970	1969	1970	1969	1970
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
Received from other producers	6,021	7,148	250	612	570	496
Gross production during year	68,655	84,099	3,243	3,042	2,393	3,329
Used to make other products listed here	17,140	26,430	929	1,301	1,273	1,584
Net production	51,515	57,766	2,314	1,741	1,120	1,745
Shipments	58,042	57,158	2,642	2,244	1,674	1,865
Producer stocks, Dec. 31	12,547	20,217	427	545	227	610
	Sodium molybdate		Other [2]		Total [3]	
Received from other producers	85	114	221	356	7,146	8,726
Gross production during year	617	777	13,161	13,516	88,068	104,763
Used to make other products listed here	14	34	188	31	19,543	29,380
Net production	603	743	12,973	13,486	68,525	75,480
Shipments	837	886	14,531	13,942	77,726	76,095
Producer stocks, Dec. 31	162	132	4,481	4,400	17,844	25,904

[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 totals shown because of independent rounding.

CONSUMPTION AND USES

Domestic consumption of molybdenum in concentrate increased 4 percent compared with that of 1969. Small quantities were used in producing purified molybdenum disulfide for lubricants, but most concentrates were converted to molybdic oxide for use as such or for conversion to other primary molybdenum products.

Domestic end-use consumption of molybdenum totaled 45.3 million pounds, a decrease of 12 percent compared with that of 1969. Molybdenum consumption is closely associated with the level of activity in the iron and steel industry, particularly in the production of alloy and stainless steel. Steel manufactures 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 (65 percent), ferromolybdenum (21 percent), ammonium and sodium molybdate (3 percent), and others (11 percent). By far the largest end-use consumption of molybdic oxides was in alloy additives for steel (54 percent). Other large consuming uses of molybdic oxides were stainless steel (13 percent), carbon steel (9 percent), tool steel (6 percent), and pigments and catalysts (6 percent).

The principal end-uses of ferromolybdenum were in steel and cast iron; the former consumed about 54 percent and the latter, 28 percent.

A molybdenum disilicide resistance heating element was introduced for electric gas melting operations by Thatcher Glass Manufacturing Co., Elmira, N.Y. The element provided contamination-free and precise temperature control in an experimental project. Current electric glass melting furnaces utilize other mineral-base elements, but operations have been unsatisfactory.

An important use for molybdenum arising from rapid growth and technological progress in the design of pressure vessels for all types of power generation systems, chemical, gas, petrochemical, and other industries was evaluated.[2]

[2] Dunn, R. G., G. F. Whiteley, and W. Fairhurst. Molybdenum's Place in The Pressure-Vessel Field. American Metal Climax, Inc., New York, 1970, 261 pp.

Coated molybdenum heating coils which produce cost savings up to 40 percent over platinum and platinum-rhodium coils were manufactured by Sylvania Electric Products, Inc.

Table 4.—Consumption of molybdenum materials by end uses in 1970

(Thousand pounds of contained molybdenum)

End uses	Molybdic oxides	Ferro-molybdenum [1]	Ammonium and sodium molybdate	Other molybdenum materials [2]	Total [3]
Steel:					
Carbon	2,590	405	------	W	2,995
Stainless and heat resisting	3,927	1,765	------	52	5,744
Alloy (excludes stainless and heat resisting)	16,010	2,137	------	29	18,176
Tool	1,631	878	------	W	2,509
Cast irons	1,093	2,743	------	80	3,916
Superalloys	532	355	------	1,621	2,508
Alloys (exclude alloy steels and superalloys):					
Cutting and wear resistant materials	W	238	------	3	241
Welding and alloy hardfacing rods and materials	------	334	------	W	334
Magnetic alloys	W	W	------	W	W
Other alloys [4]	W	93	------	123	216
Mill products made from metal powder	W	W	W	1,716	1,716
Chemical and ceramic uses:					
Pigments	694	------	364	W	1,058
Catalysts	1,139	------	674	------	1,813
Other	66	W	W	786	852
Miscellaneous and unspecified	1,743	681	73	761	3,258
Total [3]	29,426	9,628	1,112	5,171	45,337
Consumer stocks Dec. 31	3,036	1,353	364	953	5,706

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 nonferrous alloys.

STOCKS

The industrial inventory of molybdenum in concentrate and compounds totaled nearly 41.1 million pounds, 30 percent higher than at yearend 1969. Stocks of concentrate at mines and plants increased nearly 16 percent, stocks of primary products at producer plants increased 44 percent, and those at consumer plants increased 4 percent.

PRICES

The price per pound of contained molybdenum f.o.b. point of shipment, as quoted in Metals Week, was unchanged during the year, as follows: concentrate, 95 percent molybdenum sulfide (MoS_2), $1.72; molybdic trioxide (MoO_3) in bags $1.91, and in cans $1.92. The same publication quoted molybdenum powder, hydrogen reduced, at $4.00 per pound; ferromolybdenum, per pound of contained molybdenum, 5,000 pounds or more, f.o.b. New York, powdered, packed, was quoted at $2.27.

FOREIGN TRADE

Exports.—The United States continued to be a major supplier of molybdenum for the free world. In 1970, exports of molybdenum in concentrate (including roasted concentrates) totaled 55.7 million pounds and accounted for about 50 percent of domestic output. The Netherlands and Japan received over 68 percent of the molybdenum exported, about 6 percent more than in 1969. Most of the concentrate exported to the Netherlands was converted into technical-grade molybdic oxides for reshipment to other European countries.

In 1970, molybdenum concentrate exports were 3 percent lower than in 1969, a record year. The decline in exports was due to lower shipments to the United Kingdom and West Germany, two large steel-producing countries. Exports to these countries declined from about 11 million pounds in 1969 to about 7 million pounds in 1970.

Imports.—Although the nation is self-sufficient in molybdenum material, a small quantity of concentrate, manufactured molybdenum products, and waste and scrap enters the United States from numerous countries throughout the free world. High tariff rates preclude the importation of such material in large quantities. Import

Table 5.—Molybdenum reported by producers as shipments for exports from the United States

(Thousand pounds of contained molybdenum)

Product	1969	1970
Molybdenite concentrate	29,528	32,998
Molybdic oxide	18,295	15,801
All other primary products	1,484	1,929

duties negotiated under the 1967 "Kennedy round" of Tariff Negotiation effective on January 1, 1971, are shown in table 8.

According to the Department of Commerce, wrought molybdenum products containing 28,835 pounds of molybdenum were imported during 1970, an increase of more than 22 percent over 1969. Austria supplied about 68 percent of the total; the remainder came from seven other countries. The importation of 4,175 pounds of molybdenum contained in unwrought molybdenum products, all from West Germany, was considerably higher than in 1969.

Molybdenum concentrate, containing 25,348 pounds of molybdenum and valued at nearly $50,000 was imported from Chile and the Philippines. The molybdenum content of waste and scrap imported from five countries totaled 175,576 pounds, valued at nearly $369,000. Netherlands and West Germany were the principal suppliers.

Molybdenum chemicals and related materials entering the United States included molybdenum compounds, inorganic compounds, and molybdenum orange. Imports of molybdenum compounds totaling 2,023 pounds contained weight, valued at nearly $9,000 were reported in 1970. Japan was the principal supplier (45 percent); the remain-

Table 6.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by countries

(Thousand pounds and thousand dollars)

Destination	1969		1970	
	Molybdenum (content)	Value	Molybdenum (content)	Value
Australia	r 387	$677	890	$1,408
Austria	794	1,345	203	386
Belgium-Luxembourg	1,379	2,465	786	1,465
Brazil	64	112	199	260
Canada	464	768	517	846
Czechoslovakia	630	1,033	642	915
France	2,170	3,687	3,022	5,155
Germany:				
East	628	1,235	368	638
West	7,346	11,962	5,569	8,810
India	38	43	326	477
Italy	1,487	2,508	805	1,457
Japan	11,446	20,002	13,738	23,386
Mexico	207	370	335	473
Netherlands	24,634	43,087	24,411	42,861
New Zealand	5	10	14	24
Philippines	22	36	58	114
South Africa, Republic of	86	141	105	168
Spain	------	------	11	19
Sweden	1,950	3,079	1,980	3,322
United Kingdom	3,654	6,157	1,533	2,728
Venezuela	157	290	186	259
Other	27	48	39	75
Total	r 57,575	99,055	55,737	95,246

r Revised.

Table 7.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1969		1970	
	Quantity	Value	Quantity	Value
Ferromolybdenum: [1]				
Argentina	32	$43	52	$71
Australia	144	204	167	228
Bolivia	------	------	33	20
Brazil	55	78	18	24
Canada	483	1,036	65	144
Finland	51	71	112	172
Germany, West	------	------	33	51
Hungary	------	------	99	154
India	51	67	504	902
Japan	44	66	336	426
Mexico	46	62	119	176
Mozambique	------	------	12	16
Romania	110	135	------	------
South Africa, Republic of	57	76	63	87
Spain	------	------	22	33
Sweden	239	332	364	561
Taiwan	36	49	4	7
Yugoslavia	100	151	------	------
Other	7	11	11	16
Total	1,455	2,381	2,014	3,088
Metal and alloys in crude form and scrap:				
Canada	------	------	9	12
France	3	12	3	11
Germany, West	11	42	25	96
India	------	------	68	84
Italy	------	------	11	17
Japan	1	1	50	80
Mexico	3	11	(2)	3
Netherlands	------	------	318	374
United Kingdom	2	2	186	119
Other	1	2	1	6
Total	21	70	671	802
Wire:				
Australia	1	6	5	38
Brazil	10	127	8	116
Canada	15	343	20	194
France	(2)	44	14	91
Germany, West	1	7	9	56
India	4	43	4	44
Japan	9	74	32	244
Mexico	3	72	4	115
Netherlands	11	202	5	120
United Kingdom	1	44	1	111
Other	6	121	5	123
Total	61	1,083	107	1,252
Powder:				
Canada	r 11	r 28	41	36
Germany, West	2	7	6	20
Japan	6	44	83	128
Mexico	(2)	1	7	11
South Africa, Republic of	------	------	10	14
Sweden	r 20	73	18	71
United Kingdom	(2)	3	11	43
Venezuela	------	------	146	173
Other	5	12	7	32
Total	r 44	r 168	329	528
Semifabricated forms, n.e.c:				
Australia	11	14	(2)	(2)
Canada	26	92	3	27
France	3	29	18	138
Germany, West	3	21	1	19
India	3	23	4	24
Italy	1	17	7	16
Japan	123	235	74	215
Mexico	7	43	1	8
Netherlands	33	108	16	99
South Africa, Republic of	7	39	(2)	2
United Kingdom	2	28	5	56
Other	10	33	4	39
Total	229	682	133	643

r Revised.
[1] Ferromolybdenum contains about 60 to 65 percent molybdenum.
[2] Less than ½ unit.

Table 8.—U.S. import duties

Item	Articles	Rate of duty, Jan. 1, 1971 [1]
601.33	Molybdenum ore	14 cents per pound on molybdenum content.
603.40	Material in chief value molybdenum	12 cents per pound on molybednum content plus 3.5 percent ad valorem.
607.40	Ferromolybdenum	Do.
	Molybdenum:	
628.70	Waste and scrap	12.5 percent ad valorem.
628.72	Unwrought	12 cents per pound on molybdenum content plus 3.5 percent ad valorem.
628.74	Wrought	15 percent ad valorem.
	Molybdenum chemicals:	
417.28	Ammonium molybdate	12 cents per pound on molybdenum content plus 3.5 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	6 percent ad valorem.

[1] Not applicable to Communist countries.

der came from five other countries. Three countries exported a mixture of inorganic compounds to the United States in 1970. The molybdenum content of the material totaled 17,035 pounds, or 60 percent over that reported for 1969. Molybdenum orange came from four countries in 1970 and totaled 190,965 pounds, gross weight, valued at $76,968. Japan supplied 57 percent of the total value; the remainder came from Canada, Belgium-Luxembourg, and West Germany.

WORLD REVIEW

Australia.—Aquila Investment Corp. acquired a 50-percent equity from Transouth Mining Partners, Ltd., in a molybdenum deposit situated near Moliagul, Victoria. Exploratory work was continued on the property. At the completion of a drilling program, an engineering evaluation will be made to determine its economic potential.

Bulgaria.—Medet, a copper-molybdenum mine and mill complex, continued a major expansion program which will increase throughput capacity from about 6 million to 8 million metric tons of ore annually. At completion of the project, the mine is expected to produce 133,000 tons of copper concentrate, 39,000 tons of pyrite concentrate, and about 450,000 pounds of molybdenum annually.

Canada.—Production of molybdenum in 1970 was the highest on record. The reported output of 35.4 million pounds of molybdenum was over 19 percent higher than in 1969. Canada ranked second to the United States among world producers of molybdenum and supplied approximately 21 percent of the estimated 1970 free world production, the same as in 1969.

Table 9.—Molybdenum: Free World production of ore and concentrates, by countries

(Thousand pounds of contained molybdenum)

Country [1]	1968	1969	1970 p
Canada (shipments)	r 22,463	29,652	35,353
Chile	8,521	10,675	13,448
Japan	r 630	593	974
Korea, Republic of (South)	423	287	254
Mexico	176	445	311
Norway	487	635	553
Peru	r 1,785	494	1,167
Philippines	r 139	51	71
United States	93,447	99,807	111,352
Total	r 128,071	142,639	163,648

p Preliminary. r Revised.

[1] In addition to the countries listed, Argentina, Australia, North Korea, Nigeria, Romania, South-West Africa, and Spain also produce molybdenum, but available information is inadequate to make reliable estimates of production levels.

In the short range, a substantial increase in molybdenum output was expected because of intensive exploration and development activity in the Western Provinces of Canada. Early in the year, Brenda Mines, Ltd., under management of Noranda Mines Ltd., started production at a mine situated 24 miles west of Kelowna, British Columbia. The open pit mine and mill facility, a $63 million investment, is designed to process 24,000 tons of copper-molybdenum ore per day. The ore deposit is estimated at 165 million tons averaging 0.182 percent copper and 0.049 percent molybdenite.

Lornex Mining Corp. Ltd., managed by Algom Mines Ltd., announced that construction of an open pit mine and mill complex was substantially on schedule, but expenditures are projected to reach about $133 million, or 6 to 8 percent over those previously estimated for the project. The large copper-molybdenum deposit, containing 0.427 percent copper and 0.014 percent molybdenite, is located 33 miles south of Ashcroft in the Highland Valley of British Columbia. At yearend, 47 million tons of overburden was removed from the orebody; excavation for the crusher, concentrator, and service building was completed; and good progress was being made in building a company town, Logan Lake. The throughput of the mine and mill facility is estimated at 1.4 million tons of ore annually from which 162,000 tons of copper concentrate and 2.5 million pounds of molybdenum will be produced. Initial production was scheduled for the second quarter of 1972. The Provincial government has approved a 12-year sales contract consigning the entire output to Japan's industrial complexes.

Design and construction work continued on a copper-molybdenum mine and mill near Port Hardy in the northern part of Vancouver Island by Utah Construction & Mining Co. Completion of the $73.5 million project was scheduled for yearend 1971. Ore reserves are reported at 280 million tons, averaging 0.52 percent copper and 0.029 percent molybdenite. Annual production is expected to be about 230,000 tons of copper concentrate and 1.9 million pounds of molybdenum. Most of the mine output of copper concentrate has been consigned to Mitsui Mining & Smelting Co. Ltd. and Mitsubishi Shoji Kaisha Ltd. of Japan as part of a financing arrangement in developing the property.

Placer Development Ltd. was proceeding with design and construction of an open pit mine and concentrator located in central British Columbia, approximately 380 miles northeast of Vancouver near the community of William Lake. The project is a $74 million investment. The copper-molybdenum deposit has an estimated minable ore reserve of nearly 200 million tons, with an average grade of 0.39 percent copper and 0.016 percent molybdenite. Approximately 1 million tons of ore will be mined annually. A sales agreement, approved by the Government of British Columbia, has been made with the Nippon Mining Co. Ltd. of Japan consigning all of the copper concentrate production to yearend 1976.

At midyear, King Resources Co. announced the startup of its Mt. Copeland mine, situated 18 miles north of Revelstoke, British Columbia. The mine and mill facility was designed to process 200 tons of molybdenum ore per day. The company planned to produce and market lubricant-grade molybdenum disulfide.

Kerr Addison Mines, Ltd., completed a $2.5 million feasibility study on the Ruby Creek molybdenum deposit owned by Adanac Mining and Exploration Ltd. The work included drilling 16,000 feet of exploratory holes, and driving 2,733 feet of development drifts and crosscuts and 921 feet of development raises. A 100-ton pilot mill was built to conduct metallurgical testing. Underground bulk sampling and surface drilling indicated a molybdenum ore reserve tonnage in excess of 70 million tons grading 0.141 percent molybdenite. The deposit is located near Surprise Lake, about 25 miles northeast of Atlin, British Columbia.

Among other copper-molybdenum and molybdenum deposits in various stages of exploration and development in the western Provinces of Canada are Brameda Resources Ltd., located 190 miles northwest of White Horse; Sileurian Chieftain Mining Company Ltd., located in the Alice Arm area; Bethlehem Copper Corp., Ltd., located in the Cache Creek area; and Highmont Mining Corp., Ltd., located in the Highland Valley area.

Chile.—Output of molybdenum, a byproduct of copper, was reported as nearly

13.5 million pounds, the highest on record. Chile ranked third among free world producers of molybdenum. Production came from three producing mines, namely El Teniente, Chuquicamata, and El Salvador.

Atlas Exploration of Canada, Ltd., announced discovery of a copper-molybdenum deposit in the Sierre Gorda area of northern Chile. The orebody was estimated to contain 50 million tons of ore, averaging 1 percent copper and 0.182 percent molybdenite.

India.—Molybdenum deposits have been discovered in the Mudurai district of Tamil Nadu, according to the Director of the Geological Survey of India. Exploratory drilling was conducted on the deposit, and about 20 holes were completed during the year.

Japan.—Japan's consumption of molybdenum during the past decade has recorded an average annual growth rate of nearly 15 percent, increasing from 4.1 million to 16.4 million pounds. The growth rate is expected to continue through the 1970's. In a joint venture with 10 Japanese companies, American Metal Climax, Inc. (AMAX) announced construction of a 15-million-pound-per-year molybdenum conversion plant in Japan. AMAX will have a 34-percent equity in the new Japanese corporation, Nihon Moribuden K.K. (Nihon). The plant was scheduled for completion in middle to late 1971. Tariff schedules permit duty-free importation of molybdenum concentrate, while duty is charged for oxides and ferromolybdenum.

Mexico.—Compañiá Minera de Nacozari S.A., jointly owned by The Anaconda Co. and Mexican interests, continued diamond drilling and underground development of a copper-molybdenum deposit in the Nacozari district of Sonora. The tonnage of commercial-grade ore was substantially increased during the year and mining by open pit methods was contemplated by Government officials.

Panama.—The Government of Panama awarded a mining concession for development of the Petaquilla copper-molybdenum deposit to a consortium comprised of Duval Corp., United States, Mitsui Mining & Smelting Co. Ltd., Japan, and Metallgesellschaft AG, West Germany. The ore body was found last year by a United Nations survey team, and the discovery created considerable interest among international mining concerns. Because of its remote location and the unusual climactic condition prevailing in the region, development of the mineral deposit will require considerable expenditures and a lead time ranging from 5 to 10 years.

Peru.—Output of molybdenum was over 1 million pounds, significantly higher than reported in 1969. Most of the increased production came from the Toquepala mine of Southern Peru Copper Corp. (SPCC). The increase in output was due to SPCC utilizing a recovery process more suitable to the mineralogical characteristics of the ore and less downtime due to labor problems. Development of the Cuajone mine by SPCC continued during the year, a new access road was completed to the property, work began on driving a railroad tunnel, and stripping of overburden from the ore deposit was started. The project ultimately will cost approximately $400 million to bring into production. The company was negotiating with international financing institutions to arrange funding for the project.

TECHNOLOGY

Molybdenite roasting and rhenium volatilization in a multiple-hearth furnace were investigated.[3] Results of the study indicated that rhenium volatilization was more rapid as the MoS_2 oxidation approached completion. Molybdenite roasting rate depends on oxygen diffusion when the sulfur content is high, but toward the end, a surface reaction phenomenon controls the process. Some engineering criteria have been developed for the optimum operating conditions on industrial roasting plants. The experimental methods and calculations also can be applied to roasting of other sulfide minerals.

Beneficiation studies were conducted on molybdenite-chalcopyrite ore, and results of the investigation were published.[4]

[3] Coudurier, Lucien, Igor Wilkomirsky, and George Moizot. Molybdenite Roasting and Rhenium Volatilization in a Multiple-Hearth Furnace. Inst. Min. Met. Trans. sec. 6, v. 79, March 1970, pp. 34–40.

[4] Rustagi, M. C., P. Dayal, and A. K. Biswas. On Molybdenite-Chalcopyrite Separation. J. Mines, Metals, and Fuels, v. 18, February 1970, pp. 50–51.

While rough xanthate flotation yielded concentrate with high recovery of copper and molybdenum, attempts toward subsequent separation of molybdenite from chalcopyrite met with limited success. Best results were obtained by removal of the collector film by steaming in presence of oxidants or depressors, followed by flotation. Some hydrometallurgical beneficiation step was required.

A definitive publication on economics of molybdenum and rhenium recovery from porphyry copper was released.[5] The author evaluated the current and future production potential of byproduct sources of these minerals. Most of the world's active mining and milling facilities were visited, and their operation was described. Attention was directed to the high value of rhenium content in molybdenum concentrate and to the economic and technical value of its recovery.

The Bureau of Mines released a comprehensive publication on the supply and demand of molybdenum.[6] The author analyzed the supply of molybdenum in relation to mining, milling practices, and ore reserves at mines producing molybdenum as a primary product and those producing it as a byproduct and/or coproduct of copper, tungsten, and uranium. Also examined were the effects on molybdenum supply of such factors as Government stockpiling, world trade, prices, and the use of substitute materials.

The oxidizing characteristics of potassium permanganate as compared to those of the conventional oxidants H_2O_2 and NaCl0 in the selective flotation of molybdenite from flotation-plant bulk copper concentrate were investigated.[7] The effectiveness of these reagents in the depression of copper sulfide minerals was affected by reagent concentration, pH, temperature, and conditioning time.

Bureau of Mines researchers demonstrated the economic recovery of oxides from superalloy grinding wastes which contain substantial quantities of nickel, cobalt, molybdenum, and chromium.[8] The recovery process includes scrap preparation, dissolution of metallics in chlorinated acid solutions, carbon adsorption, successive solvent extraction separation, and selective chemical precipitation.

A study was made of the dynamic strain aging processes in carbide strengthened molybdenum alloys, and the results were published.[9] Strengthening due to dynamic strain aging was observed in the temperature range from 1,500° to 2,400° F. The strengthening was believed to arise from the pinning of mobile dislocations by metal-carbon pairs or clusters and/or carbide precipitates. This immobilization of the dislocations led to a high work-hardening rate and to the observed strengthening.

A new operational technique for rapid identification of metal alloys was published.[10] The method utilizes a signature-comparison technique involving a number of known standards. An inherent feature of the technique was that a set of two numbers is generated for each element, which is characteristic of a specific alloy. By using more than one characteristic element as a basis for identification, additional sets of numbers are generated, which taken together, become positively indicative of a specific alloy.

Patents were granted for eliminating hydrogen sulfide or other noxious gaseous effluents formed during desulfurizing of molybdenum,[11] for chemical precipitation of molybdenum, vanadium, and/or uranium,[12] and on a process for separating molybdenite from copper sulfide concentrate.[13]

[5] Sutulov, Alexander. Molybdenum and Rhenium Recovery From Porphyry Copper. University of Concepción, Concepción, Chile, 1970, 259 pp.

[6] Bieniewski, Carl L. Demand and Supply of Molybdenum in The United States. BuMines Inf. Circ. 8446, 1970, 61 pp.

[7] Escalera, Saul J., and Roshan B. Bhappu. Selective Flotation of Molybdenite From Chalcopyrite Concentrates By Potassium Permanganate. New Mexico Inst. of Min. and Technol. Circ. 106, 1970, 15 pp.

[8] Brooks, P. T., G. M. Potter, and D. A. Martin. Processing of Superalloy Scrap. J. Metals, v. 22, November 1970, pp. 25–29.

[9] Raffo, Peter L. Dynamic Strain Aging In Carbide-Strengthened Molybdenum Alloy. Met. Trans., v. 1, April 1970, pp. 835–841.

[10] Sellers, Bach, and Joris Brinkerhoff. Signature Comparison Technique For Rapid Alloy Sorting With A Radioisotope Excited X-Ray Analyzer. Material Research and Standards, v. 10, November 1970, pp. 16–18.

[11] Griffith, W. A. (assigned to Phelps Dodge Corp.). Desulfurizing of Molybdenum. U.S. Pat. 3,514,283, May 26, 1970.

[12] Fitzhugh, E. F., and D. C. Seidel (assigned to Republic Steel Corp.). Recovery of Molybdenum, Vanadium, and/or Uranium From Acidic Ore Leach Solution by Precipitation. U.S. Pat. 3,510,273. May 5, 1970.

[13] Last, A. W., and G. L. Fraser (assigned to Kennecott Copper Corp.). Separating Molybdenite From Copper Sulfide Concentrates. U.S. Pat. 3,539,002, Nov. 10, 1970.

Natural Gas

By William B. Harper [1] and Leonard L. Fanelli [2]

Consumption of natural gas aggregated about 22 trillion cubic feet in 1970, which was 5.4 percent higher than in 1969. Likewise, production rose to a new high of 21.9 trillion cubic feet, a 5.9-percent gain. Imports, primarily from Canada, helped to fill the supply gap. Unlike the reductions in 1968 and in 1969, proved reserves of natural gas increased in 1970. However, this increase came about entirely from a change in reporting by the Reserves Committee of the American Gas Association (AGA). Estimates of proved reserves for the Prudhoe Bay area of Alaska, for example, were included for the first time in the 1970 totals. This increase more than offset declines in other States. Prices for natural gas at the wellhead moved upward to 17.10 cents per thousand cubic feet (Mcf), and prices paid by consumers and other users were higher.

In 1970, another one-half million residential gas users were added to the 38 million already using gas. Also, there were 31,000 commercial users added to the 3.2 million accounts already consuming gas. About 2,600 miles of natural gas transmission lines and another 17,700 miles of distribution lines were added to the 570,000 miles in service. Capital expenditures for new plants and equipment amounted to $2.5 billion in 1970, and again most of the expansion was related to the transportation and distribution of gas. During 1970, there was considerable activity in expansion of liquefaction plants and liquefied natural gas (LNG) storage facilities, and even greater expansions were anticipated for 1971 and subsequent years.

Data on natural gas production, consumption, and value are collected by annual surveys of oil and gas producers, natural gas processing operators, gas pipeline companies, and gas utility companies, with separate reports obtained for each State in which they operate.

These reports reflect approximately 80 percent of gross natural gas production. The large number of respondents and the difficulty of canvassing each small producer have made direct acquisition of total production impractical. Most of the output of

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Table 1.—Salient statistics of natural gas in the United States
(Million cubic feet unless otherwise specified)

	1966	1967	1968	1969	1970
Supply:					
Marketed production [1]	17,206,628	18,171,325	19,322,400	20,698,240	21,920,642
Withdrawn from storage	1,141,614	1,132,534	1,329,536	1,379,488	1,458,607
Imports	479,780	564,226	651,885	726,951	820,780
Total	18,828,022	19,868,085	21,303,821	22,804,679	24,200,029
Disposition:					
Consumption	17,191,711	18,172,894	19,459,939	20,922,800	22,045,799
Exports	24,639	81,614	93,745	51,304	69,813
Stored	1,210,469	1,317,363	1,425,075	1,498,988	1,856,767
Lost in transmission, etc	401,203	296,214	325,062	331,587	227,650
Total	18,828,022	19,868,085	21,303,821	22,804,679	24,200,029
Value at wellhead:					
Total ... thousand dollars	2,702,759	2,898,741	3,168,688	3,455,615	3,745,680
Average ... cents per Mcf	15.7	16.0	16.4	16.7	17.1

[1] Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

nonreporting producers has been shown in purchase listings of reporting companies. Marketed production for each State equals consumption in the State, plus losses in transmission, gas placed in storage, and withdrawals from storage and receipts from other States.

Gas volumes in this chapter are reported or converted to a pressure base of 14.73 pounds per square inch absolute at 60°F.

Legislation and Government Programs.—On December 24, 1970, the Federal Power Commission, (FPC), granted a motion by 30 producers to reopen the original South Louisiana (61–2 et al) and to consolidate it with the then pending Area Rate Proceeding (AR69–1) in order to reconsider rate levels and refunds established by Opinions 546 and 546-A in light of additional evidence on the current shortage of gas and other relevant factors. The FPC continued a stay of rate reductions, refunds, and other obligations as required by Opinion 546.[3] Also, the Commission incorporated into the consolidated proceeding the United Distribution Companies (UDC) Settlement Proposal, which has been filed earlier in AR69–1.

Initial briefs including the UDC Settlement Proposal were filed by the following groups:

(1) Major Producer Group (35 companies).

(2) Mobil Oil Corp.

(3) Amoco Production Co.

(4) United Distribution Companies (UDC Settlement Proposal).

(5) Associated Gas Distributors.

(6) Pipeline Purchaser Group.

(7) Federal Power Commission (FPC) Staff.

(8) New York Public Service Commission.

(9) Municipal Distributor Group.

Five of the nine groups numbered (1, 4, 5, 6, and 7) endorsed adoption of the UDC Settlement Proposal, which provided for the following:

(1) Ceiling rates of 22.375 cents per Mcf onshore (including the disputed zone) and 21.375 cents offshore for future deliveries under contracts dated prior to October 1, 1968, and 26.0 cents both onshore and offshore for future deliveries under contracts dated on or after October 1, 1968, on acreage committed to contracts prior to October 1, 1968, with no differentiation between nonassociated and other types of gas for pricing purposes:

(2) Fixed escalations of 0.5 cents on October 1, 1973 in the case of contracts prior to October 1, 1968 and 1.0 cents on October 1, 1974, in the case of contracts after October 1, 1968;

(3) Contingent successive escalations of 0.5 cents, in the case of contracts prior to October 1, 1968 only, upon the commitment of 7.5 trillion cubic feet, 11.25 trillion cubic feet and 15.0 trillion cubic feet, respectively, of new gas reserves in the south Louisiana area to jurisdictional sales prior to October 1, 1977;

(4) Refund of revenues collected in excess of 20.625 cents onshore and 19.625 cents offshore for deliveries prior to January 1, 1965, revenues collected in excess of 21.25 cents onshore and 20.25 cents offshore for deliveries from January 1, 1965 to October 1, 1968, and 30.5 percent of revenues collected in excess of Opinion 546 and 546–A rates for deliveries during the period October 1, 1968 to January 1, 1971. (The 30.5 percent refund factor is subject to increase, up to 33 percent, to the extent that total refund obligations calculated for the three periods to January 1, 1971, fail to come to within 1 percent of $150 million.) After January 1, 1971, all amounts collected in excess of the proposed settlement rates would be subject to refund.

The FPC issued Opinion 598 accepting, virtually without change, the UDC Settlement Proposal.

In addition, the FPC has established higher ceiling rates in the Rocky Mountain area, ranging from 22.5 cents to 24 cents for sales under contracts dated after June 17, 1970. Hearings on the Area Rate Proceeding, Permian Basin Area (AR70–1), were to carry over into 1971.

Pipeline Safety.—The Natural Gas Pipeline Safety Act of 1968 (Public Law 90–481) provides, among other things, that the Secretary of Transportation establish minimum Federal safety standards applicable to pipeline facilities used in the transportation of natural gas.

The annual report for the calendar year 1970, issued by the Department of Trans-

[3] The FPC's Opinions 546 Established Price Ceilings for Sales of State of Louisiana Gas, Both Onshore and Offshore; also Federal Domain Offshore. These Ceilings Applied to Contracts Dated Prior to Jan. 1, 1961; Dated Between Jan. 1, 1961 and Sept. 30, 1968; Dated Oct. 1, 1968 and later.

portation (DOT), cites the need for a single agency in each State with safety jurisdiction over all intrastate natural gas facilities and elimination of overlapping jurisdiction between natural gas and liquefied petroleum gas systems in a number of States. An appendix to the report shows that 48 States and the District of Columbia have submitted certifications under section 5a of the act and that five States entered into section 5b agreements with respect to intrastate facilities over which they lacked safety jurisdiction under State law. Twenty-two States agreed to act as DOT agents in connection with interstate transmission systems. Leak data, which is required to be reported under the act, was summarized in the report as follows:

	Distribution	Transmission
Number of leaks reported	676	343
Cause:		
Corrosion	102	51
Outside force	462	181
Material defect or failure	53	88
Other	59	23
Fatalities	21	1
Injuries	202	16
Property damage—million dollars	0.2	2.8

DOMESTIC PRODUCTION

The marketed production of natural gas in 1970 rose to 21,920,642 million cubic feet (Mmcf) or 5.9 percent above the 1969 level as shown in table 1. Texas leads all States in production with 38.1 percent of the Nation's total (table 3). Between the end of 1969 and 1970 the volume produced in Texas increased about 504 billion cubic feet. During 1970 Louisiana had 35.5 percent of the total volume of marketed natural gas, a production increase of 560 billion cubic feet. During 1970, production of natural gas in Alaska more than doubled to 111,576 Mmcf. Most of the new production (39.7 percent) was exported to Japan in the form of LNG.

In addition to gains to Louisiana, Texas, and Alaska, marketed production of natural gas in 1970 increased in Arkansas, Oklahoma, Illinois, Kansas, Ohio, Michigan, North Dakota, West Virginia, and Wyoming. Volumes declined in Arizona and California in 1970. In the Rocky Mountain area, output in Utah and Colorado was down. Likewise, marketed production declined in Nebraska and Indiana. The reason for lower production was evident in the decline in well drilling. In 1970 there were 28,120 wells drilled (excluding stratigraphic core tests and service wells). This was 4,067, or 12.6 percent fewer wells drilled than in 1969. Patterns of decline in natural gas production in many States related closely to declines in the number of oil and gas well completions in 1970. This pattern did not apply, however, to offshore Louisiana, and to Texas and Oklahoma.

CONSUMPTION AND USES

Consumer uses of natural gas, which includes residential, commercial, industrial, electric utilities, and deliveries to municipalities and public authorities (table 4) accounted for 86.3 percent of the natural gas consumed. The use of natural gas as fuel in the oil and gasfields consumed about 6.3 percent and pipelines used another 3.3 percent for fuel. In addition, the extraction of ethane and liquefied petroleum gases such as butane and propane accounted for another 4.1 percent of natural gas consumption.

Natural gas consumption during 1970 rose to 22 trillion cubic feet, an increase of 1.1 trillion cubic feet, or 5.4 percent over the 1969 usage. Since 1967, consumption has exceeded production, but imports, largely from Canada, have helped to close the gap.

Two of the largest consumers of natural gas for all uses, including industrial and electrical utilities, are Texas and Louisiana. These States are also leaders in natural gas production. Texas produced 8,358 billion cubic feet of natural gas in 1970 and consumed 4,559 billion cubic feet, or a volume equal to 54.6 percent of production. In Louisiana, consumption of natural gas in 1970 was equal to 26 percent of production. Oklahoma consumed 656 billion cubic feet and produced 1,595 billion cubic feet. In New Mexico, the fourth largest gas-producing State, consumption was equal to 28 percent of the 1,139 billion cubic feet produced.

Industrial consumption of natural gas for fuel and for carbon black production is by far the largest outlet for natural gas. In 1970 industrial use of nearly 7.9 trillion cubic feet exceeded the combined residential and commercial use of natural gas by nearly 1 trillion cubic feet. Residential and commercial use combined has also increased from 4.1 to 6.9 trillion cubic feet, or 68 percent.

The growth trend in the use of natural gas by electrical utilities, the third largest consumer, has been even more spectacular. Between 1960 and 1970, use more than doubled, from 1.7 trillion cubic feet to almost 3.9 trillion cubic feet.

About 27 percent of all the natural gas used by utilities is concentrated in Texas. California is the second largest user with 16.3 percent of the total volume. Electric utilities in six States including Louisiana, Oklahoma, Florida, and Kansas, consume 67 percent of all the natural gas used in the electric utility segment (table 4). Proximity to markets provides natural gas a competitive cost advantage in the Southwest. Coal has never been readily available in California or in Florida, and Kansas has extensive gasfields. In 1970 consumption by utilities increased 408 billion cubic feet, or 12 percent compared with that of 1969.

Also in the industrial consumption category as shown in figure 2, are the natural gas extraction losses. Natural gas processing plants processed 18.5 trillion cubic feet, or 84.4 percent of gross production of natural gas in 1970. From this gas, 606 million barrels of natural gas liquids and ethane were recovered. To obtain these liquids 906.4 Mmcf of natural gas were consumed in the extractive process, a volume 4.6 percent greater than in 1969. About 13.4 trillion cubic feet of this processed natural gas was shipped to transmission pipelines and an additional 2.1 trillion cubic feet was delivered directly to consumers. Comparisons with 1969 figures in terms of natural gas processed, extraction losses, and shipments to transmission companies, are shown in table 7.

Residential consumption constitutes the second largest category in the uses of natural gas. Between 1961 and 1970, the number of residential gas customers has risen from 32,052,000 to 38,604,000, or 20 percent. At the same time, however, natural gas consumption climbed from 3.2 to 4.8 trillion cubic feet, or 50 percent. In 1970 gas customers increased by 508,000, or 1.3 percent. The rise in gas use over the decade reflects in part new family formation and new home construction, but even more significant is the increased use of natural gas for heating purposes. At the end of 1961, according to AGA, there were 22,459,000 househeating customers. By yearend 1970 that number had expanded to 31,659,000, or 41 percent. However, the increase in 1970 was only 3 percent.

Growth in househeating customers is shown by Census regions for the 1961–70 period, as follows:

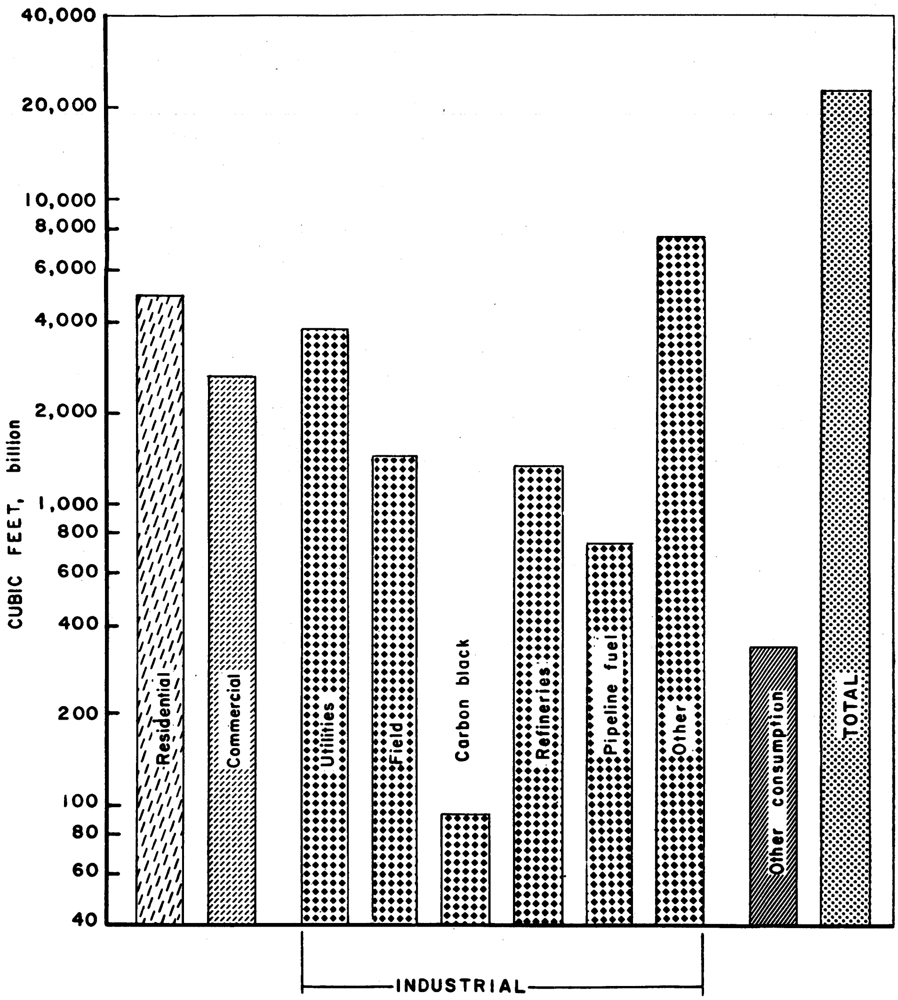

Figure 1.—Disposition of natural gas consumed in the United States by principal use.

Region	Thousand customers			Percent change	
	1961	1969	1970	Dec. 31, 1961 to Dec. 31, 1969	Dec. 31, 1969 to Dec. 31, 1970
New England	449	714	742	65.3	3.9
Middle Atlantic	2,678	3,719	3,819	42.6	2.7
East North Central	4,932	7,378	7,594	54.0	2.9
West North Central	2,161	2,889	2,956	36.8	2.3
South Atlantic	1,693	2,581	2,699	59.4	4.6
East South Central	1,283	1,697	1,777	38.5	4.7
West South Central	3,584	4,271	4,337	21.0	1.5
Mountain	1,189	1,623	1,686	41.8	3.9
Pacific	4,490	5,855	6,049	34.7	3.3
U.S. total	22,459	30,727	31,659	41.0	3.0

Supplying natural gas to all types of consumers has made it necessary to expand pipeline networks appreciably. At the end of 1970, there were 907,000 miles of natural gas pipelines made up of field and gathering, transmission lines, and distribution lines. The following table shows the trend over the decade in pipeline expansion, in miles:

	1960	1965	1969	1970
Field and gathering	55,850	61,760	64,914	66,555
Transmission	181,770	210,660	247,559	252,606
Distribution	370,360	484,260	569,999	587,753
Total	607,980	756,680	882,472	906,914

Although mileage provides some indications of growth, it should be recognized that much of the new mileage laid in recent years has been in larger diameter line pipe, which offers greater transporting capacity.

During 1970 the gas industry expended an estimated $2.5 billion for new plants and equipment. About $1 billion, or 40 percent, involved transmission facilities such as pipelines, compressor stations, etc., and another 900 million, or 36 percent, involved distribution-related facilities, such as miles of main.

RESERVES

The Committee of Natural Gas Reserves of the AGA estimated that the total proved recoverable reserves of natural gas in the United States as of December 31, 1970 was 290.7 trillion cubic feet, an increase of 15.6 trillion cubic feet from 1969. This estimate of proved natural gas reserves included an estimate for the Permo-Triassic Reservoir in the Prudhoe Bay, Alaska area, which was discovered in 1968, but not previously included in AGA's estimate of proved reserves. Conversely, the AGA committee has made downward revisions in its estimates of reserves in five of the 12 Railroad Commission of Texas districts. Only 12 out of the 25 States listed in table 8 realized some improvement in natural gas reserves. As a result of including Prudhoe Bay, Alaska's reserves increased by nearly 26 trillion cubic feet. Other significant gains were made in Colorado, Kentucky, Michigan, Ohio, and Pennsylvania. Texas reserves decreased 6 trillion cubic feet to 106 trillion cubic feet. Other sizable declines occurred in California, Kansas, north Louisiana, New Mexico, and Oklahoma.

"Dedicated" reserves, as defined in Form 15 of the FPC, are the volume of remaining recoverable salable gas reserves committed to, controlled by, or possessed by the pipeline company. They are used for acts and services for which both the seller and the company have received certificate authorization from the FPC. Reserves include both company-owned reserves and reserves under contract from independent producers. Based on preliminary figures, 66 companies own or control "dedicated" reserves of 173.5 trillion cubic feet.

Intrastate gas contracts are exempt from the jurisdiction of the FPC, and prices in contracts for new intrastate gas are higher than those allowed for interstate natural gas under FPC jurisdiction. Also, intrastate gas has the added attraction of shorter reserve life requirements than interstate gas; hence, the shift to intrastate sales. This is the principal reason why "dedicated" natural gas reserves have been declining. The shift to intrastate market can be seen in the following 5-year comparison (all figures except those for "number of companies" are in trillion cubic feet at 14.73 pounds per square inch absolute at 60°F).

Twenty-four of the companies reported more than 900 billion cubic feet of natural gas reserves in 1969. These companies control 97.8 percent of the reported gas reserves and 97.2 percent of the gas production and purchases reported on FPC Form 15 for 1969. Revisions and additions to the gas reserves of the 24 major companies during 1969 declined from 9.3 to 6.3 trillion cubic feet. Annual volumes produced and purchased increased from 12.4 to 13.3 trillion cubic feet. A complete list of 65 companies is available in the FPC staff report, "The Gas Supplies of Interstate Natural Gas Pipeline Companies, 1969," which was released in March 1971. The following is a list of 24 companies that have over 900 billion cubic feet of domestic natural gas reserves:

Arkansas Louisiana Gas Co.
Cities Service Gas Co.
Colorado Interstate Gas Co.
Consolidated Gas Supply Corp.
El Paso Natural Gas Co.
Florida Gas Transmission Co.
Kansas-Nebraska Natural Gas Co., Inc.
Michigan Wisconsin Pipe Line Co.
Montana-Dakota Utilities Co.
Mountain Fuel Supply Co.
Natural Gas Pipeline Co. of America
Northern Natural Gas Co.
Panhandle Eastern Pipe Line Co.
South Texas Natural Gas Gathering Co.
Southern Natural Gas Co.
Tennessee Gas Pipeline Co. (Tenneco, Inc.)
Texas Eastern Transmission Corp.
Texas Gas Transmission Corp.
Transco Gas Pipe Line Corp.
Transwestern Pipeline Co.
Trunkline Gas Co.
United Fuel Gas Co.
United Gas Pipe Line Co.
West Texas Gathering Co.

	1966	1967	1968	1969	1970 p
Number of companies	67	68	64	65	66
Gas reserves at yearend:					
Company-owned	22.2	22.2	21.7	18.6	17.1
Independent producer contracts	176.2	179.9	177.0	172.9	156.4
Total	198.4	202.1	198.7	191.5	173.5
Annual production and purchases:					
Company-owned	1.0	1.0	1.1	1.1	1.0
Independent producer contracts	10.3	11.0	11.7	12.7	13.1
Total	11.3	12.0	12.8	13.8	14.1

p Preliminary.

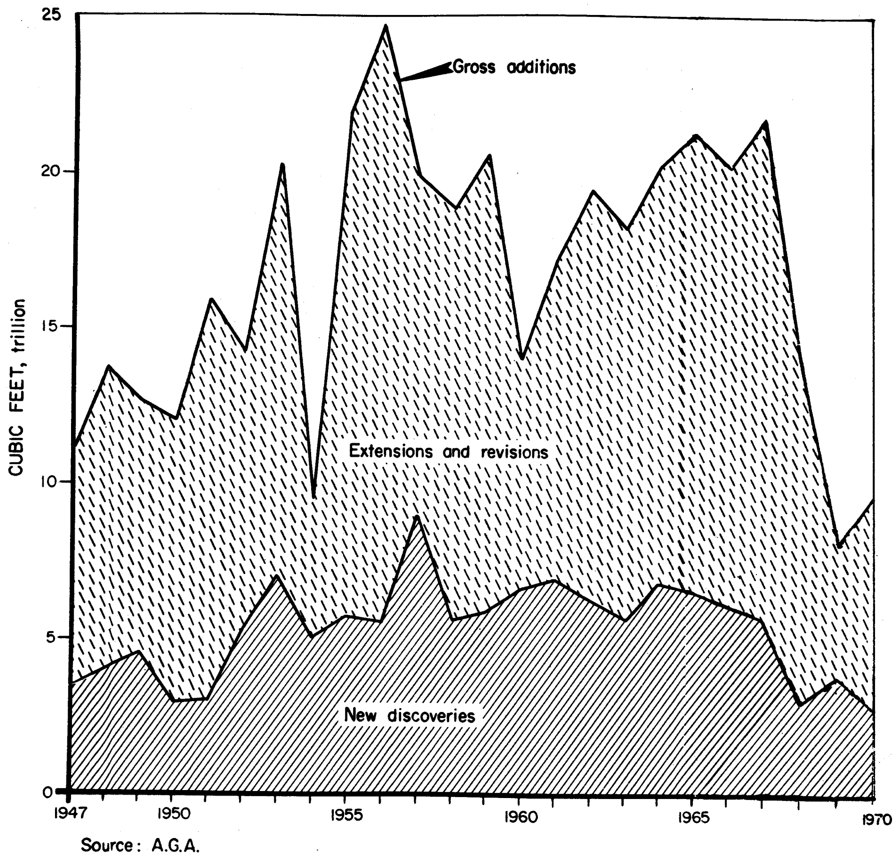

Figure 2.—Trends in annual gross additions to natural gas reserves.

PRODUCTIVE CAPACITY

The Natural Gas Reserves Committee of AGA has also prepared an estimate of daily productive capacity. As of December 31, 1970, it estimates a productive capacity in nonassociated gas as 79,528 Mmcf per day and in associated dissolved gas as 19,738 Mmcf. Total capacity was 99,266 Mmcf per day at yearend 1970 (table 9). This capacity is slightly lower than the 100,794 Mmcf per day as of December 31, 1969.

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 preceeding December 31.

The productive capacity of associated-dissolved gas is based on the productive capacity of crude oil and the estimated producing gas-oil ratios that would result from such capacity operation during the first 90 days of a given year.

The productive capacity of associated gas from gas wells is usually based on the volumetric withdrawal of crude oil from related oil wells at capacity rates during the first 90 days of a given year.[4]

STORAGE

The development of underground gas storage facilities expanded in 1970 at a slower pace than in 1969. About 251.2 billion cubic feet of capacity was added, which boosted the total to 5.178 trillion cubic feet by yearend 1970.

The ability to store gas in these underground facilities close to markets during off-season periods has been a major factor in the industry's growth. There were 325 pools in 26 States, and 83 companies were participating in such facilities at the end of 1970.

In addition to underground storage, there is the growth in aboveground storage for LNG. At present, most of this storage is associated with peak-shaving facilities of gas-distributing utilities and storage facilities for natural gas transmission pipelines. In the United States there were 31 of these installations either operating or under construction at the end of 1970. In addition, three companies were planning new facilities at yearend 1970.

The continued growth and expansion of the natural gas industry has created a need for large-volume storage near metropolitan areas to meet the winter peak loads. Requirements for natural gas on a peak winter day is currently about seven times that required on a summer day because of growth in use of natural gas for home heating. This places a heavy burden on a local gas utility to supply the gas when needed, particularly if there is a prolonged cold spell; hence, the growth in LNG facilities. The primary purpose of liquefaction is storage. By lowering the temperature at atmospheric pressure to minus 258°F (minus 161° C) it occupies only 1/620th of the space necessary for conventional vapor storage. Relatively small amounts of gas are liquefied over a long period and stored for use during peak winter loads. The regasification rate, how-

[4] American Petroleum Institute. Definitions for Petroleum Statistics. Tech. Prog. Rept. 1, 1st. ed., July 1, 1969, p. 14.

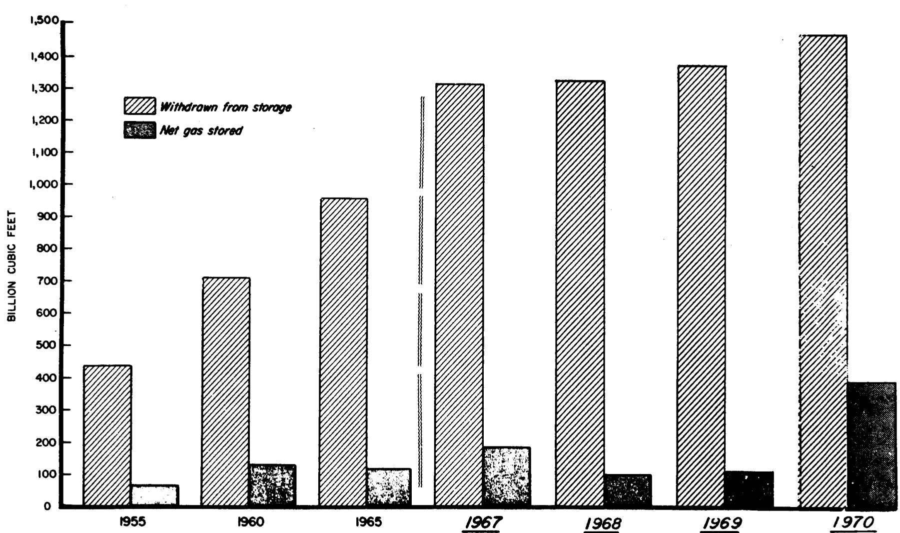

Figure 3.—Trends in net gas stored underground in U.S. storage fields.

ever, is high; in some instances, high enough to empty storage in 4 days. Conventional peak-shaving facilities are connected directly with long-distance natural gas-transmission lines, and there is an expanding interest in the import of LNG for base-load purposes on a commodity basis, and not a peak-shaving basis, such as the two cargoes of LNG shipped from Algeria to Boston Gas and the over-the-road deliveries from Canada to gas distributors in New England.

VALUE AND PRICE

The average value of natural gas at the wellhead increased 0.4 cent to 17.1 cents per Mcf. Prices at the wellhead, however, varied widely with the highest price in States near large consumer markets. In New York, for example, the wellhead price of natural gas per Mcf was 30.3 cents; in California, 32.1. Wellhead prices near the large eastern markets were 25.4 cents for West Virginia and 27.9 cents for Pennsylvania.

According to the FPC, the average wholesale prices charged by pipelines to distributing utility companies in 14 cities, as of July 1, 1970, were markedly higher than 1 year earlier. Increases ranged from 6.13 cents in Los Angeles to 0.13 cents in Philadelphia. Boston was the only one of 14 cities in which wholesale prices declined nominally. Most of the increases were subject to refund, contingent on the outcome of pending rate proceedings.

The specific charges in the 14 cities are as follows:

Average cents per Mcf (14.73 psia) charged by pipelines to distributors

Metropolitan area	7/1/69	7/1/70
Baltimore	41.58	[1] 44.37
Boston	[2] 69.21	[1] 68.39
Chicago [3]	29.12	[1] 33.31
Cleveland [3]	[2] 40.43	[1] 43.34
Detroit [3]	[2] 39.32	[1] 39.72
Los Angeles [3]	[2] 30.85	[1] 36.98
Minneapolis-St. Paul	36.72	36.29
Newark [3]	[2] 43.79	[1] 44.56
New York [3]	[2] 41.63	[1] 42.22
Philadelphia [3]	[2] 43.56	[1] 43.69
Pittsburgh [3]	[2] 38.64	[1] 40.24
St. Louis (Mo. portion only)	33.80	37.17
San Francisco—Oakland [3]	[2] 29.71	[1] 33.28
Washington, D.C.[3]	[2] 46.71	[1] 49.73

[1] Reflects rates in effect subject to refund.
[2] Reflects rates in effect subject to refund in pending rate cases.
[3] Wholesale service furnished by more than one pipeline company in 1969. Average prices are computed from the weighted average charges of all suppliers.

The average cost of natural gas, of course, varies widely because of transportation costs. In Maine, New Hampshire, and Vermont, for example, in 1970 the price to residential consumers was $1.985 per Mcf, compared with 92 cents per Mcf in Texas. In West Virginia, which is a producer of natural gas and which has an average wellhead price of 25.4 cents per Mcf, the price of gas to residential consumers is 89 cents per Mcf, or nearly the same paid by a residential user in Texas.

Cost to commercial consumers follow the same pattern as indicated with residential uses; that is, the highest prices are in New England and the lowest are in the West South-Central States of Arkansas, Louisiana, Oklahoma, and Texas. The average price of natural gas to commercial users in the latter region was 54 cents per Mcf in 1970. In New England a commercial user paid $1.53 cents per Mcf. Industrial accounts excluding the electric utilities averaged 101.0 cents per Mcf. In the West South Central Region the average was about 22.5 cents per Mcf. In this area, however, the low average price reflects sales of natural gas on an interruptible basis to industrial users. Gas purchased in an interruptible contract may be sold at substantial discounts compared with prices paid on firm contracts. In the East North-Central Region, however, even though volumes used for industrial purposes are the second largest in the Nation, there is less gas available for sale on an interruptible basis. Hence with this factor plus more distant sources of supply, the price per Mcf is more than double that for the West South-Central Region.

The total value of marketed production of natural gas was $3,745.7 million in 1970. This value was 8.4 percent higher than the wellhead value of $3,455.6 million for 1969 as shown in table 2.

The total value of the 22,045,799 Mmcf of natural gas was used in 1970 is estimated to be $11,825 million as indicated in table 6. This value was $1,056 million (or 9.8 percent) greater than in 1969.

FOREIGN TRADE

Exports of natural gas were to Japan, Mexico, and Canada. Japan provides the largest export market. The large-scale export of LNG began with one LNG tanker late in 1969 and reached full scale with two LNG tankers transporting gas to Japan after January 1970. During 1970, 44.3 billion cubic feet of natural gas was exported to Japan. Canada received 10.9 billion cubic feet; most of this gas left the United States at Detroit River, Mich. Exports to Mexico amounted to nearly 14.7 billion cubic feet in 1970, which was 9.7 percent greater than in 1969. Most of this gas leaves the United States at Laredo and El Paso, Tex. and at Naco, Ariz.

At present, most of the foreign trade relating to natural gas is in the form of imports from Canada and Mexico and exports to Japan. Imports from Canada have increased from 10.9 billion cubic feet in 1955 to 778.7 billion cubic feet in 1970, and the trend is still upward. In 1970, imports from Canada increased 98.6 billion cubic feet, or 14.5 percent compared with those of 1969.

About 527.7 billion cubic feet, or 68 percent, of Canadian imports enter the United States in the West; 22 percent at Sumas, Wash. and 45 percent at Eastport, Idaho. Another 172 billion entered the United States at Noyes, Minn. In addition, 78.7 billion cubic feet imported from Canada entered the United States at Massena and Niagara Falls, and Highgate Falls; also at Whitlash and Babb, Mont. This gas was imported to augment the supply of gas utility systems in upper New York State, Vermont, and in Montana.

The plan of El Paso Natural Gas to import into the United States from Algeria 1 billion cubic feet per day of LNG for 25 years is the most extensive program for LNG imports to date. The FPC is considering this request.

The FPC has granted approval to the proposal by Distrigas Corporation to import the equivalent of 15.4 billion cubic feet of LNG per year from Algeria over a 20-year period which was to begin in 1971.

In addition, the Columbia LNG Corporation filed with the FPC an application to import 425 Mmcf per day from Venezuela.

WORLD REVIEW

The United States, the Soviet Union, Canada, and the Netherlands lead the world in the production of natural gas. These four countries accounted for 32.4 trillion cubic feet, or 85.4 percent of the total world figure. Natural gas production in the Netherlands is increasing significantly. The main reason is that the gas reserves in the Groningen field are considered to be among the largest in the world. During 1970, production in the Netherlands totaled 1.1 trillion cubic feet, an increase of 345 billion cubic feet, or 45 percent. As a result of this increase in production, the Netherlands became the world's fourth largest producer of natural gas and Romania dropped into fifth position.

Concerning outlets, some of the Netherlands' gas is being exported to Belgium-Luxembourg, to West Germany, and to the United Kingdom. Also, Italy signed an agreement with the Netherlands in which Italy's State-owned company Ente Nazionale Idrocarburi (ENI) will buy 4,237.7 billion cubic feet over a 20-year period, beginning with 1974.

In the United Kingdom, development of gasfields in the North Sea has caused marketed natural gas production in 1970 to more than double that of 1969; from 178.7 billion cubic feet to 392 billion cubic feet. This gas has been rapidly absorbed into distribution channels. During 1970 the Gas Council of the United Kingdom has added about 493 miles of pipeline to the national distribution system, bringing that total to 1,565 miles. The United Kingdom's needs also are being supplied in part, at least, by LNG imported from Arzew, Algeria, to Canvey Island in the Thames Estuary.

Natural gas use is rapidly becoming an important factor in the energy patterns of many other nations since large gasfields have been found in the Soviet Union, Algeria, the United Arab Republic, Austria, Iran, Bolivia, Afghanistan, Pakistan, Canada, and France.

Next to Western Europe, gas usage in

the Soviet Union is growing faster than in any other part of the world. In 1970, the Soviet Union produced 7 trillion cubic feet of natural gas, which is five times the 1959 production. Soviet gas now flows into Eastern Europe and Austria. Austria is negotiating for increases in its purchases from the Soviet Union.

ENI signed an agreement with the Soviet Union in December 1969 for 110 billion cubic meters in 1970, or a total of 3,884.6 billion cubic feet over a 20-year period. The Soviet Union plans to sell natural gas to ENI, and in exchange will receive $200 million in Italian industrial products, primarily as large diameter steel pipe and related equipment. Beginning in 1973, ENI will receive 42.4 billion cubic feet of natural gas; by 1978 the Soviet Union is expected to export to Italy an average 211.8 billion cubic feet. Volumes are expected to build up gradually to possibly 353 billion cubic feet by 1980.

In February 1970 an agreement was signed with a West German company to import 1,836 billion cubic feet of natural gas from the Soviet Union. This gas would be imported over a 20-year period beginning in 1973.

Meanwhile, the Soviet Union has been importing natural gas from Afghanistan since 1967, and late in 1970, Iranian gas began to move into the U.S.S.R.

The Soviet Union plans to increase its initial 1971 importation goal of 211.8 billion cubic feet of Iranian gas to 353.3 billion cubic feet by 1975; the increase gradually reaching 535 billion cubic feet by 1980 and hold at that level until 1984. Deliveries from Afghanistan began in 1967. Cumulative delivery during the 25 year period is to reach 58 billion cubic meters, or 2,030 billion cubic feet, by 1992. Exports of the Soviet Union were estimated to have been about 68 billion cubic feet in 1970.

In Africa, the movement of LNG from Libya to Italy and Spain is another significant development. The Esso Standard Libya, Inc. project involves the sale of 245 million standard cubic feet per day of 1,350-Btu gas, which is the equivalent of 465 million standard cubic feet of 1,000 Btu gas per day. The gas is liquefied at Marsa el Brega, Libya, and then transported in LNG tankers to La Spezia, Italy, and Barcelona, Spain. Nearly all of the gas liquefied is gas associated with oil from the Zelton and Reguba fields in the Libyan Desert.

Table 14 offers both gross production and marketed production of natural gas by countries. Gross production includes natural gas which is vented and/or flared. As shown, the volumes of natural gas flared is large. The widening demand for natural gas world-wide, however, suggest that growth in the amount of gas flared will be arrested significantly in the foreseeable future.

Table 2.—Quantity and value of marketed production of natural gas in the United States

State	1969			1970		
	Quantity (million cubic feet) [1]	Value (thousands)	Average wellhead value, cents per Mcf	Quantity (million cubic feet) [1]	Value (thousands)	Average wellhead value, cents per Mcf
Alabama	180	$24	13.4	627	$87	13.9
Alaska	50,864	12,665	24.9	111,576	27,448	24.6
Arizona	1,136	199	17.5	1,101	188	17.1
Arkansas	169,257	26,743	15.8	181,351	29,560	16.3
California	677,689	207,440	30.6	649,117	208,367	32.1
Colorado	118,754	17,219	14.5	105,804	15,553	14.7
Florida	50	8	15.7	----------	----------	----------
Illinois	3,800	536	14.1	4,850	761	15.7
Indiana	171	40	23.6	153	36	23.7
Kansas	883,156	122,759	13.9	899,955	125,994	14.0
Kentucky	81,304	20,407	25.1	77,892	19,161	24.6
Louisiana	7,227,826	1,387,743	19.2	7,788,276	1,503,137	19.3
Maryland	978	248	25.4	813	202	24.9
Michigan	36,163	9,294	25.7	38,851	10,373	26.7
Mississippi	131,234	23,097	17.6	126,031	23,190	18.4
Missouri	126	17	13.8	87	21	24.5
Montana	41,229	4,205	10.2	42,705	4,399	10.3
Nebraska	6,989	1,209	17.3	5,991	1,024	17.1
New Mexico	1,138,133	155,924	13.7	1,138,980	162,874	14.3
New York	4,861	1,458	30.0	3,358	1,017	30.3
North Dakota	33,587	5,441	16.2	34,889	5,722	16.4
Ohio	49,793	12,837	25.8	52,113	14,123	27.1
Oklahoma	1,523,715	233,128	15.3	1,594,943	248,811	15.6
Pennsylvania	79,134	21,841	27.6	76,841	21,439	27.9
Tennessee	57	11	19.6	64	13	19.9
Texas	7,853,199	1,075,888	13.7	8,357,716	1,203,511	14.4
Utah	46,733	7,197	15.4	42,781	6,460	15.1
Virginia	2,846	845	29.7	2,805	864	30.8
West Virginia	231,759	62,575	27.0	242,452	61,583	25.4
Wyoming	303,517	44,617	14.7	338,520	49,762	14.7
Total	20,698,240	3,455,615	16.7	21,920,642	3,745,680	17.1

[1] Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

Table 3.—Marketed production, interstate shipments, and total consumption of natural gas in the United States in 1970

(Million cubic feet)

State by 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	------------	159,916	97,541	62,375	------------	1,801	60,574
Maine, New Hampshire, and Vermont	------------	12,801	1,916	10,885	------------	194	10,691
Massachusetts	------------	184,738	36,489	148,249	200	742	147,307
Rhode Island	------------	102,880	76,820	26,060	------------	967	25,093
Total	------------	460,335	212,766	247,569	200	3,704	243,665
Middle Atlantic:							
New Jersey	------------	850,669	516,649	334,020	439	10,728	322,853
New York	3,358	979,735	245,028	734,707	6,261	20,919	710,885
Pennsylvania	76,841	2,107,804	1,344,650	763,154	88,988	−21,460	772,467
Total	80,199	3,938,208	2,106,327	1,831,881	95,688	10,187	1,806,205
East North Central:							
Illinois	4,850	2,368,114	1,099,907	1,268,207	78,193	6,821	1,188,043
Indiana	153	1,905,929	1,344,232	561,697	10,025	6,457	545,368
Michigan	38,851	791,773	10,643	781,130	27,127	−18,600	811,454
Ohio	52,113	2,922,669	1,927,523	995,146	9,338	−15,012	1,052,933
Wisconsin	------------	369,637	20,620	349,017	------------	11,195	337,822
Total	95,967	8,358,122	4,402,925	3,955,197	124,683	−9,139	3,935,620
West North Central:							
Iowa	------------	1,385,306	1,023,394	361,912	4,233	9,017	348,662
Kansas	899,955	2,106,380	2,375,467	−269,087	5,898	10,433	614,537
Minnesota	------------	526,913	181,757	345,156	------------	2,834	342,322
Missouri	87	1,729,750	1,292,000	437,750	1,213	7,098	429,526
Nebraska	5,991	1,401,041	1,197,396	203,645	−782	−12,472	222,890
North Dakota	34,889	8,899	7,264	1,635	------------	−683	37,207
South Dakota	------------	46,551	9,392	37,159	------------	840	36,319
Total	940,922	7,204,840	6,086,670	1,118,170	10,562	17,067	2,031,463
South Atlantic:							
Delaware	------------	28,913	2,014	26,899	−211	689	26,421
Florida	------------	335,829	------------	335,829	------------	−2,816	338,645
Georgia	------------	1,451,528	1,114,192	337,336	------------	4,810	332,526
Maryland and District of Columbia	813	893,459	705,782	187,677	2,352	4,003	182,135
North Carolina	------------	928,285	773,117	155,168	------------	3,941	151,227
South Carolina	------------	1,092,190	928,285	163,905	------------	4,075	159,830
Virginia	2,805	1,022,945	883,702	139,243	1,982	3,543	136,523
West Virginia	242,452	1,374,977	1,391,586	−16,609	24,430	9,073	192,340

Total	246,070	7,128,126	5,798,678	1,329,448	28,553	27,318	1,519,647
East South Central:							
Alabama	627	3,331,382	3,036,629	294,753	566	−3,908	298,722
Kentucky	77,892	3,841,778	3,653,585	188,193	10,376	1,087	254,622
Mississippi	126,031	6,427,316	6,179,522	247,794	3,910	8,263	361,652
Tennessee	64	4,104,085	3,840,823	263,262		7,178	256,148
Total	204,614	17,704,561	16,710,559	994,002	14,852	12,620	1,171,144
West South Central:							
Arkansas	181,351	2,875,836	2,658,022	217,814	206	13,773	385,186
Louisiana	7,788,276	1,242,036	6,911,945	−5,669,909	62,510	21,808	2,034,049
Oklahoma	1,594,943	1,544,187	2,454,115	−909,928	11,416	17,504	656,095
Texas	8,357,716	554,406	4,299,426	−3,745,020	−924	54,247	4,559,373
Total	17,922,286	6,216,465	16,323,508	−10,107,043	73,208	107,332	7,634,703
Mountain:							
Arizona	1,101	1,501,765	1,307,787	193,978		2,083	192,996
Colorado	105,804	300,071	120,686	179,385	3,127	−3,671	285,733
Idaho		462,158	414,340	47,818		1,248	46,570
Montana	42,705	90,179	27,412	62,767	10,476	4,173	90,823
Nevada		53,293		53,293		735	52,558
New Mexico	1,138,980	897,881	1,707,781	−810,400	157	5,673	322,750
Utah	42,781	261,741	179,333	82,408	108	1,651	123,430
Wyoming	338,520	87,625	293,278	−205,653	3,181	6,827	122,859
Total	1,669,891	3,654,213	4,050,617	−396,404	17,049	18,719	1,237,719
Pacific:							
Alaska	111,576		44,257	−44,257		[1] 3,329	63,990
California	649,117	1,566,146		1,566,146	28,025	30,871	2,156,367
Oregon		395,557	296,839	98,718		3,434	95,284
Washington		533,744	376,204	157,540	5,340	2,208	149,992
Total	760,693	2,495,447	717,300	1,778,147	33,365	39,842	2,465,633
Total United States	21,920,642	[2] 57,160,317	[3] 56,409,350	750,967	398,160	227,650	22,045,799

[1] Liquefied natural gas.

[2] Includes receipts from Canada of 353,640 million cubic feet into Idaho, 174,098 million cubic feet into Washington, 172,219 million cubic feet into Minnesota, 42,560 million cubic feet into Montana, 33,638 million cubic feet into New York, 2,532 million cubic feet into Vermont, and from Mexico 41,336 million cubic feet into Texas. LNG imports of 757 million cubic feet into Massachusetts.

[3] Includes deliveries into Canada of 10,643 million cubic feet from Michigan, 126 million cubic feet from New York, 109 million cubic feet from Montana, and into Mexico 10,634 million cubic feet from Texas and 4,044 million cubic feet from Arizona, also 44,257 million cubic feet from Alaska to Japan (LNG).

Table 4.—Quantity and value of natural gas delivered to

State and region	Residential			Commercial		
	Number of consumers (thousands)	Quantity (million cubic feet) [3]	Value (thousands)	Number of consumers (thousands)	Quantity (million cubic feet) [3]	Value (thousands)
New England:						
Connecticut	369	31,187	$59,630	28	10,918	$17,338
Maine, New Hampshire, and Vermont	75	5,247	10,420	5	2,747	4,259
Massachusetts	990	82,646	158,598	63	30,040	45,330
Rhode Island	152	11,940	21,874	7	3,890	5,936
Total	1,586	131,020	250,522	103	47,595	72,863
Middle Atlantic:						
New Jersey	1,583	140,219	264,733	172	54,105	77,695
New York	3,862	346,533	484,453	271	114,081	143,514
Pennsylvania	2,214	297,022	367,416	141	90,162	88,719
Total	7,659	783,774	1,116,602	584	258,348	309,928
East North Central:						
Illinois	2,739	439,152	459,353	205	187,037	142,335
Indiana	996	158,699	160,286	103	74,659	62,340
Michigan	1,901	340,033	345,133	160	130,589	109,956
Ohio	2,444	459,972	413,975	188	162,710	125,612
Wisconsin	759	105,208	131,194	62	42,069	41,059
Total	8,839	1,503,064	1,509,941	718	597,064	481,302
West North Central:						
Iowa	568	96,219	92,948	70	56,352	39,052
Kansas	596	97,317	66,662	57	45,777	21,973
Minnesota	603	101,764	111,533	53	50,688	40,449
Missouri	981	156,571	150,934	87	72,597	50,019
Nebraska	318	58,295	49,609	49	35,571	21,520
North Dakota	50	8,186	8,382	7	7,745	5,437
South Dakota	74	13,784	14,335	10	9,148	6,248
Total	3,190	532,136	494,403	333	277,878	184,698
South Atlantic:						
Delaware	78	7,843	12,431	5	2,804	3,491
Florida	345	14,702	36,961	28	21,302	23,240
Georgia	730	87,359	91,552	54	35,622	26,396
Maryland and District of Columbia	816	86,811	126,310	64	33,051	37,711
North Carolina	279	27,353	35,559	38	15,143	16,627
South Carolina	211	18,930	25,612	26	12,577	11,759
Virginia	451	49,554	73,835	46	24,641	25,577
West Virginia	350	57,973	51,654	29	18,382	13,087
Total	3,260	350,525	453,914	290	163,522	157,888
East South Central:						
Alabama	537	55,779	63,030	39	35,368	21,398
Kentucky	523	86,473	71,600	50	33,970	23,269
Mississippi	328	36,642	32,392	39	19,295	11,886
Tennessee	391	46,571	42,473	51	39,392	28,874
Total	1,779	225,465	209,495	179	128,025	85,427
West South Central:						
Arkansas	376	59,792	45,083	51	37,149	19,949
Louisiana	834	86,148	66,679	74	34,733	17,783
Oklahoma	632	77,460	65,144	68	38,661	20,568
Texas	2,612	232,189	213,846	242	94,471	52,998
Total	4,454	455,589	390,752	435	205,014	111,298
Mountain:						
Arizona	417	29,679	35,585	38	17,267	11,776
Colorado	542	82,595	59,386	69	57,635	33,140
Idaho	68	7,711	10,726	11	5,851	5,933
Montana	136	24,794	22,513	18	15,520	10,228
Nevada	69	7,262	10,944	4	5,224	4,853
New Mexico	229	30,771	28,551	24	16,642	10,501
Utah	236	44,637	37,941	16	10,164	6,007
Wyoming	75	17,984	12,265	11	12,123	5,698
Total	1,772	245,433	217,911	191	140,426	88,136
Pacific:						
Alaska	15	6,211	9,435	4	6,374	6,323
California	5,608	552,544	544,256	356	203,699	150,104
Oregon	180	19,742	29,830	25	10,394	13,970
Washington	262	31,929	44,796	35	18,236	20,315
Total	6,065	610,426	628,317	420	238,703	190,712
Total United States	38,604	4,837,432	5,271,857	3,253	2,056,575	1,682,252

[1] Includes refinery fuel use of 1,028,794 million cubic feet.
[2] Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.
[3] Quantities at 14.73 psia.
[4] Includes 85,884 million cubic feet used for carbon black production.
[5] Source: Federal Power Commission.

consumers, by type of consumer and by State in 1970

Industrial [1]		Electric utilities		Other consumers [2]		Total	
Quantity (million cubic feet) [3 4]	Value (thousands)	Quantity (million cubic feet) [3 5]	Value (thousands)	Quantity (million cubic feet) [3]	Value (thousands)	Quantity (million cubic feet) [3]	Value (thousands)
14,690	$15,336	147	$51	3,582	$4,008	60,524	$96,363
2,224	1,896	----------	----------	473	364	10,691	16,939
22,513	23,414	5,711	1,930	5,316	4,779	146,226	234,051
5,743	4,973	2,319	922	1,174	1,527	25,066	35,232
45,170	45,619	8,177	2,903	10,545	10,678	242,507	382,585
80,178	55,804	45,560	18,270	1,848	1,639	321,910	418,141
115,047	79,958	106,141	40,864	25,417	22,469	707,219	771,258
337,773	197,935	9,337	3,996	9,177	7,140	743,471	665,206
532,998	333,697	161,038	63,130	36,442	31,248	1,772,600	1,854,605
380,464	190,993	132,329	47,638	6,397	2,527	1,145,379	842,846
268,394	127,219	29,571	10,320	2,891	2,194	534,214	362,359
290,413	155,371	32,163	13,605	2,119	1,437	795,317	625,502
372,968	216,321	21,449	8,622	20,702	14,409	1,037,801	778,939
141,250	77,970	30,242	12,944	12,486	4,433	331,255	267,600
1,453,489	767,874	245,754	93,129	44,595	25,000	3,843,966	2,877,246
99,152	36,389	77,726	21,452	914	344	330,363	190,185
163,395	44,607	168,139	49,601	6,855	1,940	481,483	184,783
97,906	40,925	58,617	15,182	25,897	12,793	334,872	220,882
109,464	44,114	63,104	16,659	15,047	4,920	416,783	266,646
54,838	17,548	47,593	12,755	11,253	3,218	207,550	104,650
1,782	700	362	132	570	327	18,645	14,978
6,800	2,217	4,364	1,458	2,213	976	36,309	25,234
533,337	186,500	419,905	117,239	62,749	24,518	1,826,005	1,007,358
12,030	7,050	3,744	1,419	----------	----------	26,421	24,391
92,334	36,010	198,273	72,370	5,612	1,706	332,223	170,287
140,891	58,188	58,674	17,250	3,104	2,244	325,650	195,630
44,008	30,101	11,436	3,762	4,478	4,039	179,784	201,923
75,065	38,433	21,126	8,049	6,389	4,083	145,076	102,751
78,698	36,437	45,081	17,086	1,273	549	156,559	91,443
44,572	22,598	4,276	1,274	5,449	3,367	128,492	126,651
90,474	41,437	705	231	3,296	2,215	170,830	108,624
578,072	270,254	343,315	121,441	29,601	18,203	1,465,035	1,021,700
170,937	57,264	15,444	4,216	886	413	278,414	146,321
72,524	35,174	8,533	2,492	8,491	5,061	209,991	137,596
135,379	40,614	97,287	26,657	4,551	1,984	293,154	113,533
121,880	47,533	17,253	4,399	3,328	1,571	228,424	124,850
500,720	180,585	138,517	37,764	17,256	9,029	1,009,983	522,300
152,580	43,485	107,797	27,488	2,020	640	359,338	136,645
995,158	239,833	330,648	72,081	35,588	8,861	1,482,275	405,237
119,844	30,321	234,749	46,480	5,260	2,372	475,974	164,885
1,789,533	375,802	1,059,816	266,014	51,619	13,318	3,227,628	921,978
3,057,115	689,441	1,733,010	412,063	94,487	25,191	5,545,215	1,628,745
57,732	25,229	58,878	21,667	5,438	2,572	168,994	96,829
84,788	23,571	51,275	11,998	1,446	536	277,739	128,631
28,805	12,847	----------	----------	----------	----------	42,367	29,506
36,105	12,240	2,529	703	3,044	1,248	81,992	46,932
10,327	5,804	25,336	10,464	4,409	2,429	52,558	34,494
73,078	19,439	54,934	17,744	16,393	5,229	191,818	81,464
62,484	18,495	3,513	1,012	16	11	120,814	63,466
50,079	12,470	2,373	543	1,903	424	84,462	31,400
403,398	130,095	198,838	64,131	32,649	12,449	1,020,744	512,722
14,744	6,310	8,198	3,074	6,145	2,249	41,672	27,391
618,647	250,552	636,257	220,145	6,246	2,804	2,017,393	1,167,861
57,664	27,909	1,010	388	966	550	89,776	72,647
93,147	37,352	----------	----------	254	118	143,566	102,581
784,202	322,123	645,465	223,607	13,611	5,721	2,292,407	1,370,480
7,888,501	2,926,188	3,894,019	1,135,407	341,935	162,037	19,018,462	11,177,741

Table 5.—Interstate pipeline movements of natural gas in the United States in 1970

(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	62.4	N. Y.	137.1	Mass.	22.8			R. I.	97.5				
Maine, New Hampshire, Vermont	10.9	Mass.	8.4	Canada	2.5								
Massachusetts	148.2	N. Y.	107.2	R. I.	76.8	Algeria	.8	Conn.	22.8	N. H.	8.4	R. I.	5.3
Rhode Island	26.1	Conn.	97.5	Mass.	5.3			Mass.	76.8				
Total [1]	247.6	N. Y.	244.3	Canada	2.5	Algeria	.8						
Middle Atlantic:													
New Jersey	334.0	Pa.	850.2	N. Y.	.5			N. Y.	516.6				
New York	734.7	N. J.	516.6	Pa.	429.4	Canada	33.6	Conn.	137.1	Mass.	107.2	N. J.	.5
								Pa.	.2	Canada	.1		
Pennsylvania	763.3	W. Va.	811.0	Md.	705.8	Ohio	590.9	N. J.	850.2	N. Y.	429.4	Del.	28.9
		N. Y.	.2					Ohio	16.8	W. Va.	11.5	Md.	7.8
Total [1]	1,831.9	W. Va.	799.5	Md.	698.0	Ohio	574.1	Conn.	137.1	Mass.	107.2	Del.	28.9
		Canada	33.6					Canada	.1				
East North Central:													
Illinois	1,268.2	Mo.	1,085.9	Iowa	657.4	Ky.	457.5	Ind.	906.9	Wis.	193.0		
		Ind.	167.4										
Indiana	561.7	Ky.	999.0	Ill.	906.9			Ohio	1,086.7	Ill.	167.4	Mich.	90.2
Michigan	781.1	Ohio	680.9	Ind.	90.2	Wis.	20.6	Canada	10.6				
Ohio	995.1	Ky.	1,493.4	Ind.	1,086.7	W. Va.	325.7	Mich.	680.9	W. Va.	655.7	Pa.	590.9
		Pa.	16.8										
Wisconsin	349.0	Ill.	193.0	Minn.	176.7			Mich.	20.6				
Total [1]	3,955.2	Ky.	2,949.9	Mo.	1,085.9	Iowa	657.4	Pa.	574.1	W. Va.	330.0	Canada	10.6
		Minn.	176.7										
West North Central:													
Iowa	361.9	Nebr.	1,183.3	Mo.	201.6	S. Dak.	.4	Ill.	657.4	Minn.	354.3	S. Dak.	11.7
Kansas	−269.1	Okla.	2,102.5	Mo.	3.9			Nebr.	1,370.5	Mo.	916.0	Colo.	59.0
								Okla.	30.0				
Minnesota	345.2	Canada	172.2	Iowa	354.3	S. Dak.	.4	Wis.	176.7	N. Dak.	5.1		
Missouri	437.8	Kans.	916.0	Ark.	813.7	Okla.	.1	Ill.	1,085.9	Iowa	201.6	Kans.	3.9
								Ark.	.6				
Nebraska	203.6	Kans.	1,370.5	Wyo.	22.9	Colo.	7.6	Iowa	1,183.3	S. Dak.	11.3	Colo.	2.8
North Dakota	1.6	Minn.	5.1	Mont.	3.8			Mont.	7.3				
South Dakota	37.2	Mont.	23.5	Iowa	11.7	Nebr.	11.3	Mont.	8.1	Wyo.	.5	Iowa	.4
								Minn.	.4				
Total [1]	1,118.2	Okla.	2,072.6	Ark.	813.1	Canada	172.2	Ill.	1,743.3	Wis.	176.7	Colo.	54.2
		Wyo.	22.4	Mont.	11.9								

South Atlantic:													
Delaware	26.9	Pa.	28.9					Md.	2.0				
Florida	335.8	Ala.	326.3	Ga.	9.5								
Georgia	337.3	Ala.	1,451.5					S. C.	1,092.2	Tenn.	12.5	Fla.	9.5
Maryland and District of Columbia	187.7	Va.	879.6	Pa.	7.8	W. Va.	4.1	Pa.	705.8				
		Del.	2.0										
North Carolina	155.2	S. C.	928.3					Va.	773.1				
South Carolina	163.9	Ga.	1,092.2					N. C.	928.3				
Virginia	139.2	N. C.	773.1	W. Va.	242.8	Tenn.	7.0	Md.	879.6	W. Va.	4.1		
West Virginia	−16.6	Ky.	703.7	Ohio	655.7	Pa.	11.5	Pa.	811.0	Ohio	325.7	Va.	242.8
		Va.	4.1					Ky.	7.9	Md.	4.1		
Total [1]	1,329.4	Ala.	1,777.8	Ky.	695.8	Ohio	330.0	Pa.	1,468.6	Tenn.	5.5		
East South Central:													
Alabama	294.8	Miss.	3,331.4					Ga.	1,451.5	Tenn.	1,243.8	Fla.	326.3
								Miss.	15.0				
Kentucky	188.2	Tenn.	3,833.8	W. Va.	7.9			Ohio	1,493.4	Ind.	999.0	W. Va.	703.7
								Ill.	457.5				
Mississippi	247.8	La.	4,574.2	Ark.	1,838.2	Ala.	15.0	Ala.	3,331.4	Tenn.	2,847.8	La.	.4
Tennessee	263.3	Miss.	2,847.8	Ala.	1,243.8	Ga.	12.5	Ky.	3,833.8	Va.	7.0		
Total [1]	994.0	La.	4,573.8	Ark.	1,838.2			Ohio	1,493.4	Ga.	1,439.0	Ind.	999.0
								W. Va.	695.8	Ill.	457.5	Fla.	326.3
								Va.	7.0				
West South Central:													
Arkansas	217.8	La.	2,083.6	Tex.	641.9	Okla.	149.7	Miss.	1,838.2	Mo.	813.7	Tex.	5.8
		Mo.	.6					La.	.5				
Louisiana	−5,669.9	Tex.	1,241.2	Ark.	.5	Miss.	.4	Miss.	4,574.2	Ark.	2,083.6	Tex.	254.1
Oklahoma	−909.9	Tex.	1,514.2	Kans.	30.0			Kans.	2,102.5	Ark.	149.7	Colo.	107.0
								Tex.	94.8	Mo.	.1		
Texas	−3,745.0	La.	254.1	N. Mex.	158.4	Okla.	94.8	Okla.	1,514.2	La.	1,241.2	N. Mex.	891.5
		Mexico	41.3	Ark.	5.8			Ark.	641.9	Mexico	10.6		
Total [1]	−10,107.0	Mexico	41.3					Miss.	6,412.0	Kans.	2,072.5	Mo.	813.2
								N. Mex.	733.1	Colo.	107.0	Mexico	10.6
Mountain:													
Arizona	194.0	N. Mex.	1,495.9	Utah	5.9			Calif.	1,270.6	Nev.	27.2	N. Mex.	5.9
								Mexico	4.0				
Colorado	179.4	Okla.	107.0	Wyo.	77.9	Kans.	59.0	Utah	101.5	Wyo.	11.6	Nebr.	7.6
		N. Mex.	53.5	Nebr.	2.8								
Idaho	47.8	Canada	353.6	Utah	97.9	Wash.	10.6	Wash.	358.3	Ore.	30.0	Nev.	26.1
Montana	62.8	Canada	42.6	Wyo.	32.3	S. Dak.	8.1	S. Dak.	23.5	N. Dak.	3.8	Canada	.1
		N. Dak.	7.3										
Nevada	53.3	Ariz.	27.2	Idaho	26.1								
New Mexico	−810.4	Tex.	891.5	Ariz.	5.9			Ariz.	1,495.9	Tex.	158.4	Colo.	53.5
Utah	82.4	Wyo.	160.2	Colo.	101.5			Idaho	97.9	Wyo.	75.5	Ariz.	5.9
Wyoming	−205.7	Utah	75.5	Colo.	11.6	S. Dak.	.5	Utah	160.2	Colo.	77.9	Mont.	32.3
								Nebr.	22.9				
Total [1]	−396.4	Tex.	733.1	Canada	396.2	Okla.	107.0	Calif.	1,270.6	Wash.	347.7	Nebr.	27.7
		Kans.	59.0	N. Dak.	3.5			S. Dak.	14.9	Ore.	30.0	Mexico	4.0
								Canada	.1				

See footnotes at end of table.

Table 5.—Interstate pipeline movements of natural gas in the United States in 1970—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
Pacific:													
Alaska	−44.3	-------	-------	-------	-------	-------	-------	Japan	44.3	-------	-------	-------	-------
California	1,566.1	Ariz.	1,270.6	Ore.	295.5	-------	-------	-------	-------	-------	-------	-------	-------
Oregon	98.7	Wash.	365.6	Idaho	30.0	-------	-------	Calif.	295.5	Wash.	1.3	-------	-------
Washington	157.5	Idaho	358.3	Canada	174.1	Ore.	1.3	Ore.	365.6	Idaho	10.6	-------	-------
Total [1]	1,778.1	Ariz.	1,270.6	Idaho	377.7	Canada	174.1	Japan	44.3	-------	-------	-------	-------
Total United States [1]	751.0	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Foreign:													
Canada	----------	-------	778.7	-------	-------	-------	-------	-------	10.9	-------	-------	-------	-------
Mexico	----------	-------	41.3	-------	-------	-------	-------	-------	14.6	-------	-------	-------	-------
Japan	----------	-------	-------	-------	-------	-------	-------	-------	[2] 44.3	-------	-------	-------	-------
Algeria	----------	-------	[2] .8	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

[1] Data may not add to totals shown because of independent rounding.
[2] Liquefied natural gas.

Table 6.—Consumption of natural gas by use and by State in 1970

State and region	Delivered to consumers: Quantity (million cubic feet) [1]	Delivered to consumers: Value (thousands)	Extraction loss: Quantity (million cubic feet) [1]	Extraction loss: Value (thousands)	Lease and plant fuel: Quantity (million cubic feet) [1]	Lease and plant fuel: Value (thousands)	Pipeline fuel: Quantity (million cubic feet) [1]	Pipeline fuel: Value (thousands)	Total: Quantity (million cubic feet) [1]	Total: Value (thousands)
New England:										
Connecticut	60,524	$96,363	---	---	---	---	50	$16	60,574	$96,379
Maine, New Hampshire and Vermont	10,691	16,939	---	---	---	---	---	---	10,691	16,939
Massachusetts	146,226	234,051	---	---	---	---	1,081	342	147,307	234,393
Rhode Island	25,066	35,232	---	---	---	---	27	9	25,093	35,241
Total	242,507	382,585	---	---	---	---	1,158	367	243,665	382,952
Middle Atlantic:										
New Jersey	321,910	418,141	---	---	---	---	943	210	322,853	418,351
New York	707,219	771,258	---	---	485	$229	3,181	744	710,885	772,231
Pennsylvania	743,471	665,206	79	$24	2,251	1,033	26,666	6,720	772,467	672,983
Total	1,772,600	1,854,605	79	24	2,736	1,262	30,790	7,674	1,806,205	1,863,565
East North Central:										
Illinois	1,145,379	842,846	14,165	2,805	526	126	27,973	5,790	1,188,043	851,567
Indiana	534,214	362,359	---	---	---	---	11,154	2,398	545,368	364,757
Michigan	795,317	625,502	2,330	603	3,440	574	10,367	2,841	811,454	629,520
Ohio	1,037,801	778,939	---	---	3,140	986	11,992	2,746	1,052,933	782,671
Wisconsin	331,255	267,600	---	---	---	---	6,567	1,609	337,822	269,209
Total	3,843,966	2,877,246	16,495	3,408	7,106	1,686	68,053	15,384	3,935,620	2,897,724
West North Central:										
Iowa	330,363	190,185	---	---	---	---	18,299	3,166	348,662	193,351
Kansas	481,483	184,783	38,843	6,176	20,841	4,272	73,370	13,060	614,537	208,291
Minnesota	334,872	220,882	---	---	---	---	7,450	1,833	342,322	222,715
Missouri	416,783	266,646	---	---	---	---	12,743	2,663	429,526	269,309
Nebraska	207,550	104,650	555	95	1,650	328	13,135	2,036	222,890	107,109
North Dakota	18,645	14,978	4,490	871	14,067	2,194	5	1	37,207	18,044
South Dakota	36,309	25,234	---	---	---	---	10	2	36,319	25,236
Total	1,826,005	1,007,358	43,888	7,142	36,558	6,794	125,012	22,761	2,031,463	1,044,055
South Atlantic:										
Delaware	26,421	24,391	---	---	---	---	---	---	26,421	24,391
Florida	332,223	170,287	1,829	483	234	43	4,359	8,631	338,645	179,444
Georgia	325,650	195,630	---	---	---	---	6,876	1,348	332,526	196,978
Maryland and District of Columbia	179,784	201,923	---	---	319	152	2,032	392	182,135	202,467
North Carolina	145,076	102,751	---	---	---	---	6,151	1,156	151,227	103,907
South Carolina	156,559	91,443	---	---	---	---	3,271	677	159,830	92,120
Virginia	128,492	126,651	---	---	252	80	7,779	1,556	136,523	128,287
West Virginia	170,830	108,624	11,062	2,876	2,551	712	7,897	2,535	192,340	114,747
Total	1,465,035	1,021,700	12,891	3,359	3,356	987	38,365	16,295	1,519,647	1,042,341

See footnote at end of table.

Table 6.—Consumption of natural gas by use and by State in 1970—Continued

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)
East South Central:										
Alabama	278,414	$146,321	225	$44	214	$79	19,869	$3,954	298,722	$150,398
Kentucky	209,991	137,596	6,574	1,256	2,317	459	35,740	7,184	254,622	146,495
Mississippi	293,154	113,533	1,270	262	7,893	1,326	59,335	11,748	361,652	126,869
Tennessee	228,424	124,850	---------	---------	1,265	320	26,459	5,239	256,148	130,409
Total	1,009,983	522,300	8,069	1,562	11,689	2,184	141,403	28,125	1,171,144	554,171
West South Central:										
Arkansas	359,338	136,645	3,235	731	9,184	1,736	13,429	2,552	385,186	141,664
Louisiana	1,482,275	405,237	193,209	55,258	287,222	53,423	71,343	14,055	2,034,049	527,973
Oklahoma	475,974	164,885	58,926	11,432	98,417	14,861	22,778	4,054	656,095	195,232
Texas	3,227,628	921,978	466,016	138,873	769,500	130,046	96,229	16,648	4,559,373	1,207,545
Total	5,545,215	1,628,745	721,386	206,294	1,164,323	200,066	203,779	37,309	7,634,703	2,072,414
Mountain:										
Arizona	168,994	96,829	---------	---------	50	7	23,952	3,976	192,996	100,812
Colorado	277,739	128,631	3,405	654	2,726	357	1,863	335	285,733	129,977
Idaho	42,367	29,506	---------	---------	---------	---------	4,203	937	46,570	30,443
Montana	81,992	46,932	3,032	449	5,091	651	708	77	90,823	48,109
Nevada	52,558	34,494	---------	---------	---------	---------	---------	---------	52,558	34,494
New Mexico	191,818	81,464	52,647	9,055	47,998	5,808	30,287	5,028	322,750	101,355
Utah	120,814	63,466	1,493	272	633	101	490	105	123,430	63,944
Wyoming	84,462	31,400	12,863	2,277	19,625	2,787	5,909	999	122,859	37,463
Total	1,020,744	512,722	73,440	12,707	76,123	9,711	67,412	11,457	1,237,719	546,597
Pacific:										
Alaska	41,672	27,391	264	65	4,748	945	17,306	4,448	63,990	32,849
California	2,017,393	1,167,861	29,901	11,303	92,119	26,438	16,954	4,866	2,156,367	1,210,468
Oregon	89,776	72,647	---------	---------	---------	---------	5,508	1,212	95,284	73,859
Washington	143,566	102,581	---------	---------	---------	---------	6,426	1,401	149,992	103,982
Total	2,292,407	1,370,480	30,165	11,368	96,867	27,383	46,194	11,927	2,465,633	1,421,158
Total United States	19,018,462	11,177,741	906,413	245,864	1,398,758	250,073	722,166	151,299	22,045,799	11,824,977

[1] Quantities at 14.73 psia.

Table 7.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States, by States

(Million cubic feet at 14.73 psia at 60° F unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand barrels)[1]	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
1969										
Arkansas	1,971	56,190	3,475	4,564	524	7	29,002	18,607	11	52,715
California and Alaska	21,262	455,692	30,522	25,764	116,371	312	199,645	80,415	2,663	425,170
Colorado	2,858	85,171	4,058	3,277	6,517	107	71,079	169	−36	81,113
Kansas	24,429	1,493,907	35,813	8,571	1,238	84	1,392,782	55,776	−357	1,458,094
Kentucky and Illinois	14,227	478,291	22,004	3,024	----------	----------	449,708	2,868	687	456,287
Louisiana	125,432	4,465,379	179,117	66,001	91,590	3,667	3,560,950	564,611	−557	4,286,262
Michigan	2,118	143,802	2,705	2,178	16,549	----------	122,370	----------	----------	141,097
Mississippi and Alabama	1,254	57,208	1,570	1,931	10,286	46	41,723	1,479	173	55,638
Montana and Utah	2,794	57,793	4,117	5,147	21,989	883	25,738	----------	−81	53,676
Nebraska	536	6,415	598	438	195	----------	4,959	----------	225	5,817
New Mexico	33,973	1,079,492	50,484	49,696	4,003	13,516	777,589	176,737	7,467	1,029,008
North Dakota	2,459	37,818	4,707	3,908	7,906	84	19,367	295	1,551	33,111
Oklahoma	41,925	1,167,150	57,270	51,320	80,813	991	845,775	129,028	1,953	1,109,880
Pennsylvania	57	1,708	93	9	76	----------	1,530	----------	----------	1,615
Texas	291,227	7,613,234	447,325	345,966	983,638	21,635	5,024,396	748,455	41,819	7,165,909
West Virginia and Florida	6,767	185,937	10,162	981	26	----------	172,443	2,325	----------	175,775
Wyoming	6,951	269,921	12,540	9,001	15,101	562	220,493	13,120	−896	257,381
Total	580,240	17,655,108	866,560	581,776	1,356,822	41,894	12,959,549	1,793,885	54,622	16,788,548
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	988,971	19,798	4,904,368	1,054,582	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	1,400,627	27,805	13,413,929	2,125,457	60,894	17,602,896

[1] 42-gallons.

Table 8.—Estimated proved recoverable reserves of natural gas in the United States as of December 31, 1970

(Million cubic feet at 14.73 psia at 60° F)

State	Nonassociated	Associated-dissolved	Underground storage [1]	Total
Alabama	152,521	9,488	----------	162,009
Alaska	4,740,760	26,389,991	----------	31,130,751
Arkansas	2,413,572	130,905	36,197	2,580,674
California [2]	2,553,760	3,545,431	200,568	6,299,759
Colorado	1,473,138	131,390	24,318	1,628,846
Illinois	911	12,509	401,994	415,414
Indiana	1,580	4,233	76,861	82,674
Kansas	12,905,008	323,421	96,662	13,325,091
Kentucky	803,708	50,428	123,706	977,842
Louisiana [2]	67,761,928	15,057,199	137,561	82,956,688
Michigan	211,134	112,530	616,007	939,671
Mississippi	1,101,209	223,653	9,043	1,333,905
Montana	793,283	141,854	164,786	1,099,923
Nebraska	23,887	18,660	15,621	58,168
New Mexico	10,670,444	2,615,209	4,370	13,290,023
New York	22,635	129	103,197	125,961
North Dakota	5,593	561,761	----------	567,354
Ohio	420,234	137,221	436,003	993,458
Oklahoma	13,469,170	3,263,649	221,448	16,954,267
Pennsylvania	779,409	13,134	584,959	1,377,502
Texas [2]	77,717,675	28,541,957	93,361	106,352,993
Utah	625,153	438,587	1,420	1,065,160
Virginia	32,511	----------	----------	32,511
West Virginia	2,002,320	57,978	376,080	2,436,378
Wyoming	3,399,271	800,288	43,772	4,243,331
Other States [3]	17,738	62,324	235,993	316,055
Total	204,098,552	82,643,929	4,003,927	290,746,408

[1] Gas held in underground reservoirs (including native and net injected gas) for storage purposes.
[2] Includes offshore reserves. The remaining proved natural gas reserves in the Gulf of Mexico are estimated to be 37,781,044 million cubic feet, of which 32,093,379 million cubic feet are nonassociated, and 5,687,665 million cubic feet are associated-dissolved. As of this date the ultimate recoverable natural gas reserves in the Gulf of Mexico are estimated to be 54,519,911 million cubic feet, of which 45,430,264 million cubic feet are nonassociated, and 9,089,647 million cubic feet are associated-dissolved.
[3] Includes Arizona, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 9.—Estimated productive capacity of natural gas in the United States, December 31, 1970

(Million cubic feet per day)

State	Productive capacity			State	Productive capacity		
	Nonassociated	Associated-dissolved	Total		Nonassociated	Associated-dissolved	Total
Alabama	24	3	27	New Mexico	2,925	1,312	4,237
Alaska	600	105	705	New York	7	--------	7
Arkansas	700	85	785	North Dakota	1	109	110
California [1]	1,604	994	2,598	Ohio	210	35	245
Colorado	407	41	448	Oklahoma	8,547	2,028	10,575
Illinois	--------	7	7	Pennsylvania	214	2	216
Indiana	--------	3	3	Texas [1]	27,578	9,177	36,755
Kansas	7,934	313	8,247	Utah	127	51	178
Kentucky	190	8	198	Virginia	8	--------	8
Louisiana [1]	25,803	4,872	30,675	West Virginia	875	5	880
Michigan	184	57	241	Wyoming	1,020	318	1,338
Mississippi	377	147	524	Other States [2]	7	6	13
Montana	173	51	224				
Nebraska	13	9	22	Total	79,528	19,738	99,266

[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 10.—Underground storage statistics, December 31, 1970

(Million cubic feet at 14.73 psia at 60° F)

State	Number of pools	Number of wells	Total gas in storage reservoirs (million cubic feet)	Total reservoir capacity (million cubic feet)
Arkansas	6	27	12,523	42,510
California	6	160	125,213	288,339
Colorado	5	47	15,065	27,410
Illinois	27	1,217	389,440	656,864
Indiana	26	808	60,943	147,961
Iowa	5	227	135,236	186,200
Kansas	16	744	82,787	106,084
Kentucky	19	943	46,984	133,948
Louisiana	4	100	108,808	183,165
Maryland	1	59	26,443	64,770
Michigan	30	2,217	355,624	726,106
Minnesota	1	25	2,060	2,060
Mississippi	3	25	8,543	9,884
Missouri	1	70	27,453	45,000
Montana	5	130	125,048	178,552
Nebraska	1	15	4,562	39,270
New Mexico	1	22	----------	52,150
New York	15	723	94,972	110,171
Ohio	21	2,816	354,650	501,117
Oklahoma	11	187	200,043	317,025
Pennsylvania	65	2,139	565,226	710,038
Texas	17	171	66,298	115,126
Utah	1	8	1,420	1,447
Washington	1	51	12,344	34,426
West Virginia	33	1,190	354,290	419,830
Wyoming	4	12	30,837	78,628
Total	325	14,133	3,206,812	5,178,081

Source: American Gas Association.

Table 11.—Gas wells and condensate wells in the United States

State	Completed during 1969 [1]	Completed during 1970 [1]	Producing Dec. 31, 1970 [2]
Alabama	1	5	2
Alaska	11	5	51
Arizona	2	----------	17
Arkansas	40	36	1,008
California	59	56	[3] 980
Colorado	47	47	861
Illinois	5	5	8
Indiana	7	4	50
Kansas	184	108	8,660
Kentucky	142	111	[3] 6,913
Louisiana	543	539	9,690
Maryland	----------	----------	16
Michigan	15	19	1,235
Mississippi	16	12	[3] 325
Missouri	----------	----------	[3] 11
Montana	31	74	739
Nebraska	1	2	35
New Mexico	263	159	[3] 8,848
New York	12	17	600
North Dakota	----------	1	29
Ohio	395	683	[3] 7,789
Oklahoma	397	321	8,168
Pennsylvania	277	250	16,239
Tennessee	7	4	15
Texas	903	774	23,417
Utah	16	10	173
Virginia	----------	----------	[3] 115
West Virginia	652	553	20,702
Wyoming	57	45	[3] 800
Total	4,083	3,840	117,496

[1] From data compiled by the American Association of Petroleum Geologists and American Petroleum Institute.
[2] Data from State sources except as noted by footnote 3.
[3] Information obtained from World Oil.

Table 12.—Natural gas stored and withdrawal statistics

(Million cubic feet at 14.73 psia)

State	1969			1970		
	Total stored	Total withdrawn	Net stored	Total stored	Total withdrawn	Net stored
Alabama	577	435	142	1,153	587	566
Arkansas	1,168	507	661	1,467	1,261	206
California	77,617	64,590	13,027	80,260	52,235	28,025
Colorado	8,663	8,128	535	8,757	5,630	3,127
Delaware	179	878	−699	391	602	−211
Illinois	153,497	105,337	48,160	190,661	112,468	78,193
Indiana	26,483	22,385	4,098	35,065	25,040	10,025
Iowa	43,037	45,343	−2,306	46,301	42,068	4,233
Kansas	50,772	50,140	632	52,966	47,068	5,898
Kentucky	31,726	27,966	3,760	38,968	28,592	10,376
Louisiana	58,753	43,521	15,232	110,680	48,170	62,510
Maryland	5,281	9,417	−4,136	10,421	8,069	2,352
Massachusetts	314	567	−253	770	570	200
Michigan	257,737	260,981	−3,244	344,524	317,397	27,127
Mississippi	7,493	8,398	−905	12,489	8,579	3,910
Missouri	9,044	9,909	−865	10,957	9,744	1,213
Montana	20,409	10,854	9,555	20,891	10,415	10,476
Nebraska	4,838	3,526	1,312	3,074	3,856	−782
New Jersey	1,281	1,075	206	1,447	1,008	439
New Mexico	383	165	218	398	241	157
New York	41,874	39,148	2,726	45,802	39,541	6,261
Ohio	168,142	172,078	−3,936	182,405	173,067	9,338
Oklahoma	53,945	37,786	16,159	57,142	45,726	11,416
Pennsylvania	244,892	240,373	4,519	335,966	246,978	88,988
Texas	33,943	30,582	3,361	36,805	37,729	−924
Utah	580	367	213	547	439	108
Virginia	2,143	134	2,009	2,175	193	1,982
Washington	1,827	735	1,092	6,688	1,348	5,340
West Virginia	183,114	181,142	1,972	209,292	184,862	24,430
Wyoming	6,695	3,021	3,674	8,305	5,124	3,181
Total	1,496,407	1,379,488	116,919	1,856,767	1,458,607	398,160

Table 13.—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]
1969						
Alaska	77,816	71,831	149,647	50,864	66,240	32,543
Arkansas	119,230	56,105	175,335	169,257	4,752	1,326
California	294,026	473,316	767,342	677,689	86,579	3,074
Colorado	92,133	31,204	123,337	118,754	3,257	1,326
Illinois	158	3,735	3,893	3,800	----------	93
Indiana	171	----------	171	171	----------	----------
Kansas	744,631	142,972	887,603	883,156	1,781	2,666
Kentucky	81,086	218	81,304	81,304	----------	----------
Louisiana	6,305,897	1,255,130	7,561,027	7,227,826	174,349	158,852
Maryland	978	----------	978	978	----------	----------
Michigan	22,285	16,405	38,690	36,163	1,719	808
Mississippi	133,105	35,609	168,714	131,234	29,383	8,097
Montana	37,163	30,901	68,064	41,229	377	26,458
Nebraska	4,739	2,677	7,416	6,989	427	----------
New Mexico	837,521	305,073	1,142,594	1,138,133	403	4,058
New York	4,861	----------	4,861	4,861	----------	----------
North Dakota	127	56,415	56,542	33,587	----------	22,955
Ohio	38,540	11,253	49,793	49,793	----------	----------
Oklahoma	1,356,766	384,911	1,741,677	1,523,715	87,196	130,766
Pennsylvania	763	78,683	79,446	79,134	312	----------
Texas	6,800,882	2,113,912	8,914,794	7,853,199	950,096	111,499
Utah	21,510	53,657	75,167	46,733	25,632	2,802
Virginia	2,846	----------	2,846	2,846	----------	----------
West Virginia	229,815	2,556	232,371	231,759	612	----------
Wyoming	280,572	62,426	342,998	303,517	21,849	17,632
Other States [3]	1,794	791	2,585	1,549	241	795
Total	17,489,415	5,189,780	22,679,195	20,698,240	1,455,205	525,750
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

[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, and Tennessee.

Table 14.—Natural gas: Production, by countries

(Million cubic feet)

Country [1]	1968		1969		1970 [p]	
	Gross production [2]	Marketed production [3]	Gross production [2]	Marketed production [3]	Gross production [2]	Marketed production [3]
North America:						
Barbados	97	[r] 88	108	[r] 91	116	[e] 100
Canada	1,993,312	1,692,301	2,288,046	1,977,838	[e] 2,656,000	2,295,278
Mexico	576,871	[r] 370,687	609,056	417,085	665,026	481,106
Trinidad	151,445	67,300	137,503	69,297	121,060	66,687
United States	21,325,000	19,322,400	22,698,240	20,698,240	23,786,453	21,920,642
South America:						
Argentina	249,486	188,806	247,294	188,133	270,683	212,452
Bolivia	32,683	2,684	28,409	3,920	29,000	[e] 4,000
Brazil	34,726	[e] 7,000	44,080	[e] 8,000	44,602	[e] 8,000
Chile	246,784	68,298	263,790	79,952	269,392	94,325
Colombia	95,357	38,247	103,882	44,767	104,894	46,736
Ecuador	5,837	[e] 500	5,849	[e] 500	10,176	[e] 500
Peru	75,792	16,803	74,452	17,453	75,182	16,822
Venezuela	1,634,602	301,197	1,673,013	314,092	1,710,200	348,630
Europe:						
Austria	57,567	56,356	52,379	50,331	67,027	66,992
Bulgaria	[4] 17,875	17,875	[4] 18,537	18,537	[e] [4] 19,000	[e] 19,000
Czechoslovakia	39,799	29,735	41,989	31,606	[e] 43,000	[e] 33,000
France	304,376	197,832	346,223	229,756	[e] 360,000	243,000
Germany, West	229,119	224,000	314,722	310,732	446,987	[e] 440,000
Hungary [5]	[4] 94,890	94,890	[4] 114,242	114,242	[4] 122,506	122,506
Italy	[4] 367,744	367,744	[4] 422,335	422,335	[4] 463,953	463,953
Netherlands	498,429	487,093	773,176	762,687	1,118,375	1,107,427
Poland [6]	[4] 90,334	90,334	[r] 138,503	138,503	[4] 183,014	183,014
Romania	[4] 767,618	767,618	[4] 843,064	843,064	[4] 875,443	875,443
U.S.S.R. [7]	[e] 6,420,000	6,032,211	[e] 6,860,000	6,456,903	[e] 7,520,000	7,063,000
United Kingdom	[4] 71,351	71,351	[4] 178,673	178,673	[4] 391,958	391,958
Yugoslavia	[4] 20,651	20,651	[4] 25,784	25,784	[4] 34,502	34,502
Africa:						
Algeria	[e] 340,000	93,654	350,000	105,520	[e] 340,000	102,377
Angola	[e] 4,000	185	[e] 14,000	766	28,749	[e] 1,500
Congo (Brazzaville)	[e] 239	(8)	[e] 121	97	[e] 96	[e] 36
Gabon	[e] 900	881	900	847	1,900	762
Libya	620,000	(8)	666,525	(8)	[e] 710,000	(8)
Morocco	[4] 382	382	[4] 1,484	1,484	[4] 1,539	1,539
Nigeria	51,628	5,190	145,714	2,252	285,804	3,920
Tunisia	[4] 334	334	[4] 329	329	[4] 316	316
United Arab Republic	[e] 19,000	1,978	[e] 28,000	2,507	[e] 37,000	[e] 3,000
Asia:						
Afghanistan	[4] 59,364	59,364	[4] 71,653	71,653	[e] [4] 72,000	[e] 72,000
Bahrain	[e] 33,000	[e] 9,500	33,440	10,906	25,406	12,305
Brunei	113,555	8,662	123,266	7,655	126,654	7,965
Burma	[4] 388	388	[4] 2,900	2,900	[4] 3,400	[e] 3,400
India	[e] 50,000	21,330	[e] 55,000	25,744	50,288	23,873
Indonesia	116,025	24,067	[e] 110,000	[e] 30,161	108,435	27,649
Iran	802,490	55,534	892,583	98,201	1,094,194	396,333
Iraq	[e] 194,000	27,293	[e] 196,000	31,617	[e] 200,000	27,720
Israel	[4] 5,015	5,015	[4] 4,873	4,873	[4] 4,753	4,753
Japan	72,617	71,077	77,890	76,173	83,311	[9] 82,682
Kuwait [10]	480,007	175,774	514,563	191,627	569,680	203,782
Oman	[e] 14,000	(8)	[e] 20,000	(8)	[e] 20,000	(8)
Pakistan [11]	[4] 91,525	91,525	[4] 116,921	116,921	[4] 133,856	133,856
Qatar	79,605	23,030	125,687	37,290	127,000	[e] 39,000
Saudi Arabia [10]	574,490	78,429	637,689	93,758	710,939	103,182
Taiwan	[4] 24,877	24,877	[4] 31,553	31,553	[4] 32,400	32,400
Trucial States:						
Abu Dhabi	191,691	21,167	233,841	23,740	266,200	26,700
Dubai	----------	----------	[e] 3,000	(8)	[e] 25,000	(8)
Oceania:						
Australia	[4] 216	216	[4] 9,375	9,375	[4] 53,061	53,061
New Zealand	[4] 3	3	[4] 2	2	[4] 3,769	3,769
Total	39,341,096	31,333,856	42,770,658	34,380,472	46,504,299	37,906,953

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Albania, mainland China, Cuba, East Germany, Malaysia (Sarawak), Mongolia, Spain, Syrian Arab Republic, and Thailand 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 mainland 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] Available statistics used for both gross and marketed output comprise marketable production plus gas used for repressuring, but exclude 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.

[6] Marketed production reported includes gas produced from coal mines as follows in million cubic feet: 1968, 6; 1969, 9; 1970, not available.

[7] Marketed production reported includes gas produced from coal and oil shale as follows in million cubic feet: 1968, 60; 1969, 61; 1970, 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 one-half 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 William B. Harper [1] and Leonard L. Fanelli [2]

Production of natural gas liquids and natural gas reached new highs in 1970. The output of natural gas liquids at gas-processing plants rose to 605.9 million barrels, or 26 million barrels above the preceding year. Also, the value of output in 1970 rose to $1,275 million, which was $173 million, or 15.7 percent higher than the 1969 values shown in table 12.

Natural gas liquids are products obtained from natural gasoline plants, cycling plants, and fractionators after processing the natural gas. Included are ethane, the liquefied petroleum (LP) gases (butane, propane, and butane-propane mixtures), isobutane, and other mixed gases. Also included in the output of these plants are natural gasolines, plant condensate, and finished products such as gasoline, special naphthas, jet fuel, kerosine, distillate fuel oil, and other finished products.

Increased availability of ethane for chemical manufacture at prices well below propane, plus an expansion in ethylene-producing capacity, has resulted in a rapid growth in ethane production over the past decade—from 14,575,000 barrels in 1960 to 73,434,000 barrels in 1970. In fact, ethane production, shown in table 1, is the fastest growing segment of the five components in the natural gas liquids group. Since 1965, ethane recovery from natural gas has been growing at an annual rate of 18.4 percent.

Although production of LP gases increased, the slowdown in business, coupled with a milder 1969–70 winter, reduced demand particularly for propane. As a result, inventories climbed rapidly. Prices of LP gases recovered from the depressed levels of 1969.

The data presented in this chapter compiled from reports submitted by natural gasoline plants, cycling plants, and fractionators that handle natural gas liquids, and include all natural gas liquids except the small volume recovered at pipeline compressor stations and gas dehydration plants. Such recovery is considered to be of little significance in the national and State totals. Plant condensate is included in the category of natural gas liquids, as is ethane and liquefied gases such as butane and propane, which are recovered in certain refinery processes. Field condensate, however, is reported with crude oil and is excluded from the total for natural gas liquids.

Annual reports were received from all producers and large 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.

Full details on sales of LP gases and ethane have been published by the Bureau of Mines.[3]

For the purpose of this chapter, liquefied gases and ethane, whether obtained from natural gas or from processing in refineries, 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 Natural Gas Processors Association (NGPA) specifications for commercial and HD–5 propane.

Butane-Propane.—Includes all products covered by NGPA specifications for commercial butane mixtures.

Butane.—Includes all products covered by NGPA specifications for commercial butane, except those that contain 80 percent or more isobutane.

Isobutane.—Includes all products covered

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[2] Survey statistician, Division of Fossil Fuels.
[3] U.S. Bureau of Mines. Sales of Liquefied Petroleum Gases and Ethane in 1970. Mineral Industry Survey, 1971, 12 pp.

by NGPA specifications for commercial butane that contains 80 percent or more isobutane.

Isopentane.—Includes segregated isopentane.

Natural Gasoline.—Breakdown by various Reid vapor pressure classifications indicated.

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 shipment 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.

Recovery of finished petroleum products defined on the first page of this chapter is small in terms of volume and values; only 1.5 percent of the yield at natural gas processing plants and less than 2.5 percent of the value.

These finished small quantities of petroleum products, such as gasoline, naphthas, kerosine, distillate fuel oil and jet fuel, lose identity as "natural gas liquids" by being absorbed into the supply stream. But information on production and on stocks is available in the Minerals Yearbook Chapter, "Crude Petroleum and Petroleum Products," in the table captioned "Salient Statistics of the major refined products in the United States." Also, these data are identified as to origin, such as "at refineries or at gas processing plants," in table 2 of the Monthly Petroleum Statement, a Mineral Industry Survey published regularly by the Bureau of Mines.

Districts.—Production of natural gas liquids is reported by States, although data for Louisiana and Texas are also reported by districts.

Louisiana is divided into an Inland district and a Gulf Coast district. The Gulf Coast district includes Veron, 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 grouping of the 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).

Refineries are also grouped by the Bureau of Mines into a set of refining districts. These refining districts may be combined to correspond with the Petroleum Administration for Defense districts.

PAD *district* — *Refining districts*

I—*East Coast*—District of Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, 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, Galveston, Waller, Fort Bend, Brazoria, Wharton, Harris, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.

PAD district	Refining districts

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 Mobil and Baldwin Counties, Alabama.

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 Mountains*—Montana, Idaho, Wyoming, Utah, and Colorado.

V—*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 figure 2 of the Crude Petroleum and Petroleum Products chapter of this volume.

Legislation and Government Programs.—The Oil Import Administration (see bulletin 6) in the Code of Federal Regulations, title 32A—chapter 10, provided that on and after October 1, 1970, ethane, propane, and butane produced in the Western Hemisphere, from Western Hemisphere crude or gas, may be imported into the United States, without being subject to import quotas.

DOMESTIC PRODUCTION

Growth in the production of natural gas, coupled with a continued rise in ethylene production, resulted in further increases in the recovery of natural gas liquids in 1970. Production in the United States of natural gas liquids at natural gas processing plants, totaled 605.9 million barrels in 1970, a 4.4-percent increase over 1969 production (as shown in table 2).

The chart (figure 2) illustrates the rela-

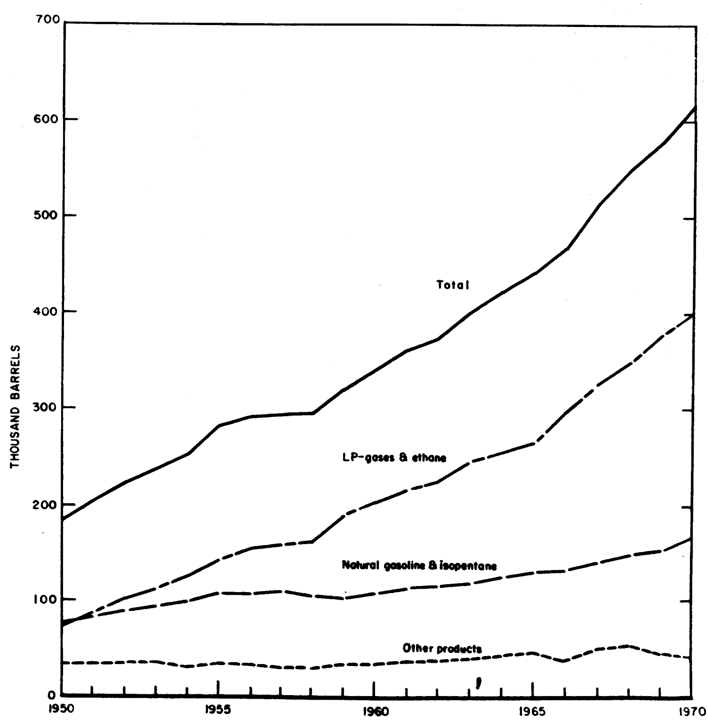

Figure 1.—Production of natural gas liquids in the United States.

tive importance, percentagewise, of the principal components of natural gas liquids. As shown in figure 2, the LP gases account for more than half, 54 percent, of natural gas liquids, and production at natural gas processing plants increased to 326.2 million barrels in 1970, or about 3.4 percent more than in 1969. Propane production totaled 202.5 million barrels for a 3.6-percent rise. Production of the butanes totaled 123.7 million barrels, an increase of 2.9 percent. In 1970 propane accounted for 62 percent of the LP gases produced; the butanes and butane propane mixtures, 38 percent, as shown in table 3.

Natural gasolines made up 27 percent of natural gas liquids. During 1970, production rose to 161.3 million barrels, an increase of 4.4 percent over that of 1969. (See table 4.)

Ethane production at gas processing plants amounted to 12 percent of the natural gas liquids volume and in 1970 aggregated 73.4 million barrels, a volume 16.5 percent greater than that in 1969 (table 2). Ethane production has been growing at a rate of 13.9 percent annually since 1960. This is a faster rate than any other segment of the natural gas liquids group. This growth is readily understandable because ethylene productive capacity has been expanding markedly, along with natural gas production. Also, ethane recovery per cubic foot of gas processed has increased impressively.

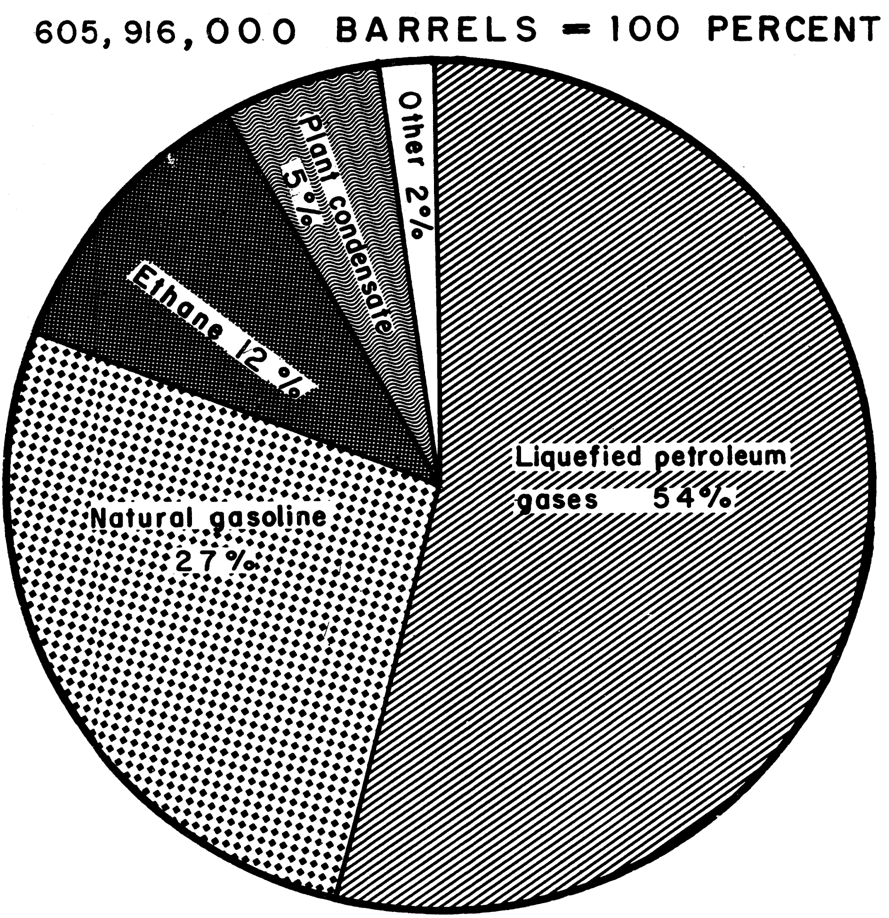

Figure 2.—The relative importance of natural gas liquids, 1970.

CONSUMPTION AND USES

The volume of natural gas liquids shipped to refineries for blending and processing increased in 1970 to 278.3 million barrels, or about 5 percent above the 1969 levels (as shown in table 5). Included in the natural gas liquids-for-blending category are natural gasoline, LP gas, and condensate. Condensate used at refineries for blending purposes declined to 32.0 million barrels, a volume 7 percent below shipments to refineries in 1969. Refinery inputs of LP gas increased in 1970, in the use of isobutane and the butane-propane mixes.

Nearly six out of each 10 barrels of blending materials used at refineries in 1970 was natural gasoline. During the year, 160.3 million barrels were used by refiners, as indicated in the tabulation below:

	1969	1970	Percent change
Natural gasoline	153,698	160,316	+4.3
Plant condensate	34,427	32,012	−7.0
LP gases	72,764	80,307	+10.4
Total	260,889	272,635	+4.5

Data on the production, shipments, and stocks at natural gas processing plants is shown by month, in table 2. Also shown in this table are data on 9.3 million barrels of finished petroleum products; 59 percent of this segment consists of motor gasoline. Production, shipments, and stocks at processing plants of jet fuel, distillate fuel oil, kerosine, and special naphthas as well as gasoline are also shown in table 2.

Excluding use at refineries, domestic demand for butane and propane for fuels and chemicals and ethane for chemicals aggregated 325.4 million barrels, or slightly below use in 1969. The use of propane and butane for chemical manufacture declined as prices stiffened, but ethane, which is more attractive from a cost standpoint, soon filled the supply gap as shown in the following table:

	1969	1970	Increase	
			Volume	Percent
Ethane	63.1	74.3	+11.2	+17.7
Propane	209.7	200.8	−8.9	−4.2
Butane	53.4	50.3	−3.1	−5.8
Total	326.2	325.4	−0.8	−0.2

Ethane is used primarily as the feedstock for which ethylene is produced. Between 1960 and 1970, the recovery of ethane from natural gas at gas processing plants has grown from 14,575,000 million barrels per year to 73.4 million in 1970, a growth rate for the decade of 13.9 percent. According to the United States Tariff Commission, at the same time, ethylene production from all sources has increased from 5,860 million pounds in 1960 to more than 18,500 million in 1970.

A general slowdown in business, a milder winter in 1969–70, and decreased use of propane as a petrochemical feedstock for ethylene manufacture resulted in propane sales decreasing from 293.8 million in 1969 to 282.3 million barrels in 1970, or nearly 4 percent, as shown in table 7. In addition to ethane, propane is used extensively as a raw material to obtain ethylene, propylene, acetylene chemicals, and other chemicals.

Sales of LP gases for residential and commercial use receded from 182.3 million barrels in 1969 to 180.2 million in 1970, or about 1 percent.

Residential and commercial use (shown in table 7) includes private households and nonmanufacturing organizations such as retail stores, restaurants, hotels, and service companies. The category includes space heating, water heating, and cooking and accounts for six out of every 10 barrels of propane consumed. In terms of LP gas use, propane accounts for 92 percent of LP gas shipments for residential and commercial use. Detailed data on shipments of LP gas by end use in 1970 are available in the Bureau of Mines Mineral Industry Survey, "Sales of Liquefied Petroleum Gases and Ethane in 1970."

Sales of LP gas for use in internal combustion engines declined from a high of 34.9 billion barrels in 1969 to 31.8 million in 1970, or nearly 9 percent.

In the butanes category, demand for isobutane, similar to 1969, was in strong demand in 1970. Production at gas processing plants and refineries totaled 32.3 million barrels, an increase of 12.8 percent (see table 1). Demand in gasoline manufacture, for chemicals such as butadiene, exceeded production. As a result, by the end of 1970, stocks of isobutane had dropped to 5.6 million barrels, or 8 percent. The principal use of the butanes—both normal and isobutane—is for gasoline blending. Some refining processes such as hydrocracking, yield propane, normal butane, and isobutane. Hence, as capacity for hydrocracking expands, so will output of LP gases at petroleum refineries. Between the end of 1964 and 1970, hydrocracking capacity has expanded from 105,550 barrels per day to 731,505 barrels per day, a growth rate of 38 percent according to the annual refining capacity surveys of the Oil and Gas Journal.

RESERVES

The downtrend in well drilling resumed in 1970 after a brief respite in 1969. Withdrawals of natural gas exceeded, by a wide margin, additions to proved natural gas reserves. As a result, reserves decreased. Likewise, proved reserves of natural gas liquids at the end of 1970 totaled 7,702,941,000 barrels, which was 440.2 million barrels, or 5.4 percent below the 1969 level, as indicated in table 9.

Estimates by the American Gas Association (AGA) Committee on Natural Gas Reserves indicated that declines in the proved reserves of 16 States, including California, Louisiana, and Texas, more than offset increases in Alabama, Kansas, Michigan, Mississippi, West Virginia, and Wyoming. It should be noted that, for the first time, the AGA included, in estimates for 1970, natural gas reserves for the Prudhoe Bay Permo Triassic reservoir (North Slope) in Alaska. These estimates were for associated-dissolved gas reserves but no accompanying natural gas liquids reserves were attributed in the North Slope discoveries in the 1970 report.

PRODUCTIVE CAPACITY

The AGA Committee on Natural Gas Reserves estimated that the productive capacity of natural gas liquids in the United States was 3,105,000 barrels per day at the end of 1970. This estimate, about 56,000 barrels per day less than in 1969, reflects declines in the productive capacities of Oklahoma and Texas, which more than offset the increases in the capacities of Kansas and Louisiana. The productive capacities of natural gas liquids in 20 States are shown in table 10.

The productive capacity of natural gas liquids is defined as the amount of hydrocarbon liquids that would be produced coincidental with the estimated productive capacity of natural gas. At the same time, it should be recognized that these estimates, which are based on the unit recoveries of natural gas at normal producing rates, are purely theoretical. There are two reasons for this: First, the estimates relate to increased production of gas from oil and gas wells operating at their productive capacities. (Actually, many wells are operating at rates below these capacities because of the absence of surface facilities.) Secondly, State production regulations may be a restrictive factor not taken into account when the estimates are made.

Capacity of natural gas processing plants has expanded markedly over the past 6 years. Between 1964 and 1970, for example, the capacity of gas processing plants has grown from 55.7 billion cubic feet per day to 74.2 billion, an average annual growth rate of 4.9 percent. According to the annual survey of the Oil and Gas Journal, between 1969 and 1970 capacity increased 6.3 billion cubic feet per day, or 9.2 percent.

Nearly all this growth occurred in Alaska, Colorado, Mississippi, Utah, Louisiana and, to a lesser extent, in Wyoming, Florida, Oklahoma, New Mexico, and Kansas. Conversely, there have been decreases in the volumes of natural gas processed in Arkansas, California, Michigan, Montana, Nebraska, North Dakota, Pennsylvania, Texas, and West Virginia. Comparisons of operating capacities as of the end of 1964 and of 1970, are as follows in billions of cubic feet:

	1964	1970	Percent change
Number of plants	839	833	−0.7
Capacity	55.7	74.2	+33.2

STOCKS

Stocks at gas processing plants and refineries of liquefied petroleum gas, exclusive of ethane, increased from 57.4 million barrels at the end of 1969 to 65.7 million by the end of 1970, an increase of 8.3 million, or 14 percent. Most of the change, as indicated in table 1, occurred in propane where stocks increased 8.6 million barrels or 25 percent. The combined stocks of the butanes, both normal and isobutane, which aggregated 22.2 million barrels at yearend 1969, had been reduced about 747,000 barrels, or 3.4 percent, by the end of 1970 (see table 1).

As a result of a mild winter and a general slowdown in business, inventories of propane have built up to record highs. Stocks of isobutane at natural gas processing plants declined from 6,854,000 barrels in 1969 to 5,355,000 barrels at the end of 1970 because demands for chemical use and refinery use were greater than production.

PRICES AND VALUE

The value per barrel of natural gas liquids increased markedly in 1970 as a sharp rise in prices of LP gases more than offset a decrease in the prices of natural gasoline, gasoline, naphthas, and other products. The overall price of the five segments in the natural gas liquids category rose from $1.90 per barrel to $2.10, or 10.5 percent. The sharpest increase occurred in LP gases and ethane, as indicated in table 12. The volumes of LP gases and ethane expanded 5.6 percent and the aggregate value of production gained 34.7 percent, resulting in a 27.3-percent increase in the unit value of LP gases and ethane.

Since there is no spot market for ethane, most of price increase occurred in the LP gases. Propane prices, for example, rose sharply. The Oklahoma price of propane averaged 5.58 cents per gallon, which was 1.66 cents above the 1969 average, as shown in table 14. As shown in the following tabulation, the average prices paid by farmers in the United States in 1970 averaged 14.7 cents per gallon, but this number conceals the broad range of prices. About half of the farms in the United States use LP gas. Thirteen thousand farms in New England used LP gas; the average price paid was 21.5 cents per gallon. At the other end of the spectrum, the average price paid at 408,000 farms in the west north-central region was 13.6 cents.

The following prices paid by U.S. farmers for LP gas apply to tank cars and transport trucks.

Division	Farms using LP gas (thousands)	Average price per gallon (cents)
New England	13	21.5
Middle Atlantic	46	19.6
East north-central	237	15.7
West north-central	408	13.6
South Atlantic	160	18.5
East south-central	188	17.6
West south-central	292	12.6
Mountain	60	14.3
Pacific	36	18.5
Total United States	1,440	14.7

Source: Annual Summer Survey, Crop Reporting Board, Statistical Reporting Service, U.S. Department of Agriculture.

Sales of ethane are usually made under long-term contracts and therefore, ethane prices do not fluctuate as widely and as frequently as propane and butane prices.

FOREIGN TRADE

Some 8.5 million barrels of the total LP gases exported were destined for Mexico, and most of these volumes were made up of butane-propane mixtures, as indicated in table 15. The total volume exported decreased from 12.8 million to less than 10 million barrels.

The volume of LP gas imported into the United States exceeded exports in 1970. Most of butane and propane imported (93.6 percent) originated in Canada. In addition, about 900,000 barrels of LP gases were imported from Venezuela. Imports in 1970 amounted to more than 19 million barrels, which was about 6.5 million barrels more than in 1969, as shown in table 1. Butane imports accounted for 9.7 million barrels; propane accounted for 9.5 million.

TECHNOLOGICAL DEVELOPMENTS

Ethane recovery has increased impressively over the past decade—from 63 gallons of ethane per million cubic feet of natural gas processed in the early 1960's to about 150 gallons of ethane recovered per million cubic feet of processed gas at the end of the decade.

Another important development is the increase production at refineries of LP gases. Production of propane, particularly, has nearly doubled; from 120,000 barrels per day in 1960 to 229,000 barrels per day in 1970. An even greater proportion of propane and butanes produced at refineries can be expected over the longer term as hydrocracking capacity continues to expand. Among the end-products of the hydrocracking processes are propane and the butanes.

Table 1.—Production, stocks, and demand of liquefied petroleum gases at gas processing plants and refineries

(Thousand barrels)

	Ethane		Propane		Butane		Butane-propane mixtures		Isobutane		Total	
	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
Production:												
At gas processing plants	63,027	73,434	195,346	202,494	86,471	87,253	6,711	5,677	26,902	30,753	378,457	399,611
At refineries:												
For fuel use	------	------	57,022	63,409	13,535	13,514	5,102	3,947	------	------	75,659	80,870
For chemical use	9,159	9,460	19,721	20,090	10,987	8,693	6,289	5,353	1,706	1,521	47,862	45,117
Total	72,186	82,894	272,089	285,993	110,993	109,460	18,102	14,977	28,608	32,274	501,978	525,598
Net change in stocks:												
Liquefied petroleum gases:												
At gas processing plants	−30	−863	−13,148	7,416	−2,811	1,067	−288	493	−882	−1,499	−17,159	6,614
At refineries	------	------	−1	80	−87	144	79	−56	−67	55	−76	223
Liquefied refinery gases:												
For fuel use	------	------	136	1,218	512	−536	−91	−31	------	------	557	651
For chemical use	------	------	142	−69	−6	−1	−1	------	−15	23	120	−47
Exports	------	------	2,412	2,165	3,084	1,655	7,299	6,135	------	------	[1] 12,783	[1] 9,955
Imports	------	------	5,251	9,467	7,400	9,694	------	------	------	------	12,651	19,161
Used at refineries	------	------	1,632	1,530	40,268	43,758	3,013	2,822	27,851	32,197	72,764	80,307
Domestic demand:												
At gas processing plants	63,057	74,297	209,702	200,770	53,417	50,323	285	198	------	------	326,461	325,588
At refineries:												
For fuel use	------	------	56,886	62,191	13,023	14,050	4,538	3,978	------	------	74,447	80,219
For chemical use	9,159	9,460	19,579	20,159	10,993	8,694	3,268	1,438	1,721	1,498	44,720	41,249
Total	72,216	83,757	286,167	283,120	77,433	73,067	8,091	5,614	1,721	1,498	445,628	447,056
Stocks:												
Liquefied petroleum gases:												
At gas processing plants	2,182	1,319	31,375	38,791	13,330	14,397	240	733	6,854	5,355	53,981	60,595
At refineries	------	------	4	84	270	414	91	35	206	261	571	794
Liquefied refinery gases:												
For fuel use	------	------	3,083	4,301	1,448	912	251	220	------	------	4,782	5,433
For chemical use	------	------	215	146	36	35	------	------	17	40	268	221
Total	2,182	1,319	34,677	43,322	15,084	15,758	582	988	7,077	5,656	59,602	67,043

[1] Includes shipments to territories.

Table 2.—Plant production, stocks at plants and terminals, and shipments from plants of natural gas processing plant products in 1970

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1970	Total 1969
All products, total:														
Production	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	580,241
Stocks	43,023	37,413	37,544	42,887	52,901	61,734	68,317	74,451	78,717	77,783	73,167	65,992	65,992	58,552
Shipments	66,164	52,868	51,743	44,299	41,465	40,762	43,755	44,230	44,839	52,309	55,682	60,360	598,476	596,985
Ethane:														
Production	5,953	5,510	6,186	5,757	6,138	5,797	6,151	6,165	6,085	6,551	6,457	6,684	73,434	63,027
Stocks	2,110	1,998	2,117	2,265	2,249	2,303	2,355	2,179	1,925	1,516	1,360	1,319	1,319	2,182
Shipments	6,025	5,622	6,067	5,609	6,154	5,743	6,099	6,341	6,339	6,960	6,613	6,725	74,297	63,057
Liquefied petroleum gases:														
Production	27,952	26,099	28,568	27,100	27,939	26,250	26,106	26,163	25,910	27,467	27,604	29,019	326,177	315,430
Stocks	36,252	31,099	31,059	36,092	45,778	54,093	60,418	66,551	70,818	70,571	66,035	59,276	59,276	51,799
Shipments	43,499	31,252	28,608	22,067	18,253	17,935	19,781	20,030	21,643	27,714	32,140	35,778	318,700	332,559
Isopentane:														
Production	325	311	368	306	292	324	315	316	283	330	346	349	3,865	3,457
Stocks	30	13	8	8	6	8	8	9	7	9	8	7	7	10
Shipments	305	328	373	306	294	322	315	315	285	328	347	350	3,868	3,491
Natural gasoline:														
Production	12,802	12,091	13,199	12,999	13,686	13,779	14,325	14,236	13,585	13,682	13,245	13,645	161,274	154,472
Stocks	3,328	3,272	3,467	3,557	3,703	4,100	4,360	4,520	4,692	4,463	4,553	4,316	4,316	3,358
Shipments	12,832	12,147	13,004	12,909	13,540	13,382	14,065	14,076	13,413	13,911	13,155	13,882	160,316	153,698
Plant condensate:														
Production	2,831	2,551	2,809	2,784	2,662	2,693	2,626	2,669	2,476	2,588	2,628	2,655	31,972	34,133
Stocks	597	510	461	531	618	615	599	639	637	568	564	507	507	547
Shipments	2,781	2,638	2,858	2,714	2,575	2,696	2,642	2,629	2,478	2,657	2,632	2,712	32,012	34,427
Other products, total:														
Production	772	696	744	696	762	752	815	815	766	757	786	833	9,194	9,722
Stocks	706	521	432	434	547	615	577	553	638	656	647	567	567	656
Shipments	722	881	833	694	649	684	853	839	681	739	795	913	9,283	9,753
Motor gasoline:														
Production	432	404	426	400	453	447	473	459	443	451	469	490	5,347	5,745
Stocks	333	379	263	224	279	301	201	165	218	189	201	198	198	308
Shipments	407	358	542	439	398	425	573	495	390	480	457	493	5,457	5,707
Special naphthas:														
Production	33	32	37	34	31	31	35	32	32	30	27	30	384	492
Stocks	15	7	9	7	11	8	10	8	7	9	11	9	9	11
Shipments	29	40	35	36	27	34	33	34	33	28	25	32	386	494
Kerosine:														
Production	86	71	80	72	77	79	111	100	97	105	101	98	1,077	1,121
Stocks	268	60	106	138	185	224	283	284	313	363	348	284	284	249
Shipments	67	279	34	40	30	40	52	99	68	55	116	162	1,042	1,162
Distillate fuel oil:														
Production	133	117	121	117	127	130	130	114	105	107	116	124	1,441	1,541
Stocks	51	51	31	37	43	52	50	60	65	59	51	58	58	50
Shipments	132	117	141	111	121	121	132	104	100	113	124	117	1,433	1,556
Jet fuel:														
Production	3	1	2	2	2	2	1	2	3	3	------	------	21	18
Stocks	21	5	7	9	11	13	14	16	18	21	21	3	3	19
Shipments	1	17	------	------	------	------	------	------	1	------	------	18	37	23
Miscellaneous products:														
Production	85	71	78	71	72	63	65	108	86	61	73	91	924	805
Stocks	18	19	16	19	18	17	19	20	17	15	15	15	15	19
Shipments	86	70	81	68	73	64	63	107	89	63	73	91	928	811

Table 3.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1970

(Thousand barrels)

States by petroleum districts	Ethane	Liquefied petroleum gases						Natural gasoline and iso-pentane	Plant con-densate	Finished gasoline and naphtha	All other products [1]	Total
		Propane	Normal butane	Other butanes	Butane-propane mixture	Iso-butane	Total					
District I:												
Georgia, Florida, and West Virginia	(2)	3,282	1,092	120	------	245	4,739	(2)	1,048	------	------	8,751
Pennsylvania	------	24	10	------	------	------	34	18	------	------	------	53
Total [3]	------	3,307	1,102	120	------	245	4,774	18	1,048	------	------	8,804
District II:												
Michigan	------	667	------	509	------	------	1,176	591	7	------	------	1,775
Kansas	1,391	12,194	3,610	2,191	261	1,167	19,423	6,519	30	------	------	27,363
Nebraska	------	220	115	30	------	------	365	121	------	------	------	486
North Dakota	------	1,121	594	71	------	54	1,840	502	2	------	------	2,344
Oklahoma	490	17,969	5,398	1,901	560	1,711	27,539	13,389	1,155	54	215	42,842
Other States [4]	[2] 9,692	4,113	640	------	------	536	5,289	[2] 1,764	9	------	------	13,788
Total	11,573	36,284	10,357	4,702	821	3,468	55,632	22,886	[3] 1,202	54	215	88,598
District III:												
Alabama and Mississippi	------	225	111	26	162	------	524	557	40	------	15	1,136
Arkansas	------	744	302	------	------	159	1,205	502	89	------	52	1,848
Louisiana:												
Gulf	20,276	31,707	11,285	646	141	10,193	53,972	38,324	8,762	1,728	991	124,054
Inland	1,484	2,506	895	340	350	562	4,653	1,305	1,150	2,835	1,431	12,857
Total	21,760	34,213	12,180	986	491	10,755	58,625	39,629	9,912	4,563	2,422	136,911
New Mexico	2,218	13,322	4,706	3,845	185	1,723	23,781	9,389	185	------	32	35,605
Texas:												
Gulf	14,365	16,667	4,414	562	959	4,240	26,842	19,133	3,345	212	191	64,087
West	7,922	43,453	8,878	9,185	553	2,424	64,493	21,653	4,815	------	8	98,891
East (field)	221	2,945	1,310	588	38	388	5,269	1,868	41	------	20	7,419
Panhandle	1,027	14,944	3,443	7,072	18	1,881	27,358	10,819	110	------	11	39,324
Other	14,348	25,390	7,804	2,213	2,178	4,746	42,331	23,508	10,381	904	496	91,967
Total [3]	37,883	103,398	25,848	19,621	3,747	13,680	166,294	76,977	18,693	1,114	727	301,688
Total	61,861	151,902	43,147	24,478	4,585	26,317	250,429	127,054	28,919	5,677	3,248	477,188
District IV:												
Colorado	------	881	46	604	------	11	1,542	745	------	------	------	2,287
Montana and Utah	------	1,286	742	------	91	74	2,193	649	------	------	------	2,842
Wyoming	------	3,042	682	791	------	41	4,556	2,274	323	------	------	7,153
Total	------	5,209	1,470	1,395	91	126	8,291	3,668	323	------	------	12,282
District V	------	5,792	398	84	180	597	7,051	11,513	480	------	------	19,044
Total United States	73,434	202,494	56,474	30,779	5,677	30,753	326,177	165,139	31,972	5,731	3,463	605,916

[1] Includes jet fuel, kerosine, distillate, and other.
[2] PAD district I data included with PAD district II, "Other States."
[3] Data may not add to totals shown because of independent rounding.
[4] Includes Florida, Georgia, Illinois, Kentucky, and West Virginia for ethane and natural gasoline and isopentane only.

Table 4.—Production of natural gasoline by vapor pressure and PAD districts in the United States in 1970

(Thousand barrels)

Reid vapor pressure	District I	District II	District III	District IV	District V	Total
12 pounds and less	629	2,240	61,971	1,185	161	66,186
Over 12 pounds including 14 pounds	393	5,718	15,938	826	167	23,042
Over 14 pounds including 18 pounds	-------	6,840	6,965	731	178	14,714
Over 18 pounds including 22 pounds	18	79	795	--------	1,774	2,666
Over 22 pounds including 26 pounds	-------	1,467	13,363	166	1,638	16,634
Over 26 pounds	11	5,325	24,346	755	7,595	38,032
Total	1,051	21,669	123,378	3,663	11,513	161,274

Table 5.—Liquefied refinery gases and ethane produced at refineries for fuel and chemical use in 1970

(Thousand barrels)

States and PAD districts	Ethane	Propane	Butane	Butane-propane mixture	Total
District I:					
New Jersey	---------	4,752	1,344	----------	6,096
Pennsylvania	---------	6,849	186	----------	7,035
Other States [1]	---------	3,229	525	----------	3,754
Total	---------	14,830	2,055	----------	16,885
District II:					
Illinois	---------	6,623	390	----------	7,013
Indiana	---------	1,311	327	----------	1,638
Kansas	316	3,667	143	13	4,139
Kentucky	---------	1,197	73	----------	1,270
Michigan	---------	1,357	83	2	1,442
Other States [2]	---------	1,600	65	254	1,919
Ohio	---------	4,430	----------	----------	4,430
Oklahoma	---------	3,325	572	1,055	4,952
Total	316	23,510	1,653	1,324	26,803
District III:					
Alabama and Mississippi	---------	1,564	5	39	1,608
Arkansas	---------	659	72	6	737
Louisiana:					
Gulf	3,130	13,266	2,693	3,448	22,537
Inland	---------	115	107	30	252
Total	3,130	13,381	2,800	3,478	22,789
New Mexico	---------	191	47	296	534
Texas:					
Gulf	5,283	18,386	11,436	1,863	36,968
West	---------	1,107	645	----------	1,752
East	---------	263	27	----------	290
Panhandle	102	941	499	----------	1,542
Other	---------	121	46	----------	167
Total	5,385	20,818	12,653	1,863	40,719
Total	8,515	36,613	15,577	5,682	66,387
District IV:					
Colorado	---------	127	200	----------	327
Montana	---------	464	31	55	550
Utah	---------	487	27	----------	514
Wyoming	---------	220	678	2	900
Total	---------	1,298	936	57	2,291
District V	629	7,248	3,507	2,237	13,621
Total United States	9,460	83,499	[3] 23,728	9,300	125,987

[1] Includes Delaware, New York, Virginia, and West Virginia.
[2] Includes Minnesota, Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin.
[3] Includes 1,521,000 barrels of isobutane used for petrochemical feedstock.

Table 6.—Natural gas liquids [1] used as refinery input in the United States in 1970, by Bureau of Mines refinery districts, and by months

(Thousand barrels)

District	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
East Coast	631	483	433	507	272	259	353	477	361	554	402	539	5,271
Appalachian	20	12	13	12	15	5	3	3	6	4	1	2	96
Indiana, Illinois, Kentucky, etc	2,219	2,163	1,746	1,606	1,341	1,277	1,396	1,515	1,381	1,829	1,894	2,221	20,588
Minnesota, Wisconsin, North Dakota, and South Dakota	461	408	555	460	470	522	510	535	600	600	692	661	6,474
Oklahoma, Kansas, Missouri	2,150	1,801	1,976	1,585	1,652	1,534	1,798	1,826	2,016	2,164	2,122	2,380	23,004
Texas:													
Inland	1,827	1,685	1,869	1,788	1,965	2,020	2,209	2,080	1,980	2,093	2,064	2,020	23,600
Gulf Coast	10,360	9,924	10,303	10,223	10,443	10,691	11,153	11,215	10,854	11,715	11,391	12,414	130,686
Total	12,187	11,609	12,172	12,011	12,408	12,711	13,362	13,295	12,834	13,808	13,455	14,434	154,286
Louisiana-Arkansas:													
Louisiana Gulf Coast	3,515	2,890	3,442	3,052	3,276	3,342	3,127	2,832	3,114	3,703	3,425	3,777	39,495
Arkansas and Louisiana Inland	359	322	304	350	308	441	420	358	346	381	379	405	4,373
Total	3,874	3,212	3,746	3,402	3,584	3,783	3,547	3,190	3,460	4,084	3,804	4,182	43,868
New Mexico	77	64	69	56	93	99	101	116	99	86	96	106	1,062
Other Rocky Mountain	521	434	487	393	409	381	418	449	461	507	490	501	5,451
West Coast	1,586	1,483	1,434	1,377	1,185	1,448	1,496	1,628	1,536	1,638	1,842	1,581	18,234
Total United States	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

[1] Comprises natural gasoline, LP gas, and condensate.

Table 7.—Sales of liquefied petroleum gases and ethane in the United States, 1966–1970

(Thousand barrels)

	1966	1967	1968	1969	1970
United States, total	[1] 400,258	422,337	468,156	531,175	537,623
For export	8,171	9,262	10,608	[2] 12,783	[2] 9,955
For use in gasoline production	68,403	68,643	72,652	72,764	80,307
For all other uses	323,685	344,432	384,896	445,628	447,361
By type:					
Ethane	36,776	44,069	55,152	72,216	83,757
Propane	195,701	226,506	256,810	293,810	282,250
Butane	40,230	43,920	44,601	50,170	52,566
Butane-propane mixture	50,977	29,937	28,333	29,431	28,788
By principal use:					
Residential and commercial	135,277	148,139	159,955	182,306	180,207
Internal-combustion	28,893	27,435	29,250	34,931	31,806
Industrial [3]	15,375	15,121	19,235	22,585	21,360
Utility gas	2,603	2,300	4,076	4,359	5,052
Chemical	121,334	129,620	148,811	178,265	184,049
Synthetic rubber	17,483	18,006	18,463	18,025	18,825
Secondary recovery of petroleum	709	1,093	1,593	577	631
Miscellaneous	2,011	2,718	3,512	4,580	5,431

[1] Data does not add to total shown because of independent roundings.
[2] Includes shipments to territories.
[3] Includes refinery fuel.

Table 8.—Refinery input of LP gas, by product and PAD districts, in the United States, 1968–1970

(Thousand barrels)

Item	District I	District II	District III	District IV	District V	Total
1968						
Propane	---------	3	575	10	999	1,587
Butane [1]	1,992	14,322	17,882	2,097	5,203	41,496
Isobutane	92	4,775	20,418	434	1,349	27,068
Butane-propane mix	---------	1,792	35	403	271	2,501
Total LP gas	2,084	20,892	38,910	2,944	7,822	72,652
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 LP gas	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 LP gas	2,167	25,744	42,936	3,562	5,898	80,307

[1] "Normal Butane" and "Other Butanes" reported separately for 1970.

Table 9.—Estimated proved reserves of natural gas liquids in the United States

(Thousand barrels)

State	Reserves as of Dec. 31, 1969	Changes in reserves during 1970			Reserves as of Dec. 31, 1970		
		Extensions and revisions [1]	Discoveries of new fields and new pools	Preliminary net production	Nonassociated with oil	Associated-dissolved	Total
Alabama	7,133	9,509	5,000	182	20,844	616	21,460
Alaska [2]	398	------	------	63	------	335	335
Arkansas	13,161	1,460	104	2,453	7,587	4,685	12,272
California [3]	185,932	2,912	------	18,660	6,306	163,878	170,184
Colorado	19,925	234	238	1,601	6,588	12,208	18,796
Illinois	1,472	(111)	5	231	3	1,132	1,135
Indiana	40	------	------	6	8	26	34
Kansas	269,261	44,667	115	19,970	286,792	7,281	294,073
Kentucky	48,983	326	2,112	3,413	48,008	-------	48,008
Louisiana [3]	2,570,298	127,419	119,692	250,429	2,136,591	430,389	2,566,980
Michigan	4,056	2,612	4,396	1,161	5,437	4,466	9,903
Mississippi	20,045	(2,386)	7,040	2,048	12,068	10,583	22,651
Montana	9,881	(13)	------	1,249	1,401	7,218	8,619
Nebraska	2,268	------	80	484	945	919	1,864
New Mexico	599,675	5,705	1,809	48,613	357,019	201,557	558,576
North Dakota	51,604	------	------	2,347	-------	49,257	49,257
Ohio	---------	------	------	------	-------	-------	-------
Oklahoma	465,694	(72,818)	5,477	39,750	233,464	125,139	358,603
Pennsylvania	974	------	------	78	896	---------	896
Texas [3]	3,651,939	(7,528)	21,520	335,772	1,859,513	1,470,646	3,330,159
Utah	38,789	(168)	------	2,331	1,123	35,167	36,290
West Virginia	81,234	7,015	------	6,742	81,507	---------	81,507
Wyoming	100,412	20,351	805	10,229	44,839	66,500	111,339
Total	8,143,174	139,186	168,393	747,812	5,110,939	2,592,002	7,702,941

[1] Parenthesis denote decrease.
[2] Natural Gas Liquids reserves for the Prudhoe Bay-Triassic reservoir are not included because the American Gas Association Reserves Committee did not have sufficient data upon which it could base an estimate of such reserves as of Dec. 31, 1970.
[3] Includes offshore reserves.
Note: The remaining proved natural gas liquids reserves in the Gulf of Mexico are estimated to be 921,569,000 barrels; of which 801,886,000 barrels are nonassociated and 119,683,000 barrels are associated-dissolved.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 10.—Estimated productive capacity of natural gas liquids in the United States, December 31, 1970

(Thousand barrels per day)

State	Productive capacity			State	Productive capacity		
	Nonassociated	Associated or dissolved	Total		Nonassociated	Associated or dissolved	Total
Alabama	6	1	7	Montana	1	3	4
Alaska	------	1	1	Nebraska	1	1	2
Arkansas	5	4	9	New Mexico	92	102	194
California	3	60	63	North Dakota	------	7	7
Colorado	2	3	5	Oklahoma	145	64	209
Illinois	------	1	1	Texas [1]	853	538	1,391
Kansas	175	7	182	Utah	1	7	8
Kentucky	10	------	10	West Virginia	19	------	19
Louisiana	830	117	947	Wyoming	19	16	35
Michigan	2	2	4				
Mississippi	3	4	7	Total	2,167	938	3,105

[1] Includes offshore.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 11.—Stocks of natural gas liquids and ethane in the United States

(Thousand barrels)

Date	LP gases and ethane		Natural gasoline and isopentane		Other finished products and plant condensate		Total at plants and terminals	Total at refineries	Grand total
	At plants and terminals	At refineries	At plants and terminals	At refineries	At plants and terminals	At refineries			
Dec. 31:									
1966	34,610	587	2,673	1,300	950	303	38,233	2,190	40,423
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:									
Jan. 31	38,362	674	3,358	1,510	1,303	182	43,023	2,366	45,389
Feb. 28	33,097	625	3,285	1,676	1,031	342	37,413	2,643	40,056
Mar. 31	33,176	659	3,475	1,837	893	350	37,544	2,846	40,390
Apr. 30	38,357	613	3,565	1,960	965	480	42,887	3,053	45,940
May 31	48,027	657	3,709	2,366	1,165	439	52,901	3,462	56,363
June 30	56,396	723	4,108	2,310	1,230	369	61,734	3,402	65,136
July 31	62,773	629	4,368	2,195	1,176	551	68,317	3,375	71,692
Aug. 31	68,730	1,003	4,529	1,969	1,192	534	74,451	3,506	77,957
Sept. 30	72,743	996	4,699	1,801	1,275	435	78,717	3,232	81,949
Oct. 31	72,087	853	4,472	1,435	1,224	411	77,783	2,699	80,482
Nov. 30	67,395	851	4,561	1,479	1,211	337	73,167	2,667	75,834
Dec. 31	[1]60,595	794	4,323	1,765	1,074	451	65,992	3,010	69,002

[1] Includes 48,244,000 barrels in underground storage.

Table 12.—Values and volumes of natural gas liquids and ethane produced in the United States

	Thousand barrels		Percent change	Thousand dollars		Percent change	Dollars per barrel		Percent change
	1969	1970		1969	1970		1969	1970	
LP gases and ethane	378,457	399,611	+5.6	498,927	672,088	+34.7	1.32	1.68	+27.3
Natural gasoline and isopentane	157,929	165,139	+4.6	457,986	468,602	+2.3	2.90	2.84	−2.1
Plant condensate	34,133	31,972	−6.3	105,863	101,723	−3.9	3.10	3.18	+2.6
Finished gasoline and naphthas	8,917	5,731	−35.7	36,954	23,234	−37.1	4.14	4.05	−2.2
Other products	805	3,463	------	2,281	9,465	------	2.83	2.73	−3.5
Total	580,241	605,916	+4.4	1,102,011	1,275,112	+15.7	1.90	2.10	+10.5

Table 13.—Natural gas liquids and ethane produced, value at plants in the United States in 1970, by States

(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	1,205	$2,482	2.06	502	$1,581	3.15	89	$243	2.73
California and Alaska	16	7,051	16,006	2.27	11,513	36,726	3.19	480	1,752	3.65
Colorado	5	1,542	2,529	1.64	745	1,937	2.60	------	------	------
Illinois and Kentucky	4	13,048	24,661	1.89	731	2,427	3.32	9	31	3.47
Kansas	13	20,814	30,597	1.47	6,519	14,537	2.23	30	80	2.65
Louisiana	40	80,385	138,262	1.72	39,629	114,924	2.90	9,912	33,701	3.40
Michigan	4	1,176	2,764	2.35	591	1,590	2.69	7	21	2.98
Mississippi and Alabama	7	524	1,100	2.10	557	1,498	2.69	40	124	3.11
Montana and Utah	7	2,193	3,048	1.39	649	1,720	2.65	------	------	------
Nebraska	2	365	858	2.35	121	386	3.19	------	------	------
New Mexico	13	25,999	37,179	1.43	9,389	24,881	2.65	185	559	3.02
North Dakota	3	1,840	2,944	1.60	502	1,370	2.73	2	6	2.86
Oklahoma	33	28,029	52,975	1.89	13,389	36,016	2.69	1,155	3,199	2.77
Pennsylvania	3	34	87	2.56	18	50	2.77	------	------	------
Texas	74	204,177	334,850	1.64	76,977	220,154	2.86	18,693	58,883	3.15
West Virginia and Florida	5	6,673	14,274	2.14	1,033	2,779	2.69	1,048	2,065	1.97
Wyoming	13	4,556	7,472	1.64	2,274	6,026	2.65	323	1,059	3.28
Total	149	399,611	672,088	1.68	165,139	468,602	2.84	[3] 31,972	101,723	3.18

State	No. of operating companies [1]	Finished gasoline and naphtha			Other products [4]			Total		
		Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]	Quantity	Value	Dollars per barrel [2]
Arkansas	3	------	--------	------	52	------	3.11	1,848	$4,306	2.33
California and Alaska	16	------	--------	------	------	------	------	19,044	54,484	2.81
Colorado	5	------	--------	------	------	------	------	2,287	4,466	1.95
Illinois and Kentucky	4	------	--------	------	------	------	------	13,788	27,119	1.97
Kansas	13	------	--------	------	------	------	------	27,363	45,214	1.65
Louisiana	40	4,563	$18,571	4.07	2,422	$7,436	3.07	136,911	312,894	2.29
Michigan	4	------	--------	------	------	------	------	1,775	4,375	2.47
Mississippi and Alabama	7	------	--------	------	15	32	2.14	1,136	2,754	2.42
Montana and Utah	7	------	--------	------	------	------	------	2,842	4,768	1.68
Nebraska	2	------	--------	------	------	------	------	486	1,244	2.56
New Mexico	13	------	--------	------	32	108	3.36	35,605	62,727	1.76
North Dakota	3	------	--------	------	------	------	------	2,344	4,320	1.84
Oklahoma	33	54	174	3.23	215	544	2.53	42,842	92,908	2.17
Pennsylvania	3	------	--------	------	------	------	------	53	137	2.59
Texas	74	1,114	4,489	4.03	727	1,345	1.85	301,688	619,721	2.05
West Virginia and Florida	5	------	--------	------	------	------	------	8,751	19,118	2.19
Wyoming	13	------	--------	------	------	------	------	7,153	14,557	2.04
Total	149	5,731	23,234	4.05	3,463	9,465	2.73	605,916	1,275,112	2.10

[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] Data may not add to total shown because of independent rounding.
[4] Includes kerosine, jet fuel, distillate fuel, etc.

Table 14.—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: [2]							
1969	7.25	7.25	7.25	6.96	6.75	6.75	6.75
1970	7.90	8.00	8.00	8.00	8.00	8.02	8.50
Oklahoma:							
1969	4.25	4.25	4.25	3.63	3.25	3.25	3.25
1970	4.95	5.22	5.25	5.25	5.25	5.25	5.25
Baton Rouge:							
1969	4.75	4.75	4.75	4.13	3.75	3.75	3.75
1970	5.45	5.72	5.75	5.75	5.75	5.75	5.75

	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
New York harbor and Philadelphia: [2]						
1969	6.75	6.78	7.50	7.54	7.50	7.09
1970	8.56	8.98	9.00	9.00	9.00	8.41
Oklahoma:						
1969	3.25	4.07	4.25	4.53	4.75	3.92
1970	5.59	6.22	6.25	6.25	6.25	5.58
Baton Rouge:						
1969	3.75	4.57	4.75	4.97	5.25	4.41
1970	5.96	6.70	6.73	6.73	6.73	6.06

[1] Producers' net contract prices (after some discounts and summer-fill allowances) for propane, tank cars/transport trucks.
[2] Prior to 1969, New York and Philadelphia listed separately. See 1968 Platt's Oil Price Handbook, 45th edition, for separate listings 1964–68.

Source: Platt's Oil Price Handbook.

Table 15.—LP gases [1] exported from the United States, by countries

(Thousand barrels and thousand dollars)

Country	1969				1970			
	Butane	Propane	Butane-propane mixtures	Total	Butane	Propane	Butane-propane mixtures	Total
Argentina	766	131	27	924	59	60	(2)	119
Bahamas	(2)	86	(2)	86	2	76	1	79
Belgium-Luxembourg	(2)	------	27	27	(2)	------	31	31
Brazil	617	------	------	617	(2)	------	------	(2)
Canada	566	19	253	838	159	16	125	300
Chile	(2)	------	29	29	------	------	1	1
France	13	(2)	------	13	(2)	31	(2)	31
Guatemala	3	11	5	19	2	4	26	32
Japan	2	509	3	514	2	508	2	512
Mexico	171	889	6,937	7,997	1,419	1,150	5,939	8,508
Portugal	6	7	4	17	------	------	(2)	(2)
Spain	931	37	(2)	968	------	------	------	------
United Kingdom	2	698	1	701	(2)	293	(2)	293
Other	5	13	14	32	6	11	9	26
Total	3,082	2,400	7,300	[3] 12,782	1,649	2,149	6,134	[3] 9,932
Total value	$7,030	$7,071	$20,196	$34,297	$4,858	$7,770	$19,046	$31,674

[1] Data include LR gases.
[2] Less than ½ unit.
[3] Excludes shipments to territories.

Nickel

By Horace T. Reno [1]

The nickel industry made an exceptionally rapid recovery in 1970 from the severe nickel shortage caused by labor strikes at Canadian mines in 1969 and 5 years of imbalance between supply and demand. At the beginning of the year the shortage affected most of the nickel industry. Consumption was less than normal, the price of merchant and scrap nickel was substantially above the producer price, and both consumer and producer stocks were low. By March, U.S. consumption of nickel was back to prestrike levels, and the Department of Commerce lifted restrictions on the use of priority ratings for replacing nickel inventories. By the end of June, the industry was operating at normal prestrike levels. By the end of September, nickel supply apparently was meeting domestic demand. Consumer stocks were at prestrike levels, and the price of merchant and scrap nickel in domestic and foreign markets was nominal. Nonetheless, at yearend it was not certain that all consumers were getting the nickel they needed.

That pattern of 1970 nickel consumption in the United States reflected the tight mineral supply of 1969. The pent-up demand for nickel in electroplating uses and in corrosion-resistant alloys was shown in rapidly increasing consumption in these categories. After the first peak in January, however, the monthly total of nickel consumed trended downward throughout the year. The International Nickel Co. of Canada, Ltd. (INCO), estimated free-world nickel consumption in 1970 at 985 million pounds, compared with 844 million pounds in 1969. Free-world production was 1,047 million pounds.

Legislation and Government Programs.—According to the July–December 1970 Statistical Supplement Stockpile report to the Congress prepared by the General Services Administration, 64,258 short tons of nickel plus cobalt was in the defense materials inventory as of December 31, 1970. Of this quantity, 48,780 short tons was in the strategic stockpile in storage or on loan; 1,220 tons was in the Defense Production Act (DPA) stocks; and 14,258 tons was held in stock for the U.S. Mint. The stockpile objective at the end of the year was 55,000 tons. The Bureau of Domestic Commerce of the U.S. Department of Commerce progressively lowered the amount of primary nickel set aside for defense purposes, from 25 percent of the average monthly producer shipments during the last 6 months of 1967 to 22 percent of the average monthly shipments in 1968.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient nickel statistics

(Short tons)

	1966	1967	1968	1969	1970
United States:					
Mine production	15,036	15,287	17,294	17,056	15,933
Plant production:					
Primary	13,237	14,615	15,154	15,616	15,319
Secondary	26,777	20,731	14,061	18,775	23,159
Exports	26,387	31,537	33,681	34,758	31,456
Imports for consumption	141,000	143,000	147,950	129,332	156,252
Consumption	187,833	173,798	159,306	141,737	155,719
Stocks Dec. 31: Consumer	31,288	31,007	27,466	16,590	24,757
Price cents per pound	77¾–85¼	85¼–94	94–103	103–128	128–133
World: Production	454,457	494,835	547,960	532,537	685,186

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. Compared with 1967–69, nickel exploration in the continental United States and Alaska was not significant in 1970.

Table 2.—Primary nickel produced in the United States

(Short tons, nickel content)

	1966	1967	1968	1969	1970
Byproduct of metal refining	1,006	1,579	2,030	2,520	2,670
Domestic ore	12,231	13,036	13,124	13,096	12,649

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	1969	1970	Form of recovery	1969	1970
New scrap:					
Nickel-base	2,170	1,634	As metal	1,514	982
Copper-base	3,486	4,742	In nickel-base alloys	2,221	2,105
Aluminum-base	630	585	In copper-base alloys	6,746	7,342
			In aluminum-base alloys	997	905
Total	6,286	6,961	In ferrous and high-temperature alloys [1]	6,965	11,612
Old scrap:			In chemical compounds	332	213
Nickel-base	11,331	15,385			
Copper-base	778	511	Total	18,775	23,159
Aluminum-base	380	302			
Total	12,489	16,198			
Grand total	18,775	23,159			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

CONSUMPTION AND USES

For the first time since 1966 the pattern of domestic nickel consumption was not influenced during the year by an imbalance between supply and demand. By the end of January the nondefense industries, which had had shortages before, were well supplied with nickel, and their use of it increased accordingly. The most significant increase was in the electroplating industry, which had not been able to supplement its primary nickel supply with secondary materials.

Because of differing interpretations of the term "superalloys" among consumers, 1969 data on nickel usage in superalloys is not accurate. The problem is universal, and a committee of experts from the principal consumers is developing an improved definition to overcome it. The data reported to the Bureau are believed to be valid for indicating the trend in the use of nickel in superalloys. Reported consumption of superalloys in 1970 indicates a 9 percent decrease from the 1969 level.

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1970

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption: New	Consumption: Old	Consumption: Total	Stocks, end of year
Smelters and refiners:						
Unalloyed nickel	90	2,102	1,174	634	1,808	384
Monel metal	756	2,818	278	2,228	2,506	1,068
Nickel silver [1]	515	3,601	727	2,791	3,518	598
Cupronickel [1]	51	498	------	516	516	33
Miscellaneous nickel-alloys	10	3,134	30	3,114	3,144	------
Nickel residues	1,743	5,786	838	989	1,827	5,702
Total	2,599	13,840	2,320	6,965	9,285	7,154
Foundries and plants of other manufacturers:						
Unalloyed nickel	7,071	24,591	6	12,154	12,160	19,502
Monel metal	34	101	28	82	110	25
Nickel silver [1]	2,080	12,032	10,603	------	10,603	1,429
Cupronickel [1]	1,142	7,797	8,331	100	8,431	1,508
Nickel residues	190	777	299	550	849	118
Total	7,295	25,469	333	12,786	13,119	19,645
Grand total:						
Unalloyed nickel	7,161	26,693	1,180	12,788	13,968	19,886
Monel metal	790	2,919	306	2,310	2,616	1,093
Nickel silver [1]	2,595	13,553	11,330	2,791	14,121	2,027
Cupronickel [1]	1,193	9,295	8,331	616	8,947	1,541
Miscellaneous nickel alloys	10	3,134	30	3,114	3,144	------
Nickel residues	1,933	6,563	1,137	1,539	2,676	5,820
Total	9,894	39,309	2,653	19,751	22,404	26,799

[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	1966	1967 [1]	1968 [1]	1969 [1]	1970
Metal	132,573	124,639	115,839	99,096	112,825
Ferronickel	29,674	25,228	15,170	17,804	15,230
Oxide powder and oxide sinter	22,845	19,349	24,362	19,133	21,369
Salts [2]	2,741	4,582	3,935	2,647	3,792
Other	-------	-------	-------	3,057	2,503
Total	187,833	173,798	159,306	141,737	155,719

[1] Metallic nickel salts consumed by plating industry are estimated.
[2] Figures do not cover all consumers for 1966.

Table 6.—U.S. consumption of nickel (exclusive of scrap), by use and form, 1970

(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	19,603	7,913	13,253	------	W	40,769
Alloys (excludes stainless)	8,343	6,691	5,801	------	39	20,874
Superalloys	11,478	W	26	------	122	11,626
Nickel-copper and copper-nickel alloys	6,309	W	18	------	227	6,554
Permanent magnet alloys	2,430	W	W	------	------	2,430
Other nickel and nickel alloys	35,656	36	W	W	87	35,779
Cast irons	3,130	282	462	W	1,060	4,934
Electroplating [1]	21,024	10	W	3,423	93	24,550
Chemicals and chemical uses	605	------	172	198	W	975
Other uses [2]	4,247	298	1,637	171	875	7,228
Total reported by companies canvassed and estimated	112,825	15,230	21,369	3,792	2,503	155,719

W Withheld to avoid disclosing individual company confidential data; included in "Other uses."
[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	1968	1969 r	1970
Metal	19,385	12,528	17,987
Ferronickel	2,603	1,868	2,286
Oxide powder and oxide sinter	4,321	1,018	3,303
Salts	502	539	501
Other	655	621	680
Total	27,466	16,574	24,757

r Revised.

PRICES

The price of electrolytic nickel of $1.28 per pound was unchanged from the beginning of 1970 until October 14, when INCO announced an increase of 5 cents to $1.33 per pound. INCO announced that the price increase was partially to compensate the company for reduced realization in Canadian currency owing to changes in the Canadian-United States exchange rate. Other major producers followed INCO and adjusted worldwide prices accordingly. At the beginning of the year merchant electrolytic nickel was quoted at $5.80 to $6.40 per pound at shipping points, and scrap nickel prices ranged from $2 to $4 per pound. By May 1 the price of merchant nickel had fallen to $2.10–$2.30 per pound and the price of scrap in large quantities was $1.75 per pound. By the end of November the price of merchant nickel was little different from that quoted by primary producers, and the price of scrap ranged downward from the primary price, depending on quality, quantity, and location.

Trade in nickel futures began February 16 on the New York Mercantile Exchange. During the first days of trading, prices for future deliveries of electrolytic cathodes ranged from $2.20 to $2.65 per pound. Thereafter futures prices trended downward until by the end of July. they were only a few cents more than the dealer price for merchant nickel.

FOREIGN TRADE

U.S. foreign trade in nickel in 1970 was 16 percent above the 1969 level. Australia for the first time joined the list of significant suppliers by providing 849 tons of metal. Imports of nickel from the U.S.S.R. declined from 1,109 to 863 tons, probably because the premium pricing system was discontinued at midyear. Total ferronickel imports declined about 10 percent, but imports from New Caledonia were 29 percent above those of 1969. Of the 14,237 tons of ferronickel imported for consumption in the United States in 1970, the French Pacific Islands supplied 13,394 tons; Greece, 779 tons; the Netherlands, 22 tons; the Republic of South Africa, 20 tons; and Israel, 11 tons. Apparently, ferroalloy producers in Greece established a larger market among Western European countries.

Table 8.—U.S. exports of nickel alloy products, by class

Class	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Unwrought	6,498	$14,211	1,851	$5,631	6,103	$13,450
Bars, rods, angles, shapes, and sections	2,880	7,277	5,052	12,405	5,311	16,047
Plates, sheets, and strip	2,308	9,784	4,218	16,582	4,653	21,893
Anodes	107	326	91	347	160	600
Wire	624	2,652	746	3,630	870	5,642
Powder and flakes	337	1,598	398	2,517	281	2,405
Foil	51	92	14	83	18	76
Catalysts	3,340	7,299	3,592	7,531	2,524	6,451
Tubes, pipes, blanks, and fittings therefor, and hollow bars	774	3,646	768	3,887	1,756	6,520
Waste and scrap	16,762	24,788	18,028	29,455	9,780	12,840
Total	33,681	71,673	34,758	82,068	31,456	85,924

Table 9.—U.S. imports for consumption of nickel products, by class

Class	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Ore	42	$2	-------	-------	21	$251
Unwrought	108,158	201,312	r 99,656	r $209,476	117,371	302,821
Oxide and oxide sinter	6,388	8,911	4,013	6,524	6,423	12,611
Slurry [1]	35,099	63,674	23,714	54,784	35,114	82,643
Bars, plates, sheets, and anodes	245	669	113	628	177	773
Rods and wire	392	1,287	540	2,171	544	2,630
Shapes, sections, and angles	-------	-------	5	30	2	12
Pipes, tubes, and fittings	146	627	10	45	22	97
Powder	2,936	6,106	2,708	6,452	3,028	10,357
Flakes	53	109	65	136	76	207
Waste and scrap	1,974	2,575	r 3,184	r 8,077	2,149	4,485
Ferronickel	10,553	5,450	15,696	9,507	14,237	9,652
Total (gross weight)	165,986	290,722	r 149,704	r 297,830	179,164	426,539
Nickel content (estimated)	147,950	XX	129,332	XX	156,252	XX

r Revised. XX Not applicable.

[1] 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.

Table 10.—U.S. imports for consumption of new nickel products,[1] by countries

(Short tons)

Country	Metal (Gross weight) 1969	Metal (Gross weight) 1970	Oxide and oxide sinter (Gross weight) 1969	Oxide and oxide sinter (Gross weight) 1970	Slurry and other [2] 1969 Gross weight	Slurry and other [2] 1969 Nickel content	Slurry and other [2] 1970 Gross weight	Slurry and other [2] 1970 Nickel content
Australia	21	849	------	------	------	------	126	32
Canada	86,242	104,248	4,008	6,412	19,458	16,376	30,156	23,871
Finland	43	4	------	------	------	------	------	------
France	20	------	------	------	------	------	------	------
Germany, West	27	122	1	11	------	------	437	200
Israel	5	50	------	------	------	------	------	------
Netherlands	r 116	21	------	------	------	------	------	------
Norway	11,224	10,789	------	------	------	------	------	------
South Africa, Republic of	246	98	------	------	3,806	1,836	4,395	1,998
Southern Africa, n.e.c	45	------	------	------	450	207	------	------
Sweden	28	2	------	------	------	------	------	------
U.S.S.R	1,109	863	------	------	------	------	------	------
United Kingdom	372	302	4	(3)	------	------	------	------
Other countries	r 158	23	(3)	------	------	------	------	------
Total	r 99,656	117,371	4,013	6,423	23,714	18,419	35,114	26,101

r Revised.

[1] Ore: 1969, 30 short tons previously reported from Peru revised to none; 1970, 21 short tons from Republic of South Africa.

[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

Australia.—Australia's nickel production more than doubled for the third year. As in 1969, Western Mining Corp. Ltd.'s Silver Lake shaft at Kambalda accounted for most of the output, but the Great Boulder Gold Mines, Ltd., Scotia mine, in its first full year of operation produced approximately 10,000 tons of 3 percent nickel ore per month.

Western Mining Corp. Ltd. reported reserves in the Kambalda-St. Ives area at 17,169,000 tons of ore containing 3.4 percent nickel. More important, Western Mining reported that the potential of the area obviously is much greater than proved reserves. This evaluation was substantiated when the Great Boulder-North Kalgurli partnership reported reserves at its Carr Boyd Rocks mine of 1 million tons averaging 1.74 percent nickel and 0.53 percent copper and 500,000 tons averaging 0.7 percent nickel and 0.24 percent copper. The latest published reserve at Great Boulder's Scotia deposits was 1.13 million tons averaging 3.07 percent nickel and 0.25 percent copper, 250,000 tons of oxide ore averaging 1.13 percent nickel, and 500,000 tons of disseminated sulfides averaging 0.64 percent nickel. To the north, Poseidon N.L., although declining to estimate reserves, reported continuing success in outlining sulfide ore bodies of minable size that contain 1.5 percent or more nickel, plus 0.2 to 0.3 percent copper.

The entire nickel industry of Western Australia was advanced when Western Mining Corp. Ltd. opened a new nickel refinery at Kwinana on September 15, just 3 years after the company began nickel mining operations at Kambalda. The new refinery uses the Sherritt-Gordon ammonia-leach, hydrogen-reduction method to produce nickel briquettes from a milling concentrate containing an average of 11 percent nickel. The first nickel briquettes were consigned to the United Kingdom. Designed capacity of the refinery is 33 million pounds of nickel per year. Ammonium sulfate and sulfides of copper and cobalt were produced as byproducts. Western Mining planned to accept concentrates from other nickel producers in the area.

Further strengthening the Western Australian nickel industry, Western Mining Corp. Ltd. and the Western Australian Government entered an agreement whereby the company is to build a smelter in the Kalgoorlie, Kambalda, nickel district and construct a rail line between Kalgoorlie and Esperance. The smelter is to have an initial capacity of 20,000 tons of nickel per year and built-in provisions for expansion to 40,000 tons per year. The smelting plant will be able to treat high-grade nickel or concentrate and recover metals of the platinoid group.[2]

Production of nickel from Australia's lateritic deposits came closer to reality when Freeport, Queensland Nickel, Inc., a subsidiary of Freeport Sulphur Co. reported that the cabinet of the Queensland Government had agreed in principle on royalty and freight arrangements for development of the Greenvale nickeliferous laterite deposits. Under the principal terms of the agreement, the company is to construct and equip a 140-mile railroad from the property to a plant site near Townsville. The agreement was subject to legislative authorization, a final feasibility study, and financial and other arrangements.

However, all was not forward progress in building a nickel mineral industry in Australia. INCO decided not to develop lateritic nickel deposits at Wingellina, despite announced discovery of natural gas at Palm Valley only 280 miles away.

Botswana.—Development of the Pikwe-Selebi copper-nickel deposit proceeded slowly as Bamangwato Concessions, Ltd., negotiated with the World Bank and the Botswana Government for financing to construct a concentrator and smelter. The economic feasibility of the project was advanced as arrangements were pushed for a road between Zambia and Botswana. Such a road would greatly benefit Botswana's mining industry because it would facilitate importing needed material for the infrastructure.[3]

Canada.—Canadian nickel production of 305,000 tons was the highest on record, almost half again as much as 1969 output. The Canadian Ministry of Industry Trade and Commerce removed all quantitative restrictions on exports of primary nickel

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[2] BuMines Mineral Trade Notes. V. 68, No. 2, February 1971, pp. 17–19.

[3] Foreign Service Despatch A–213, Sept. 2, 1970, Lusaka.

and nickel scrap on October 30. Nickel remained on the Canadian export control list, but export permits were freely issued in the last 2 months of the year. The Canadian Prices and Incomes Commission studied nickel pricing policies after INCO announced an increase of 5 cents per pound for primary nickel exported after October 14. The Commission concluded that "increases in nickel prices did not by themselves increase domestic manufacturing costs and selling prices sufficiently to jeopardize directly the domestic price restraint program."[4]

The major nickel-producing concerns of Canada and several smaller companies actively sought nickel deposits in Ontario, Manitoba, Quebec, Newfoundland, British Columbia, the Yukon, and Northwest Territories. A large copper-nickel find was reported near Atikokan by Paulpic Gold Mines and Monteagle Minerals.[5] Preliminary exploration indicated a large ore body grading 0.4 percent copper, 0.15 percent nickel, and 0.1 percent cobalt.

The Hudson-Yukon Mining Co. Ltd., subsidary of the Hudson Bay Mining and Smelting Co. Ltd., announced plans to bring its Wellgreen property in the Yukon Territory into production in 1972 and signed a provisional contract with the Sumitomo Metal Mining Co. Ltd. of Tokyo, Japan, for sale for copper-nickel concentrates produced from the property.[6]

INCO continued expansion and modernization. It opened the Copper Cliff North mine in the new Sudbury district and the Kirkwood mine in the Ontario division. Copper Cliff will produce 6,000 to 8,000 tons of ore per day, and Kirkwood will produce 1,500 tons per day. This brought to 12 the number of INCO's producing mines in Canada. Surface facilities to be built under INCO's current expansion plan were about half completed by the end of the year.

Falconbridge Nickel Mines Ltd., completed its nickel-iron refinery and started tune-up production late in the year. The company completed a 1,425-foot mine shaft at its Mainbridge property in Manitoba.

Giant Mascot Mines Ltd. in British Columbia lost its entire surface plant by fire in August; however, by the end of the year reconstruction of the concentrator was well under way, and the company had discovered a new ore shoot on the 3,050-foot level of the mine.

Canadian nickel producers and their 1970 production or delivery to customers as given in their annual reports to stockholders were as follows:

Company	Type of operation	Thousand pounds
The International Nickel Co. of Canada Ltd.	Delivery	518,870,000
Falconbridge Nickel Mines Ltd.	Delivery	84,141,000
Sherritt Gordon Ltd.	Delivery	21,643,000
Consolidated Canadian Faraday Ltd.	Production	3,048,380
Giant Mascot Mines Ltd.	Recovery	4,037,291

Dominican Republic.—Falconbridge Dominicana C. por A. continued constructing a plant to produce ferronickel from laterite deposits. The work was on schedule, and 3,915 people were employed on the project at the end of the year.

France.—The office of Foreign Assets Control of the United States rescinded its order barring imports of nickel and nickel-bearing materials of French origin. However, the order did not apply during the 1970 calendar year.

Greece.—Larco, the only nickel-producing concern in Greece, almost doubled its output for the third year and announced that further expansion plans are under consideration.

Guatemala.—The negotiations of Exploraciones y Explotaciones Mineras Izabal, S. A. (EXMIBAL), with the Guatemalan Government to construct a 60-million-pound-per-year nickel plant, which had been blocked by the Government's belief that it could achieve better terms, was again active. Guatemala's new Administration explained why it is advisable to deal with EXMIBAL. EXMIBAL is owned 80 percent by INCO and 20 percent by Hanna Mining Co.

Indonesia.—P.T. Pacific Nikkel continued exploration of lateritic nickel deposits on Waigeo Island off the Sentani area of West Irian. Nikkel's exploration work was apparently successful. The company announced that exploitation depended on economics and financing.

[4] Prices and Incomes Commission (Canada). Primary Nickel Prices. Jan. 29, 1971, 21 pp.
[5] Northern Miner. Large Tonnage Copper-Nickel Find Near Atikokan. No. 42, Jan. 8, 1970, pp. 1, 16.
[6] Skillings' Mining Review, Hudson-Yukon To Develop Copper-Nickel Mine. V. 59, No. 11, Mar. 14, 1970, p. 18.

Japan.—Japanese nickel smelters were concerned about future supplies of nickel ore. Shimura Kako, Nippon Mining, Sumitomo Metal Mining, Pacific Metal Industries, and Nippon Yakin Kogyo asked the Government to negotiate with the French Government to secure the New Caledonian nickel ore needed to expand their smelting facilities. The same group started preliminary negotiations with the U.S.S.R. for development of nickel mines in the Kazakh district near Orsk.[7]

New Caledonia.—New Caledonia experienced a large-scale mining boom, as the concerns newly competing in the former monopoly environment began active operations. Ore deposits were well delineated by the beginning of the year, so most of the activity was in planning the mining and processing operations and the necessary infrastructures. The French Government asked the private companies to produce 160,000 tons of nickel annually by 1975. Construction and mining plans announced by four participating companies indicated annual production capacity of 200,000 tons of nickel by 1979. Small, independent, mining concerns petitioned the French Government to relax its restrictions on shipment of nickel ore to Japan. However, the Government indicated a strong desire to process the ores on the island, because New Caledonia's earnings provide France with foreign currency.

Société Le Nickel, S.A., consolidated its position as the premier nickel producer of New Caledonia by modernizing its plant, developing its reserves, and making plans to open new mining areas. Le Nickel formed Société Metallurgique Calédonienne, which announced that it would build a powerplant, erect a town, develop a harbor and port, and build a smelter at Poum on the northern tip of the island. The company was also planning to exploit laterite deposits at the southwestern end of the island on the shores of Bale de Prony. Patino Mining Corp. will participate with Le Nickel in the smelter and mining complex at Poum.

INCO, as the operator of Compagnie Française Industrielle et Minière du Pacifique (COFIMPAC), completed a feasibil-

[7] The Mining Journal (London). Japan/USSR Nickel Talks. V. 275, No. 7049, Sept. 25, 1970, p. 271.

Table 11.—Nickel: World production, by countries [1]

(Short tons)

Country [2]	1968	1969	1970 [p]
Australia (content of concentrate)	5,122	11,901	[e] 31,000
Brazil (content of ferronickel)	1,186	[e] 1,200	2,762
Burma (content of speiss)	[r] 32	33	23
Canada [3]	[r] 264,358	213,611	305,296
Cuba:			
Content of oxide [e]	20,950	20,400	20,400
Content of sulfide [e]	16,200	18,400	18,400
Dominican Republic (content of ferronickel)	324	------	------
Finland:			
Content of nickel sulfate	195	211	} [e] 4,600
Content of concentrates	[r] 3,556	3,996	
Greece (nickel recovered from ore)	[r] 4,769	[e] 6,400	[e] 10,000
Indonesia (content of ore) [4]	8,663	8,404	19,842
Morocco (content of cobalt ore)	335	311	152
New Caledonia (recoverable) [5]	88,018	99,731	116,143
Norway (content of concentrate)	[r] 248	273	[e] 360
Poland (content of ore) [e]	[r] 1,650	1,650	1,650
Rhodesia, Southern (content of concentrate) [e]	[r] 1,100	4,400	5,500
South Africa, Republic of (electrolytic)	[e r] 6,100	[e] 10,000	12,739
U.S.S.R. (content of ore) [e]	[r] 110,000	116,000	121,000
United States:			
Byproduct of copper refining	2,030	2,520	2,670
Nickel recovered from domestic ore	13,124	13,096	12,649
Total	[r] 547,960	532,537	685,186

[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, but information is insufficient to make a reliable estimate of production 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 which is not recovered separately.

[5] Nickel-cobalt content of metallurgical plant products, plus recoverable nickel-cobalt in exported ores.

ity report on a project to produce 50,000 tons of nickel pellets from lateritic deposits in Plaine des Lacs. Reportedly the project is to cost $481 million, which would rank it among the largest mining operations of the world.[8]

Philippines.—Acoje Mining Co., Inc., started its 400-ton-per-day nickel ore concentrator in May. The concentrates contain nickel, cobalt, and reportedly, substantial amounts of platinum-group metals, gold, silver, and copper. All Acoje concentrates are to be sold to Japanese companies under a long-term sales agreement.[9]

Marinduque Mining and Industrial Corp. (MMIC) spent most of 1970 negotiating for the capital needed to construct its proposed laterite mining plant on the Surigao Mineral Reservation. At yearend, tentative arrangements had been made with Japanese industrial concerns to provide part of the funds and with the Central Bank of the Philippines to provide the remainder. MMIC's board of directors suspended cash dividend payments to stockholders in 1970 so that the funds would be available for the nickel project.[10]

TECHNOLOGY

Judging from published reports and United States and Canadian patents, nickel research and development in 1970 continued at the high level of activity of the last two decades. There was some slackening of extractive metallurgical research, but this was offset by increased work in secondary recovery and antipollution projects. Studies to find and develop improved nickel-bearing alloys were little changed from past years.

The Federal Bureau of Mines nickel research activities were designed to conserve the metal and control pollution from processing plant waste products. Bureau researchers developed a method for treating a variety of electroplating wastes to recover nickel, copper, silver, and other metals. The recovery process cleans the effluent from electroplating plants to the point where it will meet most water quality standards. It is economically promising because it is based on neutralizing one waste with another to the benefit of both.[11]

A method of recovering valuable metals from superalloy scrap was developed in Bureau laboratories although the process is not as economically promising as the plant waste process, it nevertheless represents significant progress after years of seeking a profitable method of treating superalloy scraps.[12]

Bureau of Mines researchers also made semi-pilot scale tests to demonstrate a newly developed electrorefinery process for producing high-purity nickel and cobalt from crude nickel metal and high-grade ferronickel.[13] Nickel and cobalt metals superior in purity to commercially available electrolytic metals were produced as industrial-size cathodes. A high-chloride electrolyte was used in conjunction with solvent extraction to remove impurities. The pilot work was on a scale that could be extrapolated to a commercial operation.

INCO metallurgists developed a nickel-copper-columbium steel with yield strengths from 70 to 100 thousand pounds per square inch, depending on the heat-treating conditions and the size of the sections.[14] Several years are needed to prove the worth of a new alloy, but the exceptional combination of strength and workability of the steel indicates probable rapid commercial acceptance.

Nickel-bearing alloys were widely investigated in the continuing search for corrosion-resistant materials with high strength at elevated temperatures. Researchers of the United Aircraft Research laboratories developed a high-strength nickel-base eutectic alloy with strength three times that

[8] World Mining. COFIMPAC Discovered Laterite; Plans $481,000,000 Mine. V. 6, No. 12, November 1970, pp. 49, 66–68.

[9] Philippines Herald. Firm Gears Up for 400-Ton-Per-Day Milling Capacity. May 30, 1970, p. 5.

[10] American Metal Market. Marinduque Board of Directors Recommends Stock Split. V. 67, No. 238, Dec. 15, 1970, p. 20.

[11] George, L. C., and Andrew A. Cochran. Recovery of Metals From Electroplating Wastes by the Waste-Plus-Waste Method. BuMines Tech. Prog. Rept. 27, August 1970, 9 pp.

[12] Brooks, P. T., G. M. Potter, and D. A. Martin. Processing of Superalloy Scrap. J. Metals, V. 22, No. 11, pp. 25–29.

[13] Brooks, P. T., and G. M. Potter. Electrochemical Recovery of High-Purity Nickel and Cobalt From Crude Nickel and Ferronickel. BuMines Rept. of Inv. 7402, 1970, 25 pp.

[14] Nickel Topics, Nickel-Copper-Columbium Steel, a New Concept in High Strength Constructional Materials. V. 23, No. 1, 1970, pp. 4–5.

of the most widely used superalloys.[15] The eutectic, a mixture of trinickel aluminide and trinickel columbium, was said to have a tensile strength of 140,000 pounds per square inch at 2,000 degrees Fahrenheit. Other investigators sought means of improving the utility and advancing the engineering properties of superalloys currently being used in commercial applications. A comprehensive study was made on the behavior of "Waspaloy" (a commercial nickel-base superalloy) with varying precipitation strengthening additives of aluminum and titanium under solution (heat) treatment.[16]

Conventional control procedures were applied to advance the engineering properties of a nickel-iron base superalloy.[17] The researchers claimed that their work clearly showed that by correlating new material characteristics with advances in processing technology it is possible to advance the state of the art (as demanded by the increasing needs of gas turbine engines) without necessarily resorting to more complex alloys.

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[15] American Metal Market. Nickel-Base Eutectic Alloy Developed by United. V. 77, No. 176, Sept. 15, 1970, p. 16.

[16] Rehrer, W. P., D. R. Muzyka, and G. B. Heydt. Solution Treatment and Al + Ti Effects on the Structure and Tensile Properties of Waspaloy. J. Metals. V. 22, No. 2, February 1970, pp. 32–38.

[17] Vinter, A., and L. G. Wilbers. Advancing the Engineering Properties of a Ni-Fe Base Superalloy Through Conventional Control Procedures. J. Metals. V. 22, No. 5, May 1970, pp. 46–54.

Nitrogen

By Ted C. Briggs [1]

Domestic production of chemically combined nitrogen increased by slightly more than 1 percent, and production of high-purity nitrogen gas increased by 12 percent. Total domestic nitrogen usage for plant nutrient increased by 7 percent for the fiscal year ending June 30, 1970. Nitrogenous fertilizers constitute about 74 percent of the total amount of chemically combined nitrogen used in the United States. World production and consumption of nitrogeneous fertilizers also increased by 7 percent for the fiscal year ending June 30, 1970.

Table 1.—Salient nitrogen statistics

(Thousand short tons of contained nitrogen)

	1966	1967	1968	1969	1970 p
United States:					
Production as ammonia	8,904	10,205	10,130	10,786	10,919
Production as high-purity nitrogen gas	3,259	3,766	4,302	4,745	5,310
Exports of nitrogen compounds	707	828	1,428	1,645	1,406
Imports for consumption of nitrogen compounds	566	691	669	738	942
Consumption [1]	7,812	9,216	9,682	9,939	10,279
World: Production [1]	27,565	31,627	35,427	39,556	42,747

p Preliminary.
1 Estimated, excludes nitrogen gas.

Table 2.—Nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1966	1967	1968	1969	1970 p
Anhydrous ammonia: Synthetic plants [1]	8,722	10,029	9,968	r 10,624	10,772
Ammonia compounds, coking plants:					
Ammonia liquor	11	12	14	12	12
Ammonium sulfate	162	156	142	r 143	135
Ammonium phosphates	9	8	6	7	(2)
Total	8,904	10,205	10,130	r 10,786	10,919
Nitrogen gas [1]	r 3,259	r 3,766	r 4,302	r 4,745	5,310

p Preliminary. r Revised.
1 Bureau of the Census Current Industrial Report.
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)

Compounds	1969 r	1970 p
Ammonium nitrate	5,891	6,185
Ammonium sulfate [1]	2,615	2,535
Ammonium phosphate	4,592	5,212
Nitric acid	6,443	6,460
Urea	2,972	3,215

p Preliminary. r Revised.
1 Includes ammonium sulfate from coking plants.

Sources: Bureau of the Census and Tariff Commission.

Gross weight and dollar value of major nitrogen compounds exported dropped significantly, but imports increased.

Major advances were made in nitric acid technology, and the Tennessee Valley Authority will scale up its pilot plants for the production of urea-ammonium phosphate and sulfur-coated urea.

1 Chemist, Division of Nonmetallic Minerals.

DOMESTIC PRODUCTION

Anhydrous ammonia production increased 1.4 percent in 1970, ammonium nitrate production increased 5 percent, ammonium sulfate production decreased 3 percent, ammonium phosphate production increased 14 percent, nitric acid production increased slightly (0.3 percent), and urea production increased 8 percent. High-purity nitrogen gas production increased 12 percent.

The most significant ammonia plant startup for 1970 was American Oil Co.'s 2,000-ton-per-day plant at Texas City, Tex. Additional capacity from other sources is scheduled to come on stream in 1971. Domestic anhydrous ammonia production was essentially static. Any closure of old units was balanced by increased production of the newer, more efficient plants.

Nitric acid capacity was added during the year, thus adding to existing excess capacity. There was, however, no significant increase in production.

The U.S. Army called for bids to modernize six nitric acid units, two units at each of three ordnance plants. The plants are the Volunteer Army Ammunition Plant, Chattanooga, Tenn., with a nitric acid capacity of 80,000 tons per year; the Joliet Army Ammunition Plant, Joliet, Ill., with a nitric acid capacity of 110,000 tons per year; and the Radford Army Ammunition Plant, Radford, Va., with a nitric acid capacity of 135,000 tons per year. Estimated cost of the project is $70 to 75 million.[2]

Ammonium phosphate production increased owing to relatively high domestic prices. The price situation prompted the first significant increase in imports in several years.

Ammonium sulfate production decreased but remained in oversupply. The excess is due, in part, to the fact that ammonium sulfate is a byproduct or coproduct of the production of other materials such as caprolactam. The possibility of using ammonia scrubbing methods to remove sulfur dioxide from stack gas could, in future years, add to the abundance of ammonium sulfate.

[2] Chemical Week. More Acid for Army Ordnance. V. 106, No. 15, Apr. 15, 1970, pp. 21–22.

Table 4.—Recent nitrogen plant construction and startups

(Capacities in short tons per year)

Company	Location	Type of plant	Date of scheduled startup	Capacity
Air Products and Chemicals, Inc.	East Fishkill, N.Y.	Nitrogen	1970	87,000
Do	Geismar, La	do	1970	NA
Do	Guayanillo, P.R.	do	1970	NA
American Cyanamid Co	Frontier, La	Melamine	1971	35,000
American Oil Co	Texas City, Tex	Ammonia	1970	730,000
Big Three Industrial Gas & Equipment Co.	Bayport, Tex	Nitrogen	Planned	402,000
Cemetron Corp	Houston, Tex	do	1971	NA
Cooperative Farm Chemicals	Lawrence, Kan	Ammonia	1971	365,000
E.I. duPont de Nemours & Co., Inc.	Gibbstown, N.J	Sodium Nitrate	1970	NA
Do	do	Nitric acid	1970	297,000
Escambia Chemical Corp	Pensacola, Fla	Nitric acid prills	Planned	NA
Do	do	Ammonium nitrate prills	do	NA
Hawkeye Chemical Corp	Clinton, Iowa	Urea	1971	33,000
Do	do	Urea solutions	1971	84,000
Olin Corp	Lake Charles, La	Nitric acid	1972	183,000
Tennessee Valley Authority	Muscle Shoals, Ala	Ammonia	1971	82,000
Do	Wilson Dam, Ala	Urea	1972	66,000
Wycon Chemical Co	Cheyenne, Wyo	Nitric acid	1970	28,000
Do	do	Ammonium nitrate	1970	33,000

NA Not available.

Sources: Nitrogen (London) and Chemical Engineering.

CONSUMPTION AND USES

Domestic consumption of contained nitrogen increased 340,000 tons, or 3.4 percent. Consumption for 1970 was measured by production plus imports minus exports, with an adjustment for change in stocks of synthetic ammonia and ammonia compounds from coking plants. Nitrogen gas was excluded.[3]

Fertilizers continued to be the major use of nitrogen, although nitrogen gas production is, at present, growing more rapidly than fixed nitrogen for use in fertilizers.

In addition to fertilizers, large quantities of chemically combined nitrogen were used in explosives, plastics, resins, synthetic fibers, animal feed, pulp and paper, and synthetic rubber. Ammonia, which is obtained by the catalyzed reaction of nitrogen and hydrogen at high temperatures and pressures, is the building block from which other large usage nitrogen-containing compounds are manufactured in the United States.

Nitrogen gas was used as an inert blanketing agent in chemical processing, for a controlled atmosphere in steelmaking, as a nonreactive purging and blanketing agent in the electronic industry, and for an inert atmosphere in glassmaking. Liquid nitrogen was used in aerospace, food processing and shipping, and to provide the low temperatures (-196° C) required for many scientific instruments and applications.[4]

Each year the Statistical Reporting Service of the U.S. Department of Agriculture publishes a comprehensive report on domestic consumption of commercial fertilizers for the fiscal year ending June 30. This year's report shows the following changes in tonnage of nitrogenous fertilizers consumed:

Anhydrous ammonia	increased 11 percent
Aqua ammonia	increased less than 1 percent.
Ammonium nitrate	increased 11 percent
Ammonium nitrate-limestone	decreased 15 percent
Ammonium sulfate	increased 2.5 percent
Calcium cyanamide	decreased 27 percent
Calcium nitrate	increased 12 percent
Nitrogen solutions	increased 16 percent
Sodium nitrate	decreased 18 percent
Urea	decreased 8 percent
Ammonium phosphate	decreased 14 percent

Total nitrogen usage for plant nutrient increased 7 percent, to 7.5 million short tons for the fiscal year ending June 30, 1970.[5]

PRICES

The prices of most of the major nitrogen compounds were stable during the year. Anhydrous ammonia increased in price 10 to 18 percent from January to December but remained below previous years' prices. The oversupply of ammonium sulfate continued: Prices for standard grade were up to $12 per ton off list prices in some areas. Industrial urea was unstable, showing a 28-percent drop in August from the January high. Sodium nitrate was very stable, reflecting no change in foreign prices. Diammonium phosphate prices increased 8 to 12 percent.

[3] Bureau of the Census Current Industrial Reports.

[4] Lewis, Richard W. Nitrogen. Chapter in Mineral Facts and Problems. BuMines Bull. 650, 1970, pp. 1099–1115.

[5] Statistical Reporting Service, U.S. Department of Agriculture, Washington, D.C. Commercial Fertilizers—Consumption in the United States—Fiscal Year Ended June 30, 1970. May 1971, 26 pp.

Table 5.—Price quotations for major nitrogen compounds in 1970

(Per short ton)

Compound	Jan. 5	Dec. 28
Ammonium nitrate, fertilizer grade, 33.5 percent nitrogen, bulk, carload lots, f.o.b. works	$41–43	$41–45
80-pound bags (same basis)	47–50	48–52
Ammonium sulfate, standard grade, bulk, carload lots, f.o.b. works	23–31	23–31
Bags, cwt., works	37	37
Anhydrous ammonia, fertilizer, tanks, freight equalized east of Rockies	50	55–59
Aqueous ammonia 29.4 percent NH_3	65	65–70
Sodium nitrate, domestic, agricultural, bulk, carload lots, f.o.b. works	47	47
Bags, cwt., f.o.b. works	51	51
Sodium nitrate, imported, commercial, bulk, carload lots, f.o.b. port warehouse	45.50	45.50
Bags, cwt., f.o.b. port warehouse	49.50	49.50
Urea:		
Industrial 46 percent nitrogen, bulk, 50 ton carlots, delivered freight equalized	92	64–66
Agricultural 46 percent nitrogen, bulk, carlots, delivered freight equalized	63	63–65
Agricultural 45 percent nitrogen, bulk, carlots, works	61	61–63
Diammonium phosphate, fertilizer grade, 18–46–0 bulk, carlots, f.o.b. works	58–60	65

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

The gross weight of United States exports of major nitrogen compounds decreased 15 percent. Also, the weight of contained nitrogen exported decreased 15 percent. The dollar value of exported nitrogen fell $33 million, or 18 percent.

Imports increased 38 percent on a gross weight basis or 28 percent on the basis of nitrogen content. Dollar value of imports increased $30 million, or 34 percent.

Trade surplus decreased from $95 million in 1969 to $32 million in 1970. Ammonium phosphates were the only major nitrogen materials that posted an increase in exports for the year.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds

(Thousand short tons and thousand dollars)

Compounds	1969 r			1970		
	Gross weight	Nitrogen content	Value	Gross weight	Nitrogen content	Value
EXPORTS						
Industrial chemicals: Anhydrous ammonia and chemical grade aqua (ammonium content)	265	217	$6,830	243	199	$6,877
Fertilizer materials:						
Ammonium nitrate	112	38	5,723	67	22	3,393
Ammonium phosphates	942	170	50,744	1,022	184	54,643
Ammonium sulfate	812	171	28,383	522	110	8,061
Anhydrous ammonia and aqua (ammonia content)	r 856	703	26,241	741	608	23,312
Nitrogenous chemical materials, n.e.c.	30	9	2,122	19	6	1,376
Sodium nitrate	(1)	(1)	52	2	(1)	93
Urea	596	274	39,944	465	223	32,439
Mixed chemical fertilizers	396	63	24,059	340	54	20,541
Total	r 4,009	r 1,645	r 184,098	3,421	1,406	150,735
IMPORTS						
Industrial chemicals: Ammonium nitrate	(1)	(1)	6	1	(1)	82
Fertilizer materials:						
Ammonium nitrate	233	r 79	r 11,710	326	109	15,125
Ammonium nitrate-limestone mixtures	(1)	(1)	1	(1)	(1)	8
Ammonium phosphates	273	52	18,391	457	87	28,086
Ammonium sulfate	138	29	r 4,566	218	46	6,501
Calcium cyanamide or lime nitrogen	14	3	878	8	2	762
Calcium nitrate	50	8	1,195	52	8	1,138
Nitrogen solutions	91	27	3,976	124	37	5,200
Anhydrous ammonia	447	367	20,577	485	398	20,678
Potassium nitrate or saltpeter, crude	11	1	449	15	2	812
Potassium nitrate, sodium nitrate mixtures	37	6	1,370	56	8	2,231
Sodium nitrate	184	29	5,252	129	21	4,142
Urea	285	131	18,561	434	200	22,373
Nitrogenous fertilizers, n.s.p.f.	16	3	981	14	3	870
Mixed chemical fertilizers	24	3	820	176	21	11,168
Total	r 1,803	r 738	r 88,733	2,495	942	119,176

r Revised.
1 Less than ½ unit.

WORLD REVIEW

Both world production and consumption of nitrogenous fertilizers for the 1970 fiscal year ending June 30, increased 7 percent over the 1969 fiscal year.

Algeria.—Ammonia production has started at the Algerian nitrogen works at Arzew. The ammonia will be used to manufacture 441 tons of urea and 551 tons of ammonium nitrate per day. In addition, 551 tons per day of ammonia will be available for export.[6]

Australia.—Western Mining Corp., Ltd.'s 193,000-short-ton-per-year ammonium sulfate plant at Kwinana became operational. The unit is a part of a new nickel refinery that uses an ammonia leaching process.[7]

[6] Chemical Age (London). Construction—Technology. V. 101, No. 2681, Dec. 4, 1970, p. 28.
[7] Nitrogen (London). New Plants and Projects. No. 67, September–October 1970, p. 16.

Table 7.—Fertilizer nitrogen compounds: World production and consumption for years ended June 30, by countries

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1967–68	1968–69	1969–70	1967–68	1968–69	1969–70
Albania [1]	6	19	32	8	21	28
Algeria	------	------	------	16	15	33
Argentina	12	27	22	41	34	39
Australia	61	105	202	151	192	190
Austria	278	281	273	109	124	133
Belgium	397	514	567	187	188	196
Brazil [1]	8	10	7	117	159	181
Bulgaria [1]	390	563	646	356	402	443
Burma	------	------	------	33	25	29
Canada	518	611	667	354	267	270
Ceylon	------	------	------	[1] 48	[1] 62	68
Chile [1]	116	129	110	22	27	45
China, mainland	[2] 937	[2] 1,036	[e] 1,200	[2] 1,791	[2] 2,304	[e] 2,800
Colombia	44	46	55	52	58	60
Costa Rica	18	21	18	[1] 17	32	31
Cuba	11	3	------	187	193	197
Czechoslovakia	[1] 270	[1] 324	[1] 371	315	391	441
Denmark	[3] 66	[3] 75	[3] 77	256	273	298
Dominican Republic	------	------	------	17	14	22
Ecuador	------	2	3	30	40	24
El Salvador	6	7	9	31	37	39
Finland	112	111	169	118	127	176
France	1,359	1,506	1,447	1,249	1,370	1,370
Germany, East [1]	370	387	431	434	563	537
Germany, West	1,719	1,761	1,735	1,047	1,028	1,196
Greece	129	140	161	173	201	210
Guatemala	------	------	------	[1] 15	[1] 26	15
Hungary [1]	204	270	331	261	336	383
Iceland [1]	9	9	9	13	13	13
India	444	621	805	1,252	1,347	1,371
Indonesia	45	47	47	116	218	182
Iran	30	25	31	51	54	61
Ireland	50	61	64	60	71	79
Israel	29	30	31	31	30	30
Italy	1,208	1,200	1,059	529	567	607
Japan	2,243	2,313	2,372	980	999	989
Korea, North	[2] 143	[2] 163	[e] 185	[2] 143	[2] 163	[e] 185
Korea, Republic of	[1] 165	[1] 348	[1] 392	[1] 306	315	353
Kuwait	61	76	83	------	------	------
Lebanon	8	12	14	14	15	18
Luxembourg	------	2	2	9	[1] 10	[1] 10
Malaysia, West	18	20	34	45	46	60
Mexico	191	284	395	328	417	427
Morocco [1]	2	1	5	29	41	38
Netherlands Antilles	39	37	39	------	------	------
Netherlands	936	1,052	998	379	374	424
Nicaragua	------	------	------	18	23	23
Norway	396	412	409	74	76	83
Pakistan	118	128	191	279	287	353
Peru	[4] 31	[4] 34	[4] 36	75	64	75
Philippines	48	50	59	71	70	78
Poland	[1] 654	[1] 837	[1] 1,034	667	773	871
Portugal	131	151	129	112	112	122
Rhodesia, Southern	------	------	25	46	46	51
Romania [1]	410	464	545	318	364	419
Senegal	1	3	3	6	4	6
South Africa, Republic of	99	160	225	144	159	165
Spain	468	545	599	527	626	666
Sudan	------	------	------	43	46	43
Sweden	[5] 154	[5] 159	[5] 159	200	210	226
Switzerland	41	40	32	35	36	37
Syria	------	------	------	19	24	22
Taiwan	179	211	215	178	188	182
Thailand	[1] 10	29	29	58	63	81
Trinidad and Tobago [6]	412	434	387	6	6	6
Turkey	[1] 35	[1] 38	58	[1] 152	[1] 206	[1] 255
U.S.S.R.	[7] 4,137	[7] 4,604	[7] 4,970	3,405	3,807	4,187
United Arab Republic	[1] 161	[1] 154	[1] 114	269	318	290
United Kingdom	942	927	783	1,002	943	716
United States (includes Puerto Rico)	[8] 7,283	[8] 7,869	[8] 8,413	6,787	6,959	7,362
Venezuela	17	19	15	[1] 21	[1] 31	[1] 24
Vietnam, South	------	------	------	[1] 76	[1] 68	135
Yugoslavia [1]	111	132	202	228	298	313

See footnotes at end of table.

Table 7.—Fertilizer nitrogen compounds: World production and consumption for years ended June 30, by countries—Continued

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1967–68	1968–69	1969–70	1967–68	1968–69	1969–70
Other:						
North America and Central America [9]	------	------	------	44	53	58
South America [10]	------	------	------	16	23	22
Europe [11]	------	------	------	4	4	4
Africa [12]	------	------	------	110	122	147
Asia [13]	------	------	------	55	65	69
Oceania [14]	------	------	------	10	14	16
World total	28,490	31,649	33,730	26,775	29,277	31,408

e Estimate.
1 Calendar year referring to the first part of the split year.
2 Source: 1967–68 and 1968–69; Nitrogen (London) No. 63, January–February 1970, pp. 13–14.
3 August–July.
4 Includes guano.
5 June–May.
6 Calendar year referring to the last part of the split year; data represent nitrogen content of anhydrous ammonia produced. Source: Department of State Airgrams.
7 Including an unspecified amount of technical nitrogen.
8 Excluding sodium nitrate.
9 Includes Barbados, British Honduras, Guadeloupe, Haiti, Honduras, Jamaica, Martinique, and Panama.
10 Includes Guyana, Surinam, and Uruguay.
11 Includes Channel Islands (Jersey only) and Isle of Man.
12 Includes Angola, Botswana, Cameroon, Central African Republic, Congo (Brazzaville), Congo (Kinshasa), Dahomey, Ethiopia, Ghana, Equatorial Guinea, Ivory Coast, Kenya, Liberia, Libya, Malagasy Republic, Malawi, Mauritius, Mozambique, Nigeria, Reunion, Somalia, Swaziland, Tanzania, Tunisia, Uganda, and Zambia.
13 Includes Afghanistan, Cambodia, Cyprus, Iraq, Jordan, Laos, Nepal, Ryukyu Islands, Saudi Arabia and Singapore.
14 Includes Fiji Islands and New Zealand.

Source: Statistical Office of the United Nations, Statistical Yearbook, 1970. New York, 1971, pp. 285–286, 538–539, unless otherwise specified.

Brazil.—June 1 marked the opening of Ultrafértil SA's nitrogen fertilizer complex near Santos. Products include 165,000 tons per year of ammonia, 206,000 tons per year of nitric acid, 228,000 tons per year of prilled ammonium nitrate, 251,000 tons per year of ammonium nitrate solution, and 177,000 tons per year of diammonium phosphate.[8]

Colombia.—Plants that produce nitrogen materials in Colombia are as follows:[9]

Company and location	Year started	Product	Annual capacity (short tons)	Raw material
Amoniacosdel Caribe (AMOCAR) at Cartagena.	1963	Anhydrous ammonia.	143,000	Natural gas.
Fertilizantes Colombianos (FERTICOL) at Barrancabermeja.	1963	----do------	25,000	Do.
Abonos Colombianos (ABOCOL) at Cartagena.	1963	Urea--------	99,000	Carbon dioxide gas and ammonia.
Fertilizantes Colombianos (FERTICOL) at Barrancabermeja.	1963	----do------	11,000	Ammonia and natural gas.
Quimica Borden and Quimica Proco at Cali.	----	----do------	5,900	

Cuba.—The $39 million Cienfuegos nitrogen fertilizer complex was scheduled for operation before yearend. The complex comprises a 208,000-short-ton-per-year ammonia plant, a 219,000-ton-per-year urea plant, a 269,000-ton-per-year nitric acid plant, and a 342,000-ton-per-year ammonium nitrate plant.[10]

Finland.—Typpi Oy's 825-ton-per-day ammonia plant came on stream at Oulu. This plant is the second one to use centrifugal gas compressors discharging at the full economic conversion pressure of 300

8 European Chemical News. Brazilian Fertilizers Get Production Boost. V. 17, No. 437, June 19, 1970, p. 10.
9 Bureau of Mines. Mineral Trade Notes. V. 67, No. 3, March 1970, p. 37.
10 Nitrogen (London). New Plants and Projects. No. [illegible], July–August 1970, p. 18.

atmospheres, the first one being the 1,200-ton-per-day plant in Norway.[11]

Germany, East.—M. W. Kellogg Co. has been granted an export license to provide the basic technology for two 1,500-ton-per-day ammonia plants to be built in East Germany. Detailed design, engineering, and procurement will be provided by Toyo Engineering Corp. of Tokyo. The first plant will be built for Leuna-Werke Walter Ulbrecht at Leuna, and the second will be built for Stickstoffwerk-Piesteritz at Piesteritz.[12]

Hungary.—The U.S.S.R. is to supply the design and equipment for a nitric acid plant with an annual capacity of 529,000 short tons. The unit is to be delivered in 1971 and will start production in 1974.[13]

India.—Plants which produced nitrogenous fertilizers in India as of December 31, 1970, are as follows:[14]

Plant and location	Product	Annual capacity (short tons)
Fertilizer Corporation of India at Sindri (Bihar)	Ammonium sulfate	391,000
Do	Ammonium sulfate-nitrate	134,000
Do	Urea	26,000
Fertilizer Corporation of India at Namrup (Assam)	Ammonium sulfate	110,000
Do	Urea	61,000
Fertilizer Corporation of India at Nangal (Punjab)	Calcium ammonium nitrate	353,000
Fertilizer Corporation of India at Trombay (Maharashtra).	Urea	109,000
Do	Nitrophosphate	254,000
Fertilizer Corporation of India at Gorakhpur (Uttar Pradesh).	Urea	197,000
Fertilizers and Chemicals Travancore Ltd. at Alwaye (Kerala).	Ammonium sulfate	270,000
Do	Ammonium chloride	72,000
Hindustan Steel Ltd. at Rourkela (Orissa)	Calcium ammonium nitrate	529,000
Neyveli Lignite Corporation Ltd. at Neyveli (Tamil Nadu).	Urea	170,000
Gujarat State Fertilizers Co. Ltd. at Baroda (Gujarat)	Ammonium sulfate	182,000
Do	Urea	430,000
Coromandel Fertilizers Ltd. at Visakhapatnam (Andhra Pradesh).	Ammonium phosphate	402,000
Do	Urea	18,000
Shriram Chemical Industries at Kota (Rajasthan)	do	265,000
Indian Explosives Ltd. at Kanpur (Uttar Pradesh)	do	496,000
Mysore Chemicals and Fertilizers Ltd. at Belagula (Mysore).	Ammonium sulfate	7,000
New Central Jute Mills Co. Ltd. at Varanasi (Uttar Pradesh).	Ammonium chloride	45,000
E.I.D. Parry Ltd. at Ennore (Madras).	Ammonium sulfate	77,000

Iran.—Shahpur Chemical Co.'s 200,000-ton-per-year urea plant, operating under the Allied Chemical Corp. process, was completed at Bandar Shahpur. The 364,000-ton-per-year ammonia plant using the M.W. Kellogg Co. process was scheduled to start production in the latter part of 1970.[15]

Israel.—Chemical & Phosphates Ltd.'s additional 91,000-short-ton-per-year ammonia plant was scheduled to come into operation at Haifa in 1971; one-third of the output was to be exported. The present plant, having a capacity of 35,000 tons of ammonia per year, is to be phased out.[16]

Ivory Coast.—Société Ivoirienne d'Engrais (SIVENG) is planning to produce fertilizers from imported raw materials at an initial annual rate of 50,000 short tons. The fertilizers will be composed of 3,000 tons of simple superphosphate, 22,000 tons of ammonium sulfate, 16,500 tons of binary fertilizers (nitrogen and phosphorus), and 8,500 tons of ternary fertilizers (nitrogen, phosphorus, and potassium).

The company is capitalized as follows: the Government of Ivory Coast, 33.3 percent; Société Tropicale d'Engrais et de Produits Chimiques, 28.3 percent; Salzdetfurth A.G. and Deutsche Entwicklungsgesellschaft, 28.3 percent; ENSA, 5 percent; and others, including the Banque Ivoirienne de Développement Industriel 5.1 percent.[17]

[11] Nitrogen (London). New Ammonia Plant in Finland On-Stream. No. 63, January–February 1970, pp. 21–23.

[12] Chemical Age (London). Kellogg Process Technology in E. German Ammonia Plant. V. 101, No. 2669, Sept. 11, 1970, pp. 7–8.

[13] Chemical Age (London). Soviet Nitric Acid Plant for Hungary. V. 100, No. 2661, July 17, 1970, p. 20.

[14] Bureau of Mines. Mineral Trade Notes. V. 68, No. 7, July 1971, pp. 20–21.

[15] Work cited in footnote 7.

[16] Work cited in footnote 7.

[17] Bureau of Mines. Mineral Trade Notes. V. 67, No. 1, January 1970, p. 9.

Japan.—Chisso-Asahi Fertilizer Corp.'s 291,000-short-ton-per-year ammonia plant under construction at Mizushima will replace Asahi Chemical's 39,000-ton unit and Chisso Corp's 30,000-ton unit.

Nihon Ammonia Co. Ltd.'s 450,000-ton-per-year ammonia and 546,000-ton-per-year urea plants currently under construction at Sodegaura, Chiba district, will replace Nissan Chemical Industries, Ltd.'s, 25,000-ton ammonia plant, Showa Denko KK's 25,000-ton ammonia unit, and Seitetsu Chemical's 84,000-ton ammonia unit.

Nippon Kasei KK planned to bring its 364,000-ton-per-year ammonia plant and 327,000-ton-per-year urea plant at Onahama on stream in March. The plant would use naphtha feedstock and would replace the 107,000-ton-per-year ammonia plant of Tohoku Hiryo and the 85,000-ton ammonia unit of Nihon Suiso.

The 125,000-ton-per-year ammonia plant of Ube Industries, Ltd., and the 115,000-ton-per-year plant of Kyowa Chemicals will be phased out when Ube Ammonia Industry brings its 455,000-ton-per-year ammonia expansion into operation.[18]

Dan Kako's new 55,000-short-ton-per-year potassium sulfate plant and 55,000-ton-per-year nitrogen-potassium compound fertilizer plants at Niigata were scheduled to begin operation in September.

Japan Gas-Chemical Co., Inc.'s 273,000-ton-per-year ammonia plant at Niigata was under construction. It will use natural gas as feed stock and will replace the existing 127,000-ton unit.

Construction was started on Mitsui-Toatsu Chemicals Inc.'s 22,000-ton-per-year melamine plant at Osaka. This project will cost an estimated $7 million. The firm currently operates a 9,000-ton-per-year melamine plant at Chiba.[19]

Korea, Republic of.—The Yong Nam Chemical Fertilizer Co., Ltd., a joint venture between Chung-Ju Fertilizer Co. of Korea and a U.S. Swift-Skelly consortium, produces both urea and complex fertilizers. Plant capacity is 93,000 short tons of urea and 200,000 tons of complex fertilizers per year.[20]

Netherlands.—A number of new ammonia plants are scheduled to come on stream. Nederlandse Stikstof's 400,000-ton-per-year plant is due on stream in 1971 and will supplement two plants with a combined capacity of 1,100 tons per day that are already in operation.

Dutch State Mines is expected to shut down some of its older units when its new 1,700-ton-per-day plant comes on stream in 1971. The company's overall ammonia capacity will be boosted to 882,000 tons per year.

Mekog Albatros will replace three older ammonia units with a 992-ton-per-day plant due on stream in late 1970. Esso Chemical has a 1,650-short-ton-per-day plant on stream in Rotterdam.[21]

Pakistan.—East Pakistan Industrial Development Corp.'s (EPIDC) urea plant at Ghorasal, Dacca, went into preliminary production in August 1970. Plant capacity is 377,000 short tons per year. Toyo Engineering Corp. of Japan constructed the project on a turnkey basis using Japanese machinery and technicians. Natural gas (39 million cubic feet daily) is piped 20 miles to the plant from the Titas gasfield.[22]

Poland.—New natural gas reserves have been discovered in the Poznan region of Poland. The nitrogen content of the gas is 48.6 percent, suggesting use as a feedstock for the production of nitrogenous fertilizers. A plant located in the Poznan area would also supply the regions of Zielona Gora, Koszalin, Szczecin, and parts of Wroclaw, thus substantially reducing fertilizer transportation cost in those areas.[23]

U.S.S.R.—A 507,000-short-ton-per-year (17 percent contained nitrogen) complex fertilizer plant went on stream at Nevinnomyssk. At Novomoskovsk another complex fertilizer plant producing a 12-percent contained nitrogen formulation went into operation in January.[24]

New ammonia facilities coming on stream were a 310,000-ton-per-year plant using coke oven gas feedstock at Cherepovetsk and an additional 109,000-ton-per-year unit at Grodno. In addition, a new 441,000-ton-per-year granulated ammonium nitrate plant and single superphosphate plant came on stream at Cherepovetsk.[25]

[18] Nitrogen (London). New Plants and Projects. No. 64, March–April 1970, p. 12.
[19] Nitrogen (London). New Plants and Projects. No. 65, May–June 1970, p. 18.
[20] U.S. Embassy Seoul, Korea. State Department Airgram A–482. Dec. 4, 1970, p. 2.
[21] Chemical Week. Ammonia Glut Spreads. V. 107, No. 2, July 8, 1970, p. 15.
[22] Bureau of Mines. Mineral Trade Notes. V. 68, No. 2, February 1971, p. 10.
[23] European Chemical News. Polish Gas Could Find Fertilizer Outlet. V. 19, No. 467, Feb. 12, 1971, p. 8.
[24] Page 10 of work cited in footnote 18.
[25] Nitrogen (London). New Plants and Projects. No. 68, November–December 1970, p. 12.

TECHNOLOGY

Two pipelines for transporting anhydrous ammonia to mid-western agricultural areas for fertilizer were in operation. The MAPCO (formerly Mid-America Pipeline Co.) pipeline, 720 miles in length and completed in 1968 at a cost of $15 million, extends from Borger, Tex., through Kansas and into Nebraska and Iowa. Gulf Central Pipeline Co.'s pipeline, 1,700 miles in length and completed in 1970 at a cost of approximately $100 million, extends from Luling, La., through Arkansas to Herman, Mo., where it branches. The eastern branch extends across Illinois and into Indiana. The northwestern branch extends into Iowa and Nebraska. The MAPCO pipeline has a capacity of 1,300 tons of ammonia per day, whereas Gulf Central Pipeline Co.'s pipeline has a capacity of about 3,000 tons per day.[26]

A number of significant developments in nitric acid technology have occurred. The decision of the U.S. Army to replace six nitric acid plants with new units could be a showcase for the latest engineering developments in nitric acid production. Specifications require that two of the plants use a direct, strong nitric acid process rather than the more frequently used (in the United States) process of concentrating a weak acid. Operation of the strong acid and weak acid processes in new plants of comparable size should provide valuable information on the economics of the two systems.

Direct methods for making concentrated nitric acid are evolving in the United States and have been used widely in Europe. Relative merits of the different methods are still under discussion.

Another facet of the new advances in nitric acid technology revolves around the process catalyst. For many years the standard catalyst has been a noble metal gause containing 90 percent platinum and 10 percent rhodium. Now C & I Girdler has developed a new nonnoble metal catalyst, thought to be based on cobalt oxide. Engelhard Industries has developed a new noble metal system that uses 60 percent less platinum than current commercial grades. It is offered with a palladium-gold "getter" system to capture volatilized platinum. The new developments in catalyst promise significant reductions in the cost of manufacturing nitric acid, perhaps as much as a 38-percent reduction in the cost of producing a ton of acid.

Another factor now considered in new nitric acid plants is pollution control. Conventional United States plants had 2,000 to 4,500 parts per million (ppm) nitric oxides in the tail gas. Early efforts focused on conversion of the reddish brown nitrogen dioxide and dinitrogen tetroxide gases to colorless nitric oxide, which was only an improvement in appearances. The use of new technology, such as dual combustors or higher absorber pressures, can reduce pollution to below 200 ppm. New plants are predicted to include the improved pollution control technology because of the national commitment to a cleaner environment, although such improvements will add to plant cost.[27]

Advances have been made in the technology of urea production, primarily in the scale-up by a factor of 10 in the production capacity of new plants versus the older units of 20 years ago. An article reviewed the current urea production methods and discussed the advances being made in parameter evaluation to determine the most efficient and economical processes.[28]

A more economical method for producing urea was announced by Montedison SpA. Economies are enhanced as a result of heat recovery from recycled carbamate. The method was developed after many years of urea-plant design and experience; it has been tested in a 772-ton-per-day plant at Sluiskil, Netherlands, since 1968. The method will also be used in another plant of 992-ton-per-day capacity, under construction at the same site.[29]

The Tennessee Valley Authority will scale up its small pilot plants for two new types of fertilizer. One of the new materials is urea-ammonium phosphate, which can be produced in grades with up to 60

[26] Chemical and Engineering News. Midwest Ammonia Pipelines Now in Operation. V. 49, No. 1, Jan. 4, 1971, pp. 17–18.

[27] Work cited in footnote 2.
Chemical Engineering. Nitric Acid Rolls On. V. 77, No. 14, June 29, 1970, pp. 24–25.

[28] Nitrogen (London). Urea Processes Today—A Review of Available Methods and New Trends in the Urea Technology. No. 64, March–April 1970, pp. 17–24.

[29] Nitrogen (London). New Urea Process From Montedison. No. 63, January–February 1970, pp. 32–33.

percent plant food. It could replace some mixed fertilizers in current use. The second new material is sulfur-coated urea which releases its nitrogen slowly throughout the growing season. Experiments have shown crop yields from a single application of sulfur-coated urea to be equal or superior to multiple applications of soluble fertilizers. The new fertilizers have a number of economic and ecological implications, such as lower application cost and reduced leaching.[30]

A new 90-foot-high prilling tower is in operation at the Plainfield, Ill., research center of Chicago Bridge & Iron Co. The new tower allows research on the prilling of very viscous materials and has a specially designed spray nozzle.[31]

[30] Chemical and Engineering News. The Next Generation of Fertilizer Materials Goes Into the Semiworks Stage at TVA. V. 48, No. 2, Jan. 12, 1970, p. 49.

[31] Nitrogen (London). Current Events. No. 63, January–February 1970, p. 34.

Peat

By Eugene T. Sheridan [1]

Peat production in the United States in 1970 totaled 516,825 short tons, 10 percent less than the output recorded in 1969, production declined in 12 States and active plants decreased by six. Most of the production loss was the result of the smaller output in Florida, Illinois, Michigan, and Washington.

Commercial sales declined 7 percent in quantity but 15 percent in value as the average plant price decreased $1.08 per ton to $11.38. The value of sales was particularly influenced by the average value of peat produced in Michigan, which decreased from $14.62 per ton in 1969 to $11.36 per ton in 1970.

Imports also decreased, and as a result, the total amount of peat available for consumption, 808,814 tons, consisting of commercial sales plus imports, reached the lowest level in 7 years.

World production was estimated at 217 million tons. The U.S.S.R. was the largest producer with an output estimated at 206 million tons, 95 percent of the world total.

DOMESTIC PRODUCTION

The 10-percent decrease in production in 1970 resulted principally from the smaller output of reed-sedge peat that is sold mainly for general soil improvement purposes. Although production declined in 12 States, the bulk of the production loss was recorded in Florida, Illinois, Michigan, and Washington. On the other hand, Colorado and Pennsylvania had substantial production increases.

Twenty-four States produced peat in 1970 compared with 23 States in 1969. The additional producing State was North Dakota, which has one operation that produces intermittently. Michigan remained the principal producer, with nearly one-third of the output. Illinois, Pennsylvania, Florida, New Jersey, Colorado, and Indiana followed in output in the order named. These States, with Michigan, accounted for about four-fifths of the total production.

Active operations decreased form 128 to 122, and average porduction per plant declined to 4,236 tons. About three-fourths of the plants, however, had outputs smaller than the average. Only 28 plants had production in excess of 5,000 tons, and only four plants produced more than 25,000 tons.

[1] Mineral specialist, Division of Fossil Fuels.

Table 1.—Salient peat statistics

	1967	1968	1969	1970
United States:				
Number of operations	131	135	128	122
Production ... short tons	617,172	618,995	572,122	516,825
Commercial sales ... do	619,687	619,161	565,760	525,603
Value of sales ... thousands	$6,768	$7,230	$7,055	$5,986
Average per ton	$10.92	$11.68	$12.47	$11.39
Imports ... short tons	280,842	287,600	299,997	283,211
Available for consumption [1] ... do	900,529	906,761	865,757	808,814
World: Production ... thousand short tons	218,546	206,686	203,536	217,471

[1] Commercial sales plus imports.

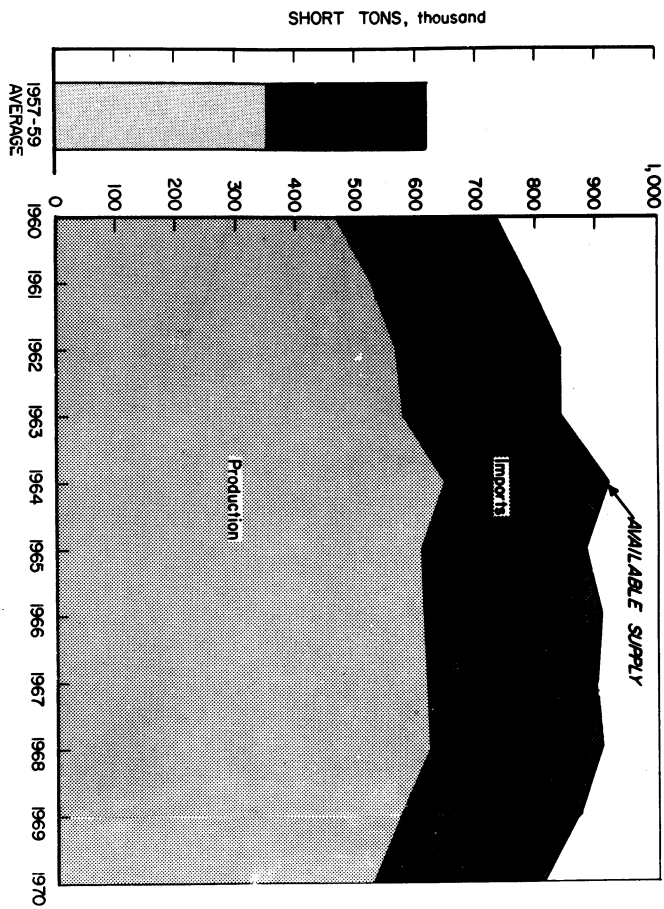

Figure 1.—Production, imports, and available supply of peat in the United States.

Of the reported production, about one-half was reed-sedge peat while the remainder was about equally divided between moss peat and humus. More than three-fourths of the output was processed by shredding and/or artificial drying before it was marketed.

Production methods varied, but virtually all peat was extracted by machinery. Equipment consisted mainly of modified conventional excavating and earthmoving machines, including power shovels, clamshells, draglines, bulldozers, and front-end loaders. Specialized machines such as harvesters, cultivators, milling machines, ridgers, and scrapers were also employed. Processing machinery included a variety of shredders, pulverizers, grinders, hammermills, screens, dryers, and hydraulic presses.

Table 2.—Peat produced in the United States in 1970, by kinds

(Short tons)

Kind	Unprepared	Processed			Total
		Shredded	Kiln-dried only	Shredded and kiln-dried	
Moss	48,718	79,161	-----	2,135	130,014
Reed-sedge	26,486	223,374	750	-----	250,610
Humus	41,925	90,633	3,643	-----	136,201
Total	117,129	393,168	4,393	2,135	516,825

Table 3.—Production and commercial sales of peat in the United States in 1970, by States

State	Active plants	Production (short tons)	Commercial sales		
			Short tons	Value: Total (thousands)	Value: Average per ton
California	3	9,792	9,792	W	W
Colorado	[1] 15	34,240	34,499	$210	$6.08
Florida	8	45,743	45,742	304	6.65
Georgia	1	432	432	W	W
Idaho	1	W	W	W	W
Illinois	6	W	W	W	W
Indiana	5	W	W	W	W
Iowa	2	W	W	W	W
Maine	[2] 3	1,223	1,000	39	39.00
Maryland	2	4,588	3,633	47	12.94
Massachusetts	1	2,000	2,000	30	15.00
Michigan	[1] 20	156,699	166,950	1,896	11.36
Minnesota	8	13,948	13,377	335	25.04
Montana	1	W	W	W	W
New Jersey	4	45,260	45,260	557	12.30
New Mexico	1	500	500	7	13.00
New York	5	15,325	14,525	145	9.98
North Dakota	1	W	W	W	W
Ohio	11	6,357	6,357	95	14.94
Pennsylvania	11	49,284	43,793	517	11.81
South Carolina	1	W	W	W	W
Vermont	1	338	244	6	24.59
Washington	9	16,625	16,625	71	4.27
Wisconsin	2	1,581	1,650	W	W
Total	122	516,825	525,603	5,986	11.39

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Excludes 1 plant which had sales, but no production.
[2] Includes 1 plant which had production, but no sales.

Table 4.—Relative size of peat operations in the United States

Size	1969 Active plants: Number	1969 Active plants: Percent of total	1969 Production: Short tons	1969 Production: Percent of total	1970 Active plants: Number	1970 Active plants: Percent of total	1970 Production: Short tons	1970 Production: Percent of total
Under 500 tons	29	22.7	5,245	0.9	32	26.2	6,872	1.3
500 to 999 tons	17	13.3	11,424	2.0	16	13.1	10,724	2.1
1,000 to 4,999 tons	51	39.8	118,210	20.7	46	37.7	101,048	19.6
5,000 to 14,999 tons	22	17.2	185,846	32.5	18	14.8	141,174	27.3
15,000 to 24,999 tons	5	3.9	88,320	15.4	6	4.9	100,511	19.4
Over 25,000 tons	4	3.1	163,077	28.5	4	3.3	156,496	30.3
Total	128	100.0	572,122	100.0	122	100.0	516,825	100.0

CONSUMPTION AND USES

Commercial sales and imports both declined in 1970, and the amount of peat available for consumption was 7 percent less than in 1969.

Although peat was used for a variety of purposes, 86 percent of the total was sold 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 improving lawns and garden soils. The remaining peat was sold for use in potting soils, mixed fertilizers, and mushroom beds; for packing flowers and shrubs; and for seed inoculant.

Producers' sales were about evenly divided between the bulk and the packaged product. Packaged peat, however, accounted for nearly two-thirds of the total value of sales. Of the packaged material, about two-thirds was reed-sedge peat, most of which was produced in Michigan. Other States leading in sales of packaged peat were Illinois, Indiana, New Jersey, Pennsylvania, and Minnesota.

Table 5.—Commercial sales of peat in the United States in 1970, by kinds and uses

(Thousand short tons and thousand dollars)

Use	Moss		Reed-sedge		Humus	
	Quantity	Value	Quantity	Value	Quantity	Value
Bulk:						
Soil improvement	57	$487	73	$735	63	$394
Other uses	16	90	10	123	39	269
Total [1]	73	577	83	858	101	663
Packaged:						
Soil improvement	49	847	179	2,180	29	394
Other uses	3	71	3	184	5	211
Total [1]	52	918	182	2,365	34	605
Total:						
Soil improvement	107	1,334	251	2,916	92	788
Other uses	19	161	13	307	44	480
Grand total [1]	126	1,495	265	3,223	135	1,268

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

Table 6.—Commercial sales of peat in the United States in 1970, by uses

(Thousand short tons and thousand dollars)

Use	In bulk		In packages		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Soil improvement	193	$1,616	257	$3,421	450	$5,038
Potting soils	14	118	6	221	20	338
Packing flowers, shrubs, etc	40	298	2	37	42	336
Seed inoculant	---	-----	3	206	2	206
Mushroom beds	3	29	(2)	(2)	3	29
Earthworm culture	1	9	(2)	2	1	11
Mixed fertilizers	6	27	---	-----	6	27
Total [1]	258	2,098	268	3,888	526	5,986

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

PRICES AND SPECIFICATIONS

The average value per ton of domestically produced peat dropped form $12.47 in 1969 to $11.38 in 1970, a decrease of $1.08 per ton, owing mainly to a decline in the value of peat sold in packages for general soil improvement. The total value of commercial sales decreased approximately 15 percent for an overall loss in plant sales value of more than $1 million.

Peat prices at individual plants varied according to the kind of peat produced, the degree of processing, and whether the peat was packaged or sold in bulk. The average value of bulk peat was $8.13 per ton, $0.46 more than the average value of bulk peat sold in 1969. Packaged peat, however, declined in average value from $17.60 per ton in 1969 to $14.51 per ton in 1970.

Imported peat had a total value of $13.5 million. This was 2 percent less than the total value of imported peat in 1969. However, the average value of imported peat in 1970 was $1.83 per ton higher than in 1969.

Although the average value of imported peat is shown as more than three times that of domestically produced packaged peat, the two are not comparable because they are assigned at different marketing levels. Also, imported peat has different physical properties and it is usually sold on a volume basis rather than by weight. Each 100 pounds of typical air-dried imported peat will measure approximately 12 bushels, whereas the same quantity of a typical domestic peat will measure only 3 or 4 bushels. Only a few U.S. peat operations produce peat with properties similar to those of the imported type.

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 1970 decreased 6 percent from the quantity imported in 1969, mainly because of decreased shipments from Canada. Canada provided the bulk of the imports, however, supplying 95 percent of the 283,000 tons imported. Most of the remainder was shipped from Europe.

European shipments to the United States decreased 9 percent, mainly because of the smaller quantities shipped from Ireland and Poland. Shipments from West Germany increased slightly. West Germany supplied about three-fourths of the peat imported from Europe.

Imported peat was classified according to use as poultry and stable grade and fertilizer grade. Of the total imported, 99 percent was duty-free fertilizer-grade peat. A tax of $0.25 per long ton was levied on poultry- and stable-grade peat.

Foreign peat entered the United States through 28 customs districts in 1970, but 83 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, 64,000 tons, was shipped through the Ogdensburg district.

[2] American Society for Testing and Materials, Committee D-29, ASTM Designation: D2607-69. Philadelphia, Pa., Apr. 25, 1969.

Table 7.—U.S. imports for consumption of peat moss, by grades and countries

Country	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1969						
Canada	2,117	$96	282,952	$13,014	285,069	$13,110
Czechoslovakia	------	------	25	2	25	2
Denmark	26	1	------	------	26	1
Finland	2	(1)	------	------	2	(1)
Germany, West	152	10	9,805	397	9,957	407
Ireland	40	2	1,293	67	1,333	69
Mexico	------	------	14	(1)	14	(1)
Norway	------	------	11	8	11	8
Poland	296	12	2,791	116	3,087	128
Portugal	------	------	49	3	49	3
Sweden	------	------	327	18	327	18
Taiwan	------	------	1	(1)	1	(1)
United Kingdom	------	------	96	6	96	6
Total	2,633	121	297,364	13,631	299,997	13,752
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

[1] Less than ½ unit.

Table 8.—U.S. imports for consumption of peat moss in 1970, 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	6	$4	1,293	$55	1,299	$59
Boston, Mass	4	3	339	18	343	21
Bridgeport, Conn	------	------	46	2	46	2
Buffalo, N.Y	------	------	32,423	1,464	32,423	1,464
Charleston, S.C	------	------	128	6	128	6
Detroit, Mich	52	3	42,213	2,278	42,265	2,281
Duluth, Minn	------	------	5,769	393	5,769	393
Great Falls, Mont	------	------	8,287	418	8,287	418
Honolulu, Hawaii	7	(1)	38	3	45	3
Houston, Tex	------	------	467	19	467	19
Los Angeles, Calif	------	------	954	46	954	46
Miami, Fla	------	------	444	21	444	21
Milwaukee, Wis	------	------	16	(1)	16	(1)
Mobile, Ala	------	------	1,935	92	1,935	92
New Orleans, La	------	------	1,509	58	1,509	58
New York, N.Y	------	------	1,884	90	1,884	90
Norfolk, Va	------	------	950	35	950	35
Ogdensburg, N.Y	10	1	64,340	2,820	64,350	2,821
Pembina, N. Dak	1,418	82	11,061	493	12,479	575
Philadelphia, Pa	30	2	599	24	629	26
Portland, Maine	13	1	6,661	378	6,674	379
Portland, Oreg	------	------	126	8	126	8
St. Albans, Vt	186	7	48,201	1,983	48,387	1,990
San Francisco, Calif	56	1	202	9	258	10
San Juan, P.R	------	------	452	18	452	18
Savannah, Ga	------	------	548	24	548	24
Seattle, Wash	------	------	49,024	2,565	49,024	2,565
Tampa, Fla	------	------	1,520	78	1,520	78
Total	1,782	104	281,429	13,398	283,211	13,502

[1] Less than ½ unit.

Table 9.—Peat moss imported for consumption from Canada and West Germany in 1970, 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	------	------	------	------	------	------	1,076	$42
Boston, Mass	------	------	------	------	------	------	8	(1)
Bridgeport, Conn	------	------	46	$2	------	------	------	------
Buffalo, N.Y	------	------	32,378	1,463	------	------	------	------
Charleston, S.C	------	------	------	------	------	------	128	6
Detroit, Mich	52	$3	42,213	2,278	------	------	------	------
Duluth, Minn	------	------	5,769	393	------	------	------	------
Great Falls, Mont	------	------	8,287	418	------	------	------	------
Honolulu, Hawaii	------	------	38	3	------	------	------	------
Houston, Tex	------	------	------	------	------	------	236	10
Los Angeles, Calif	------	------	------	------	------	------	882	38
Miami, Fla	------	------	------	------	------	------	314	15
Milwaukee, Wis	------	------	16	(1)	------	------	------	------
Mobile, Ala	------	------	------	------	------	------	1,935	92
New Orleans, La	------	------	------	------	------	------	668	27
New York, N.Y	------	------	------	------	------	------	1,023	51
Norfolk, Va	------	------	------	------	------	------	625	23
Ogdensburg, N.Y	10	1	64,316	2,818	------	------	------	------
Pembina, N. Dak	1,418	82	11,061	493	------	------	------	------
Philadelphia, Pa	------	------	------	------	30	$2	439	15
Portland, Maine	13	1	6,661	378	------	------	------	------
Portland, Oreg	------	------	------	------	------	------	119	4
St. Albans, Vt	186	7	48,135	1,981	------	------	44	2
San Francisco, Calif	------	------	------	------	56	1	202	9
San Juan, P.R	------	------	------	------	------	------	452	18
Savannah, Ga	------	------	------	------	------	------	526	23
Seattle, Wash	------	------	49,024	2,565	------	------	------	------
Tampa, Fla	------	------	------	------	------	------	1,242	54
Total	1,679	94	267,944	12,792	86	3	9,919	429

[1] Less than ½ unit.

WORLD REVIEW

World production of peat in 1970 was estimated at 217 million short tons, an increase of 7 percent over the estimated world output for 1969.

The U.S.S.R. remained the largest producer with an estimated output of 206 million tons, about 95 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. The bulk 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 1970 output of 7.6 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 1.5 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 less that 0.7 percent of the world total. Although fourth in world production, output of the United States was only 0.2 percent of the world total.

Table 10.—Peat: World production, by countries [1]
(Thousand short tons)

Country	1968	1969	1970 p
Argentina, agricultural use	2	1	NA
Canada, agricultural use	294	330	317
Denmark, fuel e	6	6	6
Finland:			
Agricultural use e	138	138	158
Fuel	e 110	120	97
France, agricultural use	79	e 80	e 80
Germany, West:			
Agricultural use	r 1,151	1,260	e 1,110
Fuel	480	397	357
Hungary, agricultural use e	72	72	72
Ireland:			
Agricultural use	45	60	e 66
Fuel	r 5,532	7,087	e 7,500
Israel, agricultural use e	22	22	22
Japan e	80	80	80
Korea, Republic of, agricultural use	9	e 10	e 10
Netherlands e	440	440	440
Norway:			
Agricultural use	r 11	12	e 13
Fuel e	4	4	4
Poland, fuel	31	24	22
Sweden:			
Agricultural use	110	e 110	e 110
Fuel e	28	28	28
U.S.S.R.:			
Agricultural use e	143,300	143,300	143,300
Fuel	r 54,123	49,383	63,162
United States, agricultural use	619	572	517
Total [2]	r 206,686	203,536	217,471
Fuel peat (included in total)	r 60,314	57,049	71,176

e Estimate. p Preliminary. r Revised. NA Not available.
[1] In addition, Austria, Canada, Iceland, Italy, and Spain produce a negligible quantity of fuel peat. No data were available on East Germany, a major producer.
[2] Total is of listed figures only.

TECHNOLOGY

A French patent[3] describes a method for preparing peat or compost for use in soil improvement. In the process, the compost or peat is freed of roots, fibers, and stones, and reduced to about 3 millimeter particles containing 40 percent water and having a pH of 5.7 to 6.2. This material is then mixed with 1 percent methyl ethyl cellulose (as a 10-percent aqueous solution) which is then extruded to give 3.0 to 4.5 millimeter-diameter fibers, then dried, and broken into granules. The granules are easily handled, but they disintegrate within 3 weeks when introduced into the soil. The granules provide good aeration and humidification of soil.

A method of using peat to break emulsions in waste water is described in a recent German patent.[4] When peat is combined with a metal salt, such as $Al_2(SO_4)_3$ or $AlCl_3$, the combination has the capacity to break highly stable emulsions, irrespective of the pH. The substance works best with emulsifiers which contain ethylene oxide groups.

The results of pilot plant tests of a method for removing nitrous oxides from exhaust gases by peat-ammonia adsorption was described.[5] It was estimated that for a plant releasing to the atmosphere 150,000 cubic meters per hour of nitrose gases containing 0.3 to 0.4 percent nitrous oxides, peat consumption is 22,000 to 24,000 tons, and ammonia consumption is 1,600 tons. The cost of this method of pollution control was estimated to be 0.866 ruble per ton of nitric acid consumed ($0.96 at official exchange rate), and the selling price of peat-ammonia fertilizers resulting from this process, 8 to 11 rubles per ton. A method was also devised for the adsorption of CO_2, H_2S, and SO_2 from gases.

[3] Jomain, Albert. Granulated Compost or Peat for Improving Soil. French Pat. 1,569,696, June 6, 1969; Chem. Abs., v. 72, Apr. 13, 1970, col. 78087q.
[4] Heidenreich, Hans. Breaking Emulsion in Waste Water by the Addition of Peat. German Pat. 1,908,791, Sept. 10, 1970; Chem. Abs., v. 73, Dec. 28, 1970, col. 133860j.
[5] Ganz, S. N., and I. E. Kuznetsov. Removal of Corrosive Impurities From Industrial Gases and Liquid Wastes. Khim. Tekhnol. No. 11, 1968; Chem. Abs. v. 72, Apr. 20, 1970, col. 82656s.

Perlite

By Arthur C. Meisinger [1]

In many respects 1970 was a continuation of the record high set in 1969 for the domestic perlite industry. Although the quantity of crude perlite mined in 1970 was the third largest on record, the quantity sold and used was just under the record total set in 1969. On the other hand, expanded perlite producers reported new records for expanded perlite output in 1970, as follows: Quantity produced, 420,000 tons; quantity sold and used, 416,000 tons; and value of quantity sold and used, approximately $25 million.

DOMESTIC PRODUCTION

Crude perlite was produced by 12 companies at 14 mines in seven States in 1970, and the quantity mined (607,000 tons) was the third largest on record. New Mexico continued to be the leading producing State contributing 87 percent (526,000 tons) of the U.S. crude perlite output. Other States producing crude perlite, in descending order, were Arizona, California, Nevada, Colorado, Idaho, and Utah. The quantity of crude perlite that producers sold or used (456,000 tons) was exceeded only by that of 1969.

Crude perlite was expanded at 89 plants in 33 States during 1970. The quantity of expanded perlite produced (420,000 tons) was 15,000 tons more than the previous record output of 405,000 tons in 1969, and the quantity sold or used (416,000 tons) by producers was also a record high. Illinois led the country in production of expanded perlite and also in the quantity sold and used.

[1] Industry economist, Division of Nonmetallic Minerals.

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
1966	548	193	$1,799	211	$2,108	404	394	394	$16,403
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

Table 2.—Expanded perlite produced and sold by producers in the United States

State	1969 Quantity produced (short tons)	1969 Sold or used Quantity (short tons)	1969 Sold or used Value (thousands)	1969 Sold or used Average value per ton r	1970 Quantity produced (short tons)	1970 Sold or used Quantity (short tons)	1970 Sold or used Value (thousands)	1970 Sold or used Average value per ton
California	16,980	16,410	$1,296	$78.98	24,190	23,980	$1,912	$79,73
Florida	10,410	9,420	676	71.76	15,490	14,390	855	59.42
Georgia	(1)	(1)	(1)	(1)	(1)	(1)	20	(1)
Illinois	(1)	(1)	3,119	(1)	(1)	(1)	3,175	(1)
Indiana	(1)	(1)	(1)	(1)	5,200	5,200	380	73.08
Kansas	900	930	80	86.02	790	790	62	78.48
Maryland	7,250	6,740	454	67.36	5,700	5,410	391	72.27
Massachusetts	(1)	(1)	(1)	(1)	1,250	1,250	147	117.60
New York	4,560	4,550	297	65.27	3,830	3,770	(1)	(1)
Ohio	7,990	7,990	472	59.07	7,790	7,790	455	58.41
Oregon	510	510	44	86.27	360	360	36	100.00
Pennsylvania	12,580	12,860	877	68.20	18,070	18,220	1,020	55.98
Texas	34,880	34,870	2,262	64.87	46,030	46,030	3,634	78.95
Other Eastern States [2]	249,120	247,680	9,321	[3] 50.23	225,340	223,190	9,245	[4] 55.74
Other Western States [5]	59,640	60,220	3,202	53.17	65,760	65,850	3,639	55.26
Total [6]	404,820	402,170	22,100	54.95	419,790	416,220	24,972	60.00

r Revised.
[1] Included with "Other Eastern States."
[2] Includes Georgia (1970 quantity only), Illinois (quantity only), Indiana (1969), Kentucky, Maine, Massachusetts (1969), Michigan, Mississippi, New Hampshire, New Jersey, New York (1970 value only), North Carolina, Tennessee, and Wisconsin.
[3] Based on quantity of 247,680 tons and value of $12,440,000 ($9,321,000 "Other Eastern States" plus $3,119,000 for Illinois).
[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] Includes Arizona, Colorado, Idaho, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, Utah, and Washington.
[6] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Major uses for expanded perlite in 1970 included filter aids, concrete aggregate, plaster aggregate, and insulation board. The percent disposition of expanded perlite by end use is shown in table 3. Compared with that of 1969, use of expanded perlite as a filter aid increased from 18 percent to 23 percent, but use in plaster aggregate declined from 16 percent to 8 percent. Some of the "Other uses" for expanded perlite included paint additives, texturing, refractories, charcoal base, and oil absorbent.

Table 3.—Disposition and end use of expanded perlite

(Percent)

Use	1969	1970
Filter aid	18	23
Plaster aggregate	16	8
Concrete aggregate	11	11
Horticultural aggregates	3	4
Low temperature insulation	2	2
Masonry and cavity fill insulation	1	1
Fillers	1	1
Formed products	1	3
Other [1]	47	47

[1] Includes insulation board.

PRICES

Producers sold crushed, cleaned, and sized crude perlite to expanding plants at an average price of $11.70 per short ton in 1970 compared with $10.19 in 1969. The portion used by producers in their own expanding plants was valued at an average of $10.16 per ton compared with $11.30 per ton in 1969. The weighted average of both categories was $10.75 per ton in 1970, compared with $10.82 per ton in 1969.

According to expanders, sold or used expanded perlite had an average value of $60.00 per ton compared with $54.95 per ton in 1969. However, average values by States in 1970 ranged from $25 to $175 per ton.

WORLD REVIEW

Greece.—In 1970 Greece produced an estimated 185,850 short tons of crude perlite.[2] Processed perlite production was reported to be nearly 117,650 short tons, of which about 95 percent was exported, primarily to Western European consumers.

Hungary.—Crude perlite was mined from deposits in the Zemplén Mountains area of northeastern Hungary. The crude material, a glassy volcanic rhyolite, was treated at a nearby modern plant built to manufacture expanded perlite products for use primarily as lightweight concrete aggregate, insulation materials, and filter aids. Hungarian perlite is also used as a batch constituent for the production of green glass.

In 1970, the Hungarian Building Research Institute reported a method for improving the bonding properties of perlite in concrete by treating the basic perlite material with a sodium silicate admixture. Although no details of the method were described, the sodium silicate bonding apparently increases stress resistance in the product and also acts as an immediate drying agent.[3]

Iceland.—During 1970, the Government continued to determine the feasibility of developing and utilizing known perlite deposits on the eastern coast of Iceland as part of an industrial diversification program.

Italy.—At yearend, Perlite S.p.A., an associated company of British Gypsum Ltd., brought on stream a new perlite crushing and screening plant at Oristano, Sardinia. Perlite S.p.A. mines and expands crude perlite on the island of Sardinia, and the new plant will service the modern storage and ship loading facilities at Oristano.

Mexico.—Perlite output totaled 13,566 short tons in 1970 and was nearly 2,400 tons more than the quantity produced in 1969.[4]

Philippines.—Perlite was mined by Trinity Lodge Mining Corp.; Vinnel Belvoir Construction Co., at Makati, Rizal, also reported mining perlite during the year. The Trinity Lodge deposit near Legaspi, Albay, was brought into production in May, and output by yearend was reported to be about 13,200 short tons. Trinity Lodge proposed to process the perlite in a plant scheduled to be in operation by mid-1971 at San Pedro, Laguna.

TECHNOLOGY

In 1970, the perlite industry placed its major technologic efforts on the development and application of new uses for perlite in the field of environmental health and safety. Principal studies included the application of perlite as a lightweight concrete crash barrier for highways, a carrier for pesticides, and as an oil absorbent for petroleum spills on inland water systems. Other studies included the use of perlite in low-cost, lightweight building panels and as a soil substitute in hydroponic farming. The industry also initiated the development of a specification for the use of perlite as an inert filler in polyester resins. In addition, contracted work to various universities and research organizations in early 1970 was related to the use of perlite for a roughage substitute in animal feed.

[2] U.S. Embassy, Athens, Greece. State Dept. Airgram A-166, Apr. 29, 1971, p. 3, encl. 1.
[3] International Report. Budapest, Hungary. Rock Products. V. 73, No. 10, October 1970, p. 97.
[4] U.S. Embassy, Mexico D.F. State Dept. Airgram Suppl. A-342, July 1, 1971, p. 8, encl. 1.

Crude Petroleum and Petroleum Products

By James G. Kirby [1] and Betty M. Moore [2]

The total demand [3] for petroleum products in 1970 averaged 14,940,000 barrels per day, an increase of 575,000 barrels per day or 4.0 percent over 1969 demand.

Supply problems were complicated by disruptions in the Mediterranean and heavy worldwide demand for residual fuel oil. The Syrian Goverment refused permission for the Trans Arabian Pipeline Co. (TAPline) to repair a small break in the pipeline that occurred early in May, demanding higher tariffs from the company. This shut off 475,000 barrels of crude oil per day from the Middle East. The Libyan government placed restrictions on the crude oil production in that country while negotiating for increased royalties from the companies. Europe is the primary market for this Mediterranean oil and supplying Europe from the Middle East around South Africa required five times as many tankers because of the long haulage time. Short supply of tankers caused astronomical increases in tanker rates throughout the world. The premium of about $1.25 per barrel that overseas oil held over domestically produced oil in the East Coast markets of the United States declined more than 60 percent. Several inland refiners were unable to dispose of their crude oil and unfinished oil import quotas before the December 31 expiration date. Waterborne imports of crude oil declined at the rate of 200,000 barrels per day in 1970 but overland imports from Canada increased 115,000 barrels per day and production of crude oil and lease condensate increased 4.3 percent for the year to 9,637,000 barrels per day.

Heavy demands for residual fuel oil for use in the generation of electric power both here and abroad caused a tight supply and, with the higher shipping rates, prices for this fuel increased substantially.

The data presented in this chapter are 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 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, away from the oil refineries.

The Bureau of Mines uses crude-oil production data (including field condensate) compiled by State agencies for those States which 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

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[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 consumers' stocks that are not reported to the Bureau of Mines, this figure varies considerably from consumption.

Domestic demand.—Total demand less exports.

New Supply of all oils.—The sum of crude oil production plus production of natural gas liquids, plus benzol (coke-oven) used for motor fuel, hydrogen, and other hydrocarbons, plus imports of crude oil and other petroleum products.

Transfers.—Crude oil conveyed to fuel-oil stocks without processing, or reclassification of products from one product category to another.

All oils.—Crude petroleum, natural gas liquids, and their derivatives.

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 of fuel oils, asphalt and road oils by uses, and refinery capacity are canvassed.

Demand by Product.—*Gasoline.*—The growth rate in domestic demand for motor gasoline in 1970 was below the level of the previous 2 years but the 4.7 percent gain was exactly the same as the previous 5-year trend and averaged 5,784,000 barrels per day. The demand for aviation gasoline continued to decline and averaged only 55,000 barrels per day in 1970.

Distillate Fuel Oil.—It is expected, that because of its lower sulfur content, more distillate fuel oil will be substituted for higher sulfur content fuels in areas with emission controls. The change was not too apparent in 1970 as the domestic demand for distillate showed only a normal 3-percent increase and averaged 2,540,000 barrels per day for the year. Most of the demand increase in 1970 was for use in gas-turbine plants of electric utility companies.

Residual Fuel Oil.—As in 1969, the use of residual fuel oil for the generation of electricity was responsible for practically all the increase in demand for that product in 1970. Domestic demand for 1970 averaged 2,204,000 barrels per day, an increase of 11.4 percent over 1969 demand. Demand in PAD district I which represents 74.2 percent of the U.S. total increased at the rate of 231,000 barrels per day to 1,635,000 barrels per day in 1970 while demand declined in both PAD districts IV and V.

Kerosine.—The amount of kerosine used for space-heating and for uses other than jet aircraft fuel was 4.4 percent less than in 1969. Demand for the year averaged 263,000 barrels per day.

Jet Fuels.—The demand for naphtha-type fuels, used primarily by the military, was down 16.2 percent in 1970, declining from 297,000 barrels per day in 1969 to 249,000 barrels per day. In an effort to curb revenue losses, the commercial airlines rearranged and regrouped schedules that resulted in a slowdown in the growth in demand for kerosine-type jet fuel. In 1970 the demand for this commercial-type jet fuel averaged 716,000 barrels per day, a gain of only 3.2 percent while in 1969 the gain was 14.0 percent.

Liquefied Gases and Ethane.—The demand for liquefied gases in 1970 was 996,000 barrels per day, 2.6 percent below the 1969 level, but the demand for ethane increased 16.2 percent for the year to 230,000 barrels per day. More detail on liquefied gases and ethane can be found in the "Natural Gas Liquids" chapter.

Other Products.—This category includes, refinery gas used for fuel, asphalt, petrochemical feedstocks, petroleum coke, lubricating oils, special naphthas, miscellaneous products, road oil, and wax. Refiners used 449,000 barrels per day of still gas for fuel in 1970 and 34,000 barrels per day for the petrochemical feedstocks. Asphalt demand averaged 420,000 barrels per day (76,450 short tons), an increase of 6.9 percent for the year. The demand for petrochemical feedstocks continued to be strong in 1970, increasing 7.0 percent to 277,000 barrels per day. More marketable coke was produced and sold in 1970, but exports accounted for almost 51.7 percent of the sales compared with 44.3 percent in 1969. Refiners utilized 4.1 percent less catalyst coke as fuel in 1970. Domestic demand for petroleum coke averaged 212,000 barrels per day compared with 221,000 barrels per day in 1969. The domestic demand for lubricating oils increased 1.9 percent in 1970 to an average of 136,000 barrels per day while exports declined 2.1 percent. Domestic demand for special naphtha increased 5.4 percent to 85,000 barrels per day, but exports declined slightly. There was a sharp decline, 9.8 percent, in the demand for miscellaneous finished products in 1970. Included in this group are various specialty oils, medicinal oils, spray oils, and petrochemicals. The demand for road oil averaged 26,000 barrels per day in 1970 and the demand for wax remained at 1969 level of 13,000 barrels per day.

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.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States

(Thousand 42-gallon barrels unless otherwise indicated)

	1966	1967	1968	1969	1970 p
Crude petroleum:					
Domestic production (including lease condensate)	3,027,763	3,215,742	3,329,042	3,371,751	3,517,450
World production	12,019,964	12,889,252	r 14,093,150	15,214,038	16,689,617
U.S. proportion ... percent	25	25	24	22	21
Exports [1]	1,477	26,541	1,802	1,436	4,991
Imports [2]	447,120	411,649	472,323	514,114	483,293
Stocks, end of year	238,391	248,970	272,193	265,227	276,367
Runs to stills	3,447,193	3,582,594	3,774,360	3,879,605	3,967,503
Value of domestic product at wells:					
Total ... thousands	$8,726,423	$9,375,727	$9,794,826	$10,426,680	$11,173,726
Average per barrel	$2.88	$2.92	$2.94	$3.09	$3.18
Total producing oil wells Dec. 31	583,302	565,289	553,920	542,227	530,990
Total oil wells completed during year (successful wells)	16,780	15,329	14,342	14,368	13,020
Refined products:					
Exports [1]	70,923	85,519	82,742	83,449	89,252
Imports [3]	492,042	514,342	567,046	641,437	764,099
Stocks, end of year [4]	602,291	629,399	r 647,439	656,344	675,502
Completed refineries, yearend	281	291	284	281	279
Daily crude-oil capacity	10,760	11,533	11,740	12,074	13,020
Natural gas liquids:					
Production	468,635	514,456	550,311	580,241	605,916
Stocks, end of year	40,423	65,742	77,940	58,552	65,992
All oils:					
Total demand	4,397,469	4,593,270	4,873,776	5,244,815	5,458,261
Exports	72,400	112,060	84,544	84,885	94,243
Domestic demand	4,325,069	4,481,210	4,789,232	5,159,930	5,364,018

p Preliminary (except for crude production and value). r Revised.
[1] U.S. Department of Commerce data.
[2] Bureau of Mines data for crude oil and unfinished oils.
[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.

Districts.—The Bureau of Mines reports production of crude petroleum and natural gas liquids and the number of wells drilled by States. Louisiana, New Mexico, and Texas are also reported by districts.

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 grouping of the 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, 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).

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 grouping originated by the Petroleum Administration for War during World War II which were called PAW districts. The PAW districts were later changed to PAD (Petroleum Administration for Defense) districts.

PAD district	*Refining districts*
I	*East Coast*—District of Columbia, 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.

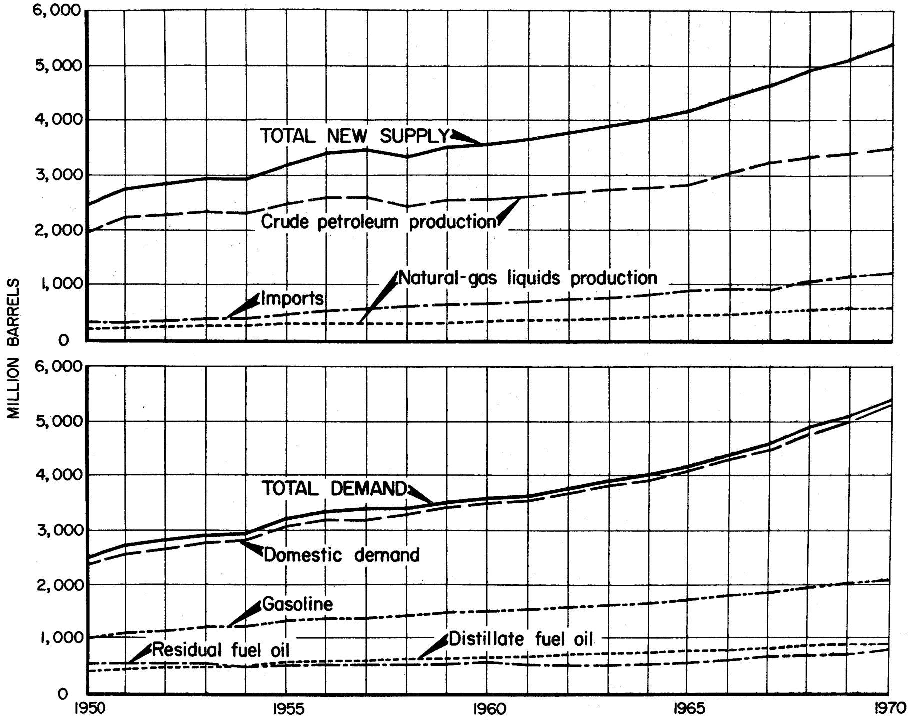

Figure 1.—Supply and demand of all oils in the United States.

PAD district	Refining districts
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.

PAD district	Refining districts
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.

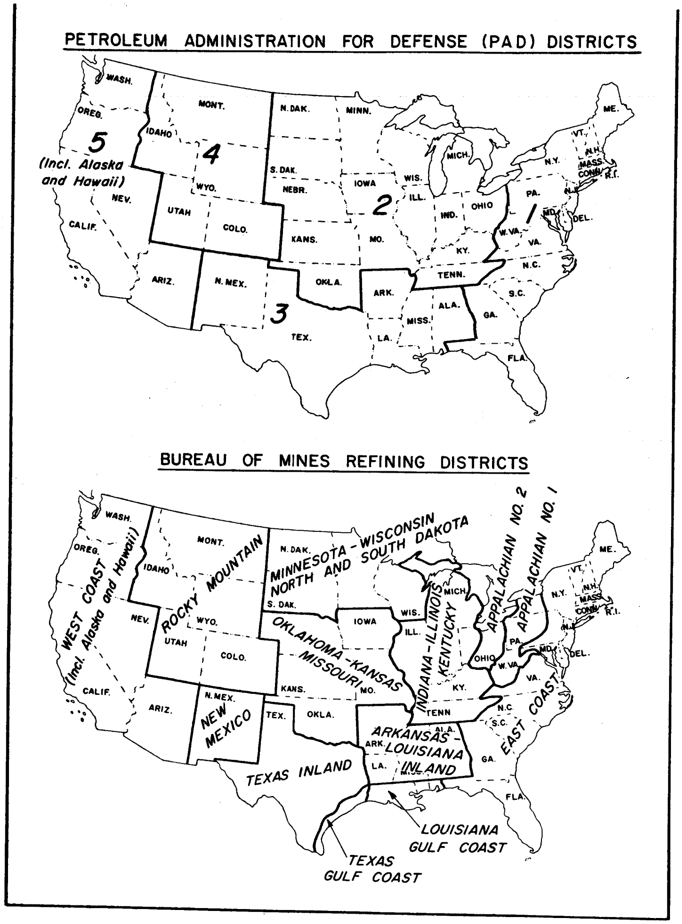

Figure 2.—Map of PAD Districts and Bureau of Mines Refining Districts.

CRUDE PETROLEUM

PRODUCTION

Crude oil production (including lease condensate) in the United States in 1970 was 3,517,450,000 barrels, 145,699,000 above the 1969 level. Production exceeded the 10,000,000-barrel-per day mark for the first time in October. The events in the Mediterranean which disrupted normal supply patterns and caused tanker rates to soar eliminated to a large extent the price advantages that overseas crude oil had over domestic crude oil in the east and west coast markets. Although crude stocks built up during the first 5 months of 1970 and major producing States reduced production levels, it became apparent late in July that overseas oil supply would be below annual quota levels, consequently domestic production was stepped up to meet demand requirements. Of the 10 States reporting production increases for the year, Texas with an increase of 97.9 million barrels and Louisiana with an increase of 62.3 million barrels, were the only States with substantial gains. Production declined in 20 States and one State reported no change for the year.

Additional data on crude oil production, by States, can be found in volume II of the 1970 Minerals Yearbook.

After two trial runs by a tanker fitted with special ice breaking equipment, it was determined that moving the vast reserves of oil from the North Slope of Alaska to the east coast by way of the Arctic Ocean was not feasible at this time. In the meantime much of the pipe for construction of the proposed pipeline from Prudhoe Bay to southern Alaska awaits in storage at Valdez pending decisions by the U.S. Government as to whether the line can or cannot be built. At recent hearings held by the U.S. Department of the Interior in Washington, D.C., and in Alaska, strong support was given to a proposal that the pipeline be built through the Mackenzie Valley in Canada. This line would connect with the Inter-Provincial Pipeline for delivery of the Alaskan Oil to the midcontinent area of the United States instead of to the west coast markets. Proponents of the Canadian route claim there is less chance of damage to the ecology since the valley route would be outside the earthquake prone area of Alaska. Since no tanker shipments would be involved as would be the case if the oil was transshipped from Valdez to the west coast markets, there would be less chance of pollution.

CONSUMPTION

The total demand for crude oil in the United States in 1970 averaged 10.9 million barrels per day of which 9.6 million barrels per day was supplied by domestic sources and 1.3 million barrels per day came from foreign sources. The demand for domestic crude oil increased 3.9 percent while the demand for foreign crude oil declined 6.6 percent.

Runs to Stills.—Refineries processed crude oil at an average rate of 10,870,000 barrels per day in 1970, compared with 10,629,000 barrels in 1969. Runs to stills reached a high of 11,183,000 barrels per day in December and, based on the total operable capacity January 1, 1970, refineries were operating at 93.0 percent of capacity.

Demand by States of Origin.—Distribution of domestic crude oil can be analyzed from the individual refinery reports that show origin of the crude oil receipts and from crude oil stock reports filed by refiners and pipeline and terminal operators which show stocks of crude oil by States of origin and location. When long-distance shipments are involved, various crude oils 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 1970 was 3,981.9 million barrels of which domestic crude oil accounted for 3,499.4 million barrels and foreign crude oil for 482.5 million barrels. The total new supply of crude oil in 1970 was 4,000.8 million barrels, including the production of crude oil and lease condensate of 3,517.5 million barrels and imports of 483.3 million barrels. Stocks of domestic crude oil increased 10.4 million barrels and foreign stocks increased 0.8 million barrels. The difference, a minus 7.7 million barrels, was classed as "unaccounted-for crude oil" to avoid making arbitrary adjustments in the reported supply or consumption.

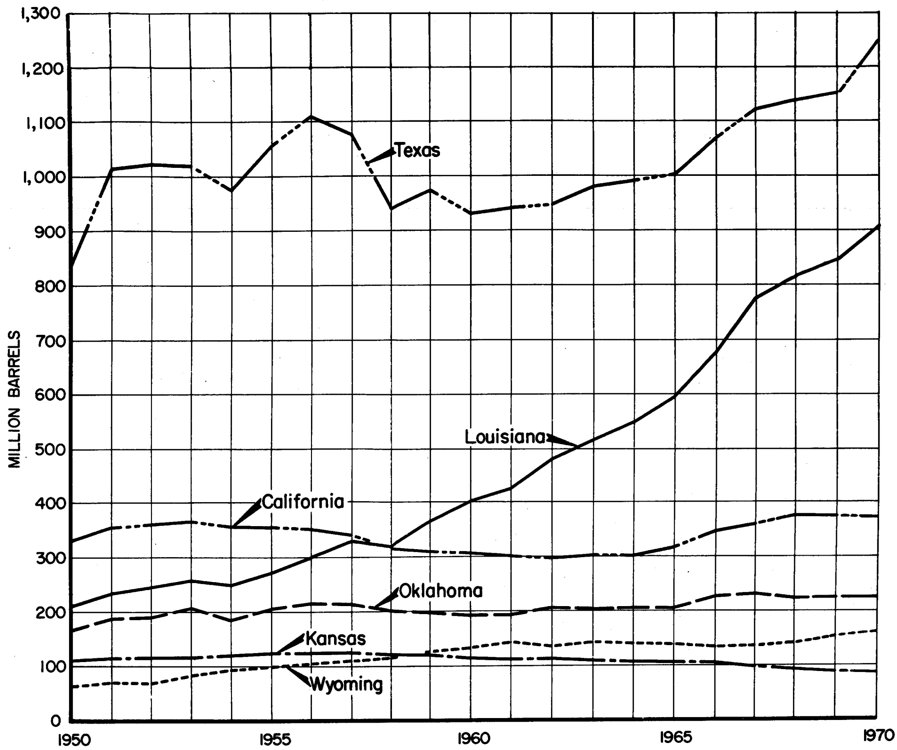

Figure 3.—Production of crude petroleum in the United States, by principal producing States.

PRODUCTION 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, 1971 was 11.2 million barrels per day, down 0.4 million barrels per day from January 1, 1970. 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.

WELLS

Drilling activity was off sharply in 1970. A total of 28,120 new wells were drilled, 4,053 or 12.6 percent less than in 1969. Of the total wells drilled for the year, 13,020 were completed as oil wells, 3,840 as gas wells, and 11,260 were abandoned as dry holes. The total footage drilled per well was 4,953 feet compared with 4,881 feet in 1969.

Offshore drilling operations were at a much slower pace in 1970. The oil spills in the Santa Barbara Channel off the coast of California in 1969 and the blowout of a well in the Gulf of Mexico off the coast of Louisiana caused concern over damage to the ecology. The U.S. Department of the Interior delayed lease sales of offshore acreage in the Gulf and withheld approval of drilling permits in the channel while environmental studies were conducted. In an effort to forestall future damage, the U.S. Geological Survey Conservation Division beefed up inspection procedures to insure that all rules and regulations governing offshore drilling and production were enforced.

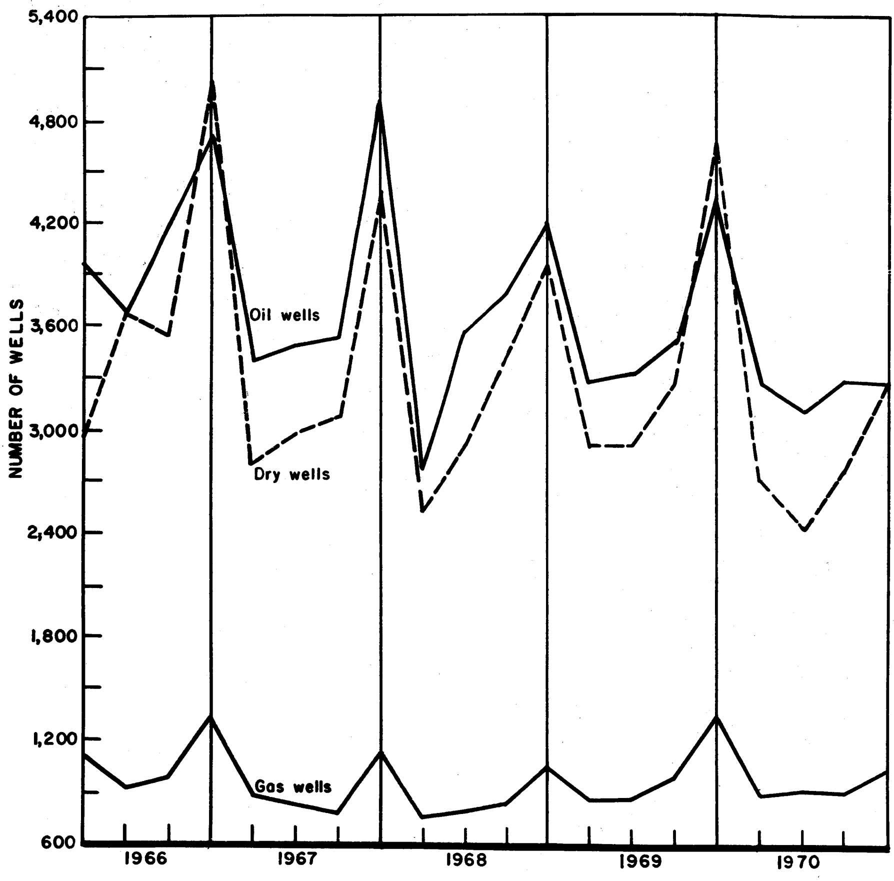

Figure 4.—Wells drilled for oil and gas in the United States, by quarters.

RESERVES

The API Committee on Petroleum Reserves estimated proved reserves of crude oil as of December 31, 1970, to be 39,001 million barrels, an increase of 9,369 million barrels for the year. Included in the reserve estimates for 1970 were 9,600 million barrels of proved reserves of crude oil in the Prudhoe Bay area on the North Slope of Alaska which were discovered in 1968. Excluding Alaska, reserves in the lower 48 States declined 348 million barrels. The only substantial addition to reserves other than in Alaska was in West Texas where 564 million barrels were added, however, all other districts in the State declined so the net addition to Texas was 132 million barrels. The largest decline for the year was in California where a decrease of 259 million barrels was reported.

REFINED PRODUCTS

Petroleum products account for approximately 43 percent of the nations energy requirements. These products supply about 96 percent of the fuels used for transportation; 45 percent of those used in household and commercial establishments; 25 percent for industrial installations; and 13 percent for the generation of electricity by the 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 in electric utilities anf for heavy-fuel use. Residual fuels usually sell 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 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 14,940,000 barrels per day in 1970, including a domestic demand of 14,696,000 barrels per day and exports of 244,000 barrels per day. Compared with 1969 figures, total demand increased 4.0 percent, domestic demand increased 4.0 percent, and exports were up 7.0 percent.

Total supply for the year averaged 15,069,000 barrels per day and after allowing for crude oil losses and exports there was an average addition to stocks of 103,000 barrels per day for the year.

GASOLINE

The 4.7 percent growth rate for motor gasoline in 1970 was below the gains reported for 1968 and 1969. Domestic demand averaged 5,784,000 barrels per day compared with 5,526,000 barrels per day in 1969. To the market in 1970, several refining companies introduced new lead-free gasolines designed to meet fuel requirements of the new cars presently being manufactured under present emission control regulations and the more stringent regulations projected for 1975.

The new supply of motor gasoline in 1970 was 2,110 millions barrels, of which 1,796 million barrels was produced from crude oil, 284 million was from natural gas liquids, 6 million from other hydrocarbons and hydrogens, and 24 million was imported.

According to data compiled by the API based on tax data reported by the States, 2,127 million barrels of motor gasoline were consumed in the United States in 1970 compared with 2,034 million in 1969. This differs from the demand data compiled by the Bureau of Mines, which do not include changes in secondary storage.

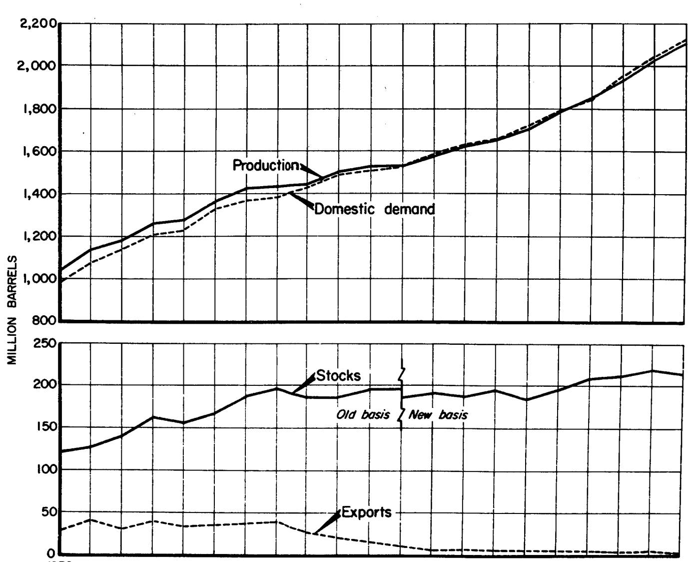

Figure 5.—Production, domestic demand, stocks, and exports of gasoline in the United States.

KEROSINE

The demand for kerosine, exclusive of that used in fuel, continued to decline in 1970. The daily average demand for 1970, 263,000 barrels, was the lowest reported since 1964. The principal use for kerosine is for space heaters; however, because it is convenient propane (bottled gas) is gradually taking over this market. Stocks of kerosine at the close of 1970 were 27.8 million barrels, 1 million above the December 1969 level.

DISTILLATE FUEL OIL

For the first half of 1970 the demand for distillate fuel oil showed a 4.7-percent gain over the previous year but the general decline in industrial activity and warmer that normal weather slowed the growth in the last half to only 1.0 percent. For the year, domestic demand averaged 2,540,000 barrels per day, an increase of 3.2 percent or 74,000 barrels per day. Electric utility companies used more gas-turbine plants to meet peak load requirements in 1970 increasing the utility use of distillate fuel oil from 9,000 barrels per day in 1969 to 66,000 barrels per day in 1970. This represents 77.0 percent of the total growth of distillate fuel oil demand for the year.

Stocks of distillate fuel oil at the end of 1970 were 195 million barrels compared with 172 million December 31, 1969. From May thru August stocks were running between 4 and 5 million above year-ago levels but built up during the last 4 months because of the low demand.

Although import restrictions on No. 4 distillate fuel oil were relaxed in 1969 and the Oil Import Administration allocated licenses to terminal operators in District I to import 40,000 barrels per day of No. 2 distillate fuel into the district during the last half of 1970, imports increased only 8,000 barrles per day during the year to 148,000 barrels per day.

RESIDUAL FUEL OIL

Since enactment of air pollution controls both here and abroad, residual fuel has become one of the most sought after petroleum products in the world market. This is especially true of residual fuel with a low sulfur content that will meet air-quality standards and can be substituted for coal. Some Caribbean refineries have installed equipment that enables them to produce a low sulfur fuel oil and others have announced plans for such facilities. In the meantime, more communities are enacting stricter regulations and the supply problem is growing more difficult. The domestic demand for residual fuel oil increased 11.4 percent in 1970 to 2,204,000 barrels per day. Electric utilities used an average of 844,000 barrels per day of residual fuel oil for the generation of electric power in 1970 compared with 678,000 barrels per day in 1969, an increase of 24.4 percent.

The United States imported an average of 1,528,000 barrels of residual fuel oil or almost 68 percent of the demand requirements in 1970, 96 percent of these imports were received in PAD district I.

The tight supply situation and the high increase in tanker rates which occurred during 1970 caused a sharp jump in residual fuel oil prices. The New York Harbor posted barge price for No. 6 residual fuel oil (no sulfur guarantee) increased from an average of $2.20 per barrel in 1969 to $2.80 in 1970. For a No. 6 fuel oil (maximum 1 percent sulfur), the posted price increased from $2.45 per barrel to $3.26.

Total residual fuel oil stocks at the end of 1970 were 54.0 million barrels, a decline of 4.4 million barrels for the year; however, this decline was limited to the west coast where stocks were down 10.8 million barrels.

JET FUELS

The slow growth in commercial air travel during 1970 and a further cutback by the military caused a decline in the demand for jet fuels for the first time since separate records were kept on these fuels. The domestic demand for jet fuels in 1970 was 965,000 barrels per day, a decline of 2.5 percent for the year. The demand for the naphtha-type jet fuel used primarily by the military declined 48,000 barrels per day to 249,000 thousand barrels. The demand for kerosine-type fuel used in commercial aircraft increased 22,000 barrels per day during the year to 716,000 barrels daily.

Imports of jet fuel averaged 143,000 barrels daily in 1970 of which 128,000 barrels daily was imported in bond for use as fuel for aircraft engaged in flights with destinations outside the United States.

There are no customs duties on these imports, and bonded imports of such fuels are not subject to import control regulations.

LUBRICANTS

According to a survey conducted by the Bureau of the Census, 51 percent of the domestic sales of lubricants in 1969 were for industrial uses and 49 percent were for automotive and aviation use. In the export market, industrial uses accounted for 85 percent.

The total demand for lubricants in 1970 was 65.5 million barrels, an increase of less than 1 percent, exports continued to decline but the domestic demand, 49.7 million barrels, was up 1.9 percent for the year.

For the most part, posted prices for lubricating oils did not change in 1970. An increase was posted in November at the Gulf Coast but was rescinded 2 days later.

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, and 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 1970 was 373,254,000 barrels compared with 386,207,000 barrels in 1969. Domestic demand for the year declined 2.6 percent and exports declined 24.6 percent. The demand for ethane (including ethylene) was 83,757,000 barrels in 1970 compared with 72,216,000 barrels in 1969.

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 1970 were 30,458,000 short tons, an increase of 8.2 percent over 1969 figures. Shipments of asphalt for paving represented 78.1 percent of the total use in 1970 and were 11.5 percent above the previous year. The continued slowdown in new construction in 1970 resulted in a further decline in roofing products of 6.7 percent for the year. After a 2-year decline shipments of asphalt products increased 8.2 percent in 1970. The shipment data include, in addition to refinery production and imports, various emulsifiers and blenders.

The domestic demand for asphalt in 1970 was 27,904,000 short tons, an increase for the year of 7.1 percent.

The demand for road oil increased 10.1 percent in 1970 to 9,641,000 barrels.

OTHER PRODUCTS

Special Naphthas.—The use of special naphthas in the domestic market increased 5.4 percent in 1970, to 31.2 million barrels. Exports declined from 2.0 million barrels in 1969, to 1.6 million barrels in 1970. Special naphthas are used primarily for paint thinners, cleaning agents, and solvents.

Waxes.—The total demand for petroleum wax in 1970 was 898,100 short tons, an increase of 3.3 percent for the year. The domestic demand, 644,840 tons, was only 0.4 percent above the 1969 level, but exports increased 11.5 percent to 253,260 tons. The API conducts an annual survey of wax sales in the United States by the petroleum industry. The 1970 survey represents about 89 percent of the domestic demand reported by the Bureau of Mines. A breakdown of the 1970 data, by end use and percentage change, from 1969 are as follows: Paperboard containers, 139,513 tons, up 6.7 percent; corrugated paperboard, 63,881 tons, up 10.3 percent; candles, molded novelties, and decorative items, 97,294 tons, up 21.7 percent; paper wrappers, 86,727 tons, down 19.5 percent; and all other uses 187,875 tons, up 0.2 percent.

Coke.—The total demand for petroleum coke in 1970 was 21,554,000 short tons compared with 20,773,000 tons in 1969. The demand for coke in the export market was exceptionally strong in 1970. A total of 6,111,000 tons was exported, an increase for the year of 32.7 percent. The domestic demand for the year, 15,444,000 tons, was 4.5 percent less than in 1969. Refiners used 10,413,000 tons as fuel in 1970, including, 9,753,000 tons of catalyst coke and 660,000 tons of marketable coke. Catalyst coke is formed on catalytic cracking units in the refining process and can only be used as a refinery fuel.

Still Gas.—Refineries used 163,905,000 barrels (1,003,633 million cubic feet) of still gas as fuel in 1970 and 12,564,000 barrels was used as petrochemical feedstocks. This compares with 160,363,000 barrels used as fuel in 1969 and 9,985,000 barrels used as petrochemical feedstocks.

Petrochemical Feedstocks.—Petroleum refineries supplied the petrochemical industry in the United States 101,026,000 barrels of feedstocks (other than LRG) in 1970 and exported 3,776,000 barrels. The domestic demand increased 6.7 percent for the year while exports declined 1.9 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 the 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 1970 was 14,843,000 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 77.4 percent of their crude oil supply by pipeline, 21.5 percent by water, and the remaining 1.1 percent by tank cars and tank trucks in 1970.

The eastern seaboard States (PAD district I), represent 39.8 percent of the domestic market for petroleum in the United States and receive a major part of their domestic supply of crude oil and refined products (3.4 million barrels per day in 1970) from PAD district III. PAD district II, the second largest consuming sector, also receives a substantial share of demand requirements of crude oil and refined products from PAD district III (2.0 million barrels per day in 1970).

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 indicate the final receipts by method of transportation—water, pipelines, 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 1970 were 3,973.3 million barrels, an increase of 94.7 million barrels for the year. Receipts from domestic sources increased 127.7 million barrels in 1970, overland receipts of foreign crude oil were 37.6 million barrels higher, but foreign receipts from overseas sources decreased 70.6 million barrels.

During 1970 refineries processed 3,967.5 million barrels of crude oil, reported a net of 1.4 million barrels used for refinery fuel and losses, and added 4.3 million barrels to inventories.

In 1970, refiners in PAD district I processed crude oil at the rate of 1,290,000 barrels per day, with 45.3 percent of the input being from foreign sources; 2.4 percent from crude oil produced in the district; 50.5 percent received from PAD district III, and the balance received by pipelines from PAD districts II and IV. This was only 22 percent of the demand for petroleum products in the district.

While crude runs to stills in PAD district II increased 141,000 barrels per day in 1970 to 3,154,000 barrels per day, crude oil production declined 45,000 barrels per day. To meet crude oil demand requirements for the district, receipts from PAD district III were increased at an average rate of 145,000 barrels per day to 1,454,000 barrels, and imports from Canada were stepped up to 317,000 barrels per day, 75,000 barrels above the 1969 daily average. PAD district IV supplied 274,000 barrels per day, an average of 28,000 barrels per day below the 1969 level.

PAD districts III and IV are surplus crude oil areas and receive only token amounts of oil from other districts or from foreign sources.

Through secondary recovery projects, crude oil production in Alaska increased enough in 1970 to offset production losses in the other district V States. However, the increase for the district was only 6,000 barrels per day and crude oil requirements for 1970 were 19,000 barrels per day higher. Overseas supplies of foreign crude oil were 26,000 barrels per day below the 1969 level because of the tight tanker situation, but overland pipeline shipments from Canada were increased at the average rate of 12,000 barrels per day for the year. To meet the crude oil requirements for district V in 1970, it was necessary to withdraw 5.2 million barrels from storage.

REFINED PRODUCTS

The domestic product demand in the United States in 1970 (14,696,000 barrels per day) is broken down by PAD districts as follows: District I, 5,853,000; district II, 4,041,000; district III, 2,478,000; district IV, 370,000; and district V, 1,954,000.

The output of refineries and natural gas liquids plants in PAD district I supply about one-fourth of that district's requirements. In 1970, an average of 4,536,000 barrels per day of refined products was shipped into the district. A breakdown of these receipts of refined products in barrels per day is as follows: From foreign sources, 1,785,000; from PAD district III by pipeline, 1,441,000; by tanker, 1,191,000; and by river barge, 63,000; from PAD district II, 54,000 by pipeline; and from PAD district V, 2,000 by tanker.

PAD district II received an average of 722,000 barrels per day of refined products in 1970. PAD district III supplied 534,000 barrels per day (212,000 by river barge and 322,000 by pipeline); pipeline shipments from PAD district I averaged 120,000 barrels per day; pipeline shipments from PAD district IV averaged 21,000 barrels per day; and imports supplied the remaining 47,000 barrels per day.

Although PAD district III is a surplus producing area and shipped a total of 3,316,000 barrels per day to the other districts, an average of 128,000 barrels of refined products were shipped into the district in 1970. This includes pipeline receipts of 68,000 barrels per day from PAD district II, 3,000 barrels per day from PAD district IV, and imports from foreign sources of 57,000 barrels per day.

PAD district IV, also a surplus producing area, shipped an average of 118,000 barrels per day but received 55,000 barrels per day in 1970 (27,000 from PAD district III, 19,000 from PAD district V, and imports of 9,000 from Canada).

PAD district V received 236,000 barrels per day of refined products in 1970. PAD district IV supplied 94,000 barrels per day; PAD district III supplied 60,000 barrels per day; and imported oil supplied the remaining 82,000 barrels per day.

PIPELINES

The Interstate Commerce Commission reported that there were 171,782 miles of interstate pipelines transporting crude oil and petroleum products as of December 31, 1970. This was an increase for the year of 5,240 miles (5,760-mile increase in refined products lines and a decrease of 520 miles in crude oil gathering and trunk lines). The Bureau of Mines conducts a survey of both interstate and intrastate pipeline on a tri-annual basis. The last survey contained data for January 1, 1968.

Crude oil pipelines delivered 3,076.7 million barrels to refineries in 1970, compared with 2,969.3 million barrels in 1969. Petroleum products lines delivered 2,559.6 million barrels in 1970, an increase of 119.7 million barrels for the year.

Clearance is still being withheld for start of construction on the 800-mile Alyeska Pipeline to bring crude oil from the North Slope of Alaska to the port of Valdez for transshipment to the west coast. In addition to satisfying Federal and State government regulations that adequate precautions will be taken to insure no damage to the ecology, suits have been filed by native

Alaskans claiming territorial rights and by conservation groups. It was originally estimated that the cost of the 48-inch crude line would be about 900 million dollars, but with the delays, it is likely the costs will be in excess of 2 billion dollars.

At hearings held in Washington early in 1971, the Canadian Government proposed an alternate route through the Mackenzie Valley that would tie into present pipelines delivering crude oil to the midcontinent area. A study of that proposed route is being conducted. There is a wide difference of opinion as to which route would be most beneficial and would be less likely to upset the ecology.

RAIL, TANK TRUCK, BARGES, AND TANKERS

The annual study by the Association of Oil Pipelines showed that the total tonnage of crude petroleum and petroleum products transported in 1969 was 1,622,775 thousand short tons, of which 46.8 percent was moved by pipelines, 23.4 percent by water carriers, 28.2 percent by motor carriers, and 1.6 percent by railroads. Petroleum products represent 63.5 percent of the total volume transported; 41.9 percent of the pipeline movements; 71 percent of the water carrier movements; 91.0 percent of motor carrier movements; and 96.3 percent of the railroad movement.

The shutdown of the pipeline from the Middle East to the Mediterranean and the production cutbacks by the Libyan Government created a tight shipping market, and triggered a series of increases in charter rates that more than doubled shipping costs between April and the end of the year. Shipping rates from the Gulf Coast to destinations north of Cape Hatteras for a vessel in excess of 30,000 deadweight tons increased in December, from $3.07 to $6.91 per long ton; and from the Caribbean to the north of Cape Hatteras, from $2.12 in April to $5.52 in November. Another example of the increase was the shipping cost from the Persian Gulf to the United Kingdom, which advanced from $10.20 per long ton in May to a high of $24.83 per long ton in October.

STOCKS

At the end of 1970 the total stocks of all oils was 1,017.9 million barrels, up 37.7 million barrels for the year. Crude oil stocks built up to 284.8 million barrels in May, the highest level in 12 years, and crude oil production was cut back. The high shipping rates and shortage of tankers cut down the overseas supplies of crude oil causing a sharp increase in the demand for domestic crude oil. By the end of August crude oil stocks were down to 254.1 million barrels. Stepped up production soon eased the supply situation and by the end of the year stocks were up to 276.4 million barrels, 11.1 million barrels above the December 31, 1969, level.

The 24.1 million barrel increase in stocks of refined products that occurred between the end of 1969 and December 31, 1970, was due to stock buildups of distillate fuel oils and the LP gas, propane. Unusually high demand for distillate fuel oil during the first half of 1970 caused the industry to take precautions that would insure adequate supplies for the 1969–70 heating season. Warmer than normal weather in the fourth quarter of the year slowed the demand growth in that quarter to less than 1 percent and stocks at the close of the year were 23.6 million barrels above the 1969 yearend level.

After several years of exceptionally high increases, the demand for liquefied gases declined in 1970 and production continued to climb upward. Although refineries increased the use of liquefied gas for blending into motor fuel, stocks at the end of the year were up 8.3 million barrels.

PRICES

Crude Oil.—With few exceptions, posted prices of crude oil during 1970 were steady until mid-November when some purchasers increased the postings by 25 cents per barrel. Others followed, and by the first part of December the increase covered almost all production except the Pennsylvania-grade crude oils. These changes, along with the several changes that occurred during 1969, caused an overall increase in the average value of a barrel of crude oil at the wellhead to increase 9 cents in 1970 to $3.18.

Refined Products.—According to the U.S. Bureau of Labor Statistics the wholesale price index for refined petroleum products increased 7.2 percent in 1970 to 109.9. The heating oils, distillate and residual accounted for the major share of the increase. The average posted price for cargo lots of No. 6 residual fuel oil at New York Harbor with a 1 percent maximum sulfur guarantee increased from $1.94 per barrel in 1969 to $2.73 in 1970, and for barge lots the price increased from $2.45 in 1969 to $3.26 per barrel. The average price for barge lots of No. 2 distillate fuel oil in New York Harbor increased from 10.3 cents per gallon in 1969 to 10.6 cents in 1970.

Platt's Oilgram Price Service publishes a series showing the average prices for regular-grade gasoline for 55 representative cities. For the year 1970, this series showed that the service station price, including State, local, and Federal taxes was 35.69 cents per gallon, an increase of 0.89 cents, including an increase of 0.15 cents in State and local taxes.

The average posted price of regular grade gasoline at refineries in Oklahoma for shipment to northern destinations was 12.56 cents per gallon in 1970, an increase of 0.38 cents for the year.

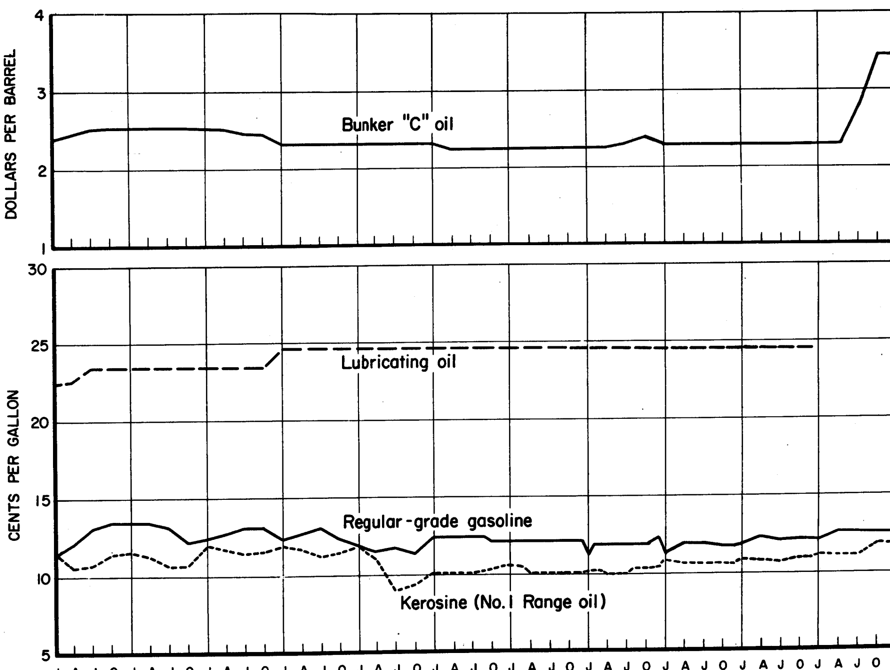

Figure 6.—Prices of Bunker "C" oil at New York Harbor, No. 1 Range oil at Chicago district, and regular-grade gasoline at refineries in Oklahoma, by quarters.

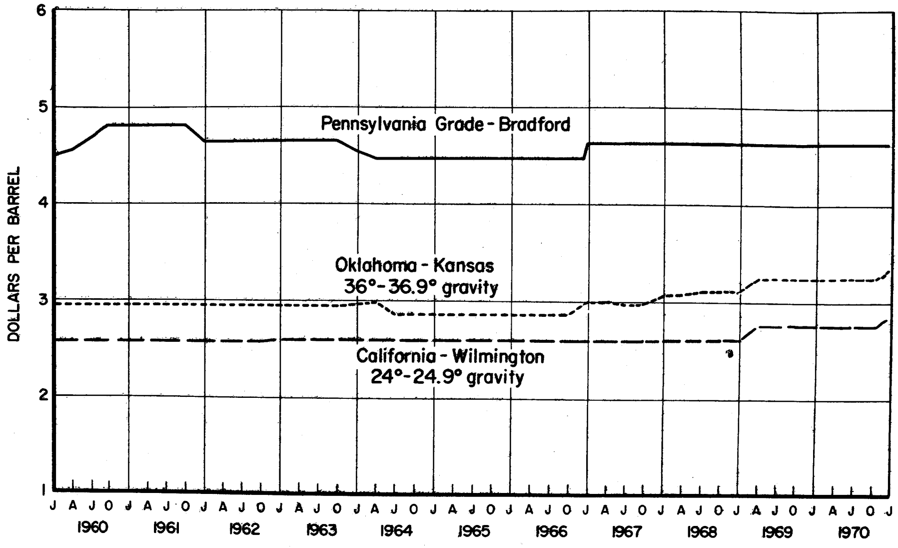

Figure 7.—Posted prices of selected grades of crude petroleum in the United States, by quarters.

FOREIGN TRADE

Foreign trade statistics reported in this section were compiled from two sources. The imports of crude and unfinished oils were obtained from the petroleum refining companies. Imports of refined products from Puerto Rico and the Virgin Islands are Bureau of Mines data but all other imports of refined products and exports were compiled by the Bureau of the Census.

Total imports of crude oil and refined products in 1970 was 1,247.4 million barrels, an increase of 91.8 million barrels for the year. Crude oil imports declined from 514.1 million barrels in 1969 to 483.3 million in 1970. Crude oil receipts from Canada were 245.3 million barrels, an increase of 42 million barrels while imports of crude oil from offshore sources declined 72.8 million barrels. As previously mentioned in this chapter, the increased shipping costs and short tanker supply eliminated most of the cost benefits of foreign oil over domestic crude oil in the coastal markets. Because of this, several inland refiners were unable to exchange their allocation of import licenses with coastal refiners for domestic crude oil and were left with unused tickets when the licenses expired on December 31, 1970.

Imports of refined products and unfinished oils were 764.1 million barrels in 1970, an increase of 122.7 million barrels. Residual fuel oil accounted for 96.2 million barrels of this increase; bonded jet fuels, 4.6 million; liquefied petroleum gases and plant condensate, 8.8 million; and petrochemical feedstocks from Puerto Rico, 5.2 million barrels. The total imports of refined products from Canada in 1970 was 34.5 million barrels, an increase for the year of 16.0 million barrels. In 1970 the Oil Import Administration, by Presidential proclamation, relaxed import controls to permit an additional 7.4 million barrels of No. 2 distillate fuel oil and 5.0 million barrels of asphalt into PAD district I. Imports of liquefied gases from Canada and other Western Hemisphere sources were excluded from the 12.2 percent limitation. Another change announced in December was the elimination of the "Brownsville Loop," thereby permitting the Mexican imports of 30,000 barrels per day to come directly by water. Prior to this these shipments of unfinished oils were shipped by water to Brownsville, Tex., unloaded in bonded trucks which transported the oil across the Mexican border, returned and reloaded the oil aboard the vessel, then shipped it to East Coast destinations. All this was done to get around provisions of the regulations which required allocations for all waterborne imports of petroleum.

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.—A total of 1,980,562 short tons of native asphalt and related bitumens were produced in the United States in 1970, an increase of 3.2 percent for the year. The value of this production was $8,879,000. Production was reported for Alabama, Missouri, Texas, and Utah.

Table 2.—Supply and demand of all oils in the United States, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1969													
New supply:													
Domestic production:													
Crude petroleum	260,575	236,405	265,690	263,542	276,460	274,644	274,677	267,778	265,774	271,804	266,085	280,562	3,203,996
Lease condensate	14,946	13,574	15,025	13,612	13,562	14,298	13,483	13,296	13,078	13,788	14,282	14,811	167,755
Natural gas plant liquids	48,468	45,169	49,184	47,203	49,017	46,839	48,247	48,578	47,061	49,723	49,112	51,640	580,241
Imports: [1]													
Crude petroleum	35,442	36,537	45,654	43,568	44,137	40,960	43,209	44,887	42,364	45,042	43,775	48,539	514,114
Unfinished oils	2,184	3,583	2,723	2,556	2,459	3,060	2,871	3,629	4,164	2,915	3,724	4,898	38,766
Refined products	66,334	54,002	57,997	48,240	43,958	38,032	42,751	45,899	48,009	46,767	45,045	65,637	602,671
Other hydrocarbons and hydrogen refinery input	275	291	399	363	321	331	473	379	374	337	349	321	4,213
Total new supply	428,224	389,561	436,672	419,084	429,914	418,164	425,711	424,446	420,824	430,376	422,372	466,408	5,111,756
Crude petroleum unaccounted for [2]	+930	−360	−830	+1,237	+1,033	−1,430	+1,402	−36	−1,287	−2,275	−1,063	+118	−2,561
Processing gain	9,621	8,649	9,653	8,768	9,401	9,723	10,315	9,643	11,305	13,344	11,872	10,118	122,412
Total supply	438,775	397,850	445,495	429,089	440,348	426,457	437,428	434,053	430,842	441,445	433,181	476,644	5,231,607
Change in stocks, all oils [3]	−61,248	−31,575	−2,033	+17,408	+28,926	+25,848	+18,156	+10,184	+9,271	+5,511	−4,736	−33,161	−17,449
Total disposition of primary supply	500,023	429,425	447,528	411,681	411,422	400,609	419,272	423,869	421,571	435,934	437,917	509,805	5,249,056
Exports: [4]													
Crude petroleum	-------	220	176	93	216	1	-------	144	83	162	240	101	1,436
Refined products	5,802	6,105	7,208	6,535	7,388	7,427	6,457	8,307	7,531	6,958	6,774	6,957	83,449
Crude losses	334	329	356	342	356	355	369	365	354	356	352	373	4,241
Domestic demand for products:													
Gasoline:													
Motor gasoline	156,448	143,671	157,195	166,128	175,220	170,694	185,854	182,739	169,081	175,227	161,741	172,997	2,016,995
Aviation gasoline	1,999	1,510	2,480	2,524	2,501	2,452	2,504	2,264	1,915	2,012	1,873	1,517	25,551
Total	158,447	145,181	159,675	168,652	177,721	173,146	188,358	185,003	170,996	177,239	163,614	174,514	2,042,546
Jet fuel:													
Naphtha-type	8,400	8,269	11,206	9,110	10,096	9,860	10,478	9,973	8,370	7,293	7,387	8,076	108,518
Kerosine-type	20,568	18,129	19,549	19,774	19,823	21,805	21,383	21,419	22,704	20,833	22,157	25,069	253,213
Total	28,968	26,398	30,755	28,884	29,919	31,665	31,861	31,392	31,074	28,126	29,544	33,145	361,731
Ethane (including ethylene)	5,954	5,423	6,008	5,603	6,021	5,580	5,756	6,343	5,877	6,147	6,504	7,000	72,216
Liquefied gases:													
LRG [5] for fuel use	6,116	5,923	5,794	5,180	5,598	6,456	6,480	6,118	6,441	6,138	6,767	7,436	74,447
LRG [5] for chemical use	2,591	2,607	3,232	3,377	3,192	3,185	3,391	3,591	2,681	2,754	2,517	2,443	35,561

LPG [6] for fuel and chemical use	37,435	25,099	23,192	17,394	14,321	14,118	14,763	16,313	18,293	24,021	27,239	31,214	263,402
Total	46,142	33,629	32,218	25,951	23,111	23,759	24,634	26,022	27,415	32,913	36,523	41,093	373,410
Kerosine	15,478	11,858	10,208	5,805	5,528	4,505	5,639	5,161	7,270	7,088	9,257	12,572	100,369
Distillate fuel oil	119,246	96,292	91,077	66,970	58,739	51,676	49,948	50,849	58,191	62,386	82,912	111,976	900,262
Residual fuel oil	82,361	68,121	67,956	58,635	51,898	47,478	48,404	51,308	54,494	58,632	55,534	77,103	721,924
Petrochemical feedstocks: [7]													
Still gas	747	711	909	791	789	877	864	995	794	895	794	819	9,985
Naphtha—400°	4,421	4,272	5,408	4,552	4,650	4,705	4,340	5,392	4,660	5,302	4,767	5,100	57,569
Other	1,847	2,225	1,845	2,200	2,101	2,408	2,482	2,244	2,047	2,519	2,451	2,725	27,094
Total	7,015	7,208	8,162	7,543	7,540	7,990	7,686	8,631	7,501	8,716	8,012	8,644	94,648
Special naphthas	2,595	1,634	2,843	2,637	2,289	2,868	2,517	2,632	2,676	2,512	2,118	2,277	29,598
Lubricants	3,705	3,663	4,016	4,153	4,403	4,090	4,331	4,135	4,084	4,619	3,676	3,907	48,782
Wax	392	381	368	325	405	399	372	343	435	434	336	398	4,588
Coke	6,141	6,142	7,222	6,070	6,475	6,401	7,411	6,518	6,855	6,932	6,880	7,783	80,830
Asphalt	3,891	4,060	5,640	9,282	13,493	16,946	18,415	19,144	19,175	16,708	9,805	6,731	143,290
Road oil	124	47	131	265	663	1,092	1,391	1,690	1,478	1,114	502	259	8,756
Still gas	11,906	11,425	12,293	12,640	13,633	13,929	14,355	14,504	14,469	13,422	14,000	13,787	160,363
Miscellaneous products	1,522	1,309	1,216	1,296	1,624	1,302	1,368	1,378	1,613	1,470	1,334	1,185	16,617
Total domestic demand	493,887	422,771	439,788	404,711	403,462	392,826	412,446	415,053	413,603	428,458	430,551	502,374	5,159,930
Stocks, all oils:													
Crude oil and lease condensate	279,483	265,298	264,178	273,204	281,271	284,544	277,482	267,721	262,528	264,285	264,756	265,227	265,227
Unfinished oils	90,528	93,335	94,411	100,759	105,318	104,081	101,914	97,454	97,818	97,976	95,609	97,819	97,819
Natural gasoline and plant condensate [8]	5,492	6,029	6,235	5,889	6,137	6,236	6,745	7,118	6,453	6,291	5,779	5,704	5,704
Refined products	560,821	540,087	537,892	540,272	556,324	580,037	606,913	630,945	645,710	649,468	647,140	611,373	611,373
Total	936,324	904,749	902,716	920,124	949,050	974,898	993,054	1,003,238	1,012,509	1,018,020	1,013,284	980,123	980,123
1970 p													
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	71,611	70,507	73,280	61,102	48,472	55,121	57,560	54,345	51,608	58,103	56,872	66,257	724,838
Other hydrocarbons and hydrogen refinery input	403	450	469	350	358	437	540	956	468	583	745	479	6,238
Total new supply	464,165	430,526	470,689	436,888	436,273	429,975	435,664	441,022	440,087	459,949	450,609	481,149	5,376,996
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

See footnotes at end of table.

Table 2.—Supply and demand of all oils in the United States, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
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	477,519	439,581	482,392	446,220	444,732	440,690	446,041	450,244	450,993	468,353	461,806	491,756	5,500,327
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	529,787	460,331	483,343	428,939	416,604	425,711	441,578	438,470	424,004	452,703	443,909	517,210	5,462,589
Exports: [4]													
Crude petroleum	93	-------	70	94	-------	302	97	11	-------	1,962	1,616	746	4,991
Refined products	6,657	7,241	7,248	7,605	7,765	7,454	8,261	6,443	8,128	7,702	6,308	8,440	89,252
Crude losses	367	335	366	348	354	356	365	372	360	367	361	377	4,328
Domestic demand for products:													
Gasoline:													
Motor gasoline	162,606	149,557	171,671	169,527	181,704	185,784	193,656	188,141	178,038	183,111	167,085	180,469	2,111,349
Aviation gasoline	1,344	1,423	1,734	1,768	1,853	1,594	1,586	2,297	1,774	1,637	1,309	1,565	19,884
Total	163,950	150,980	173,405	171,295	183,557	187,378	195,242	190,438	179,812	184,748	168,394	182,034	2,131,233
Jet fuel:													
Naphtha-type	6,718	7,153	7,080	6,729	7,503	7,060	8,911	7,937	7,890	8,524	7,424	7,980	90,909
Kerosine-type	22,116	21,528	21,082	20,430	20,210	22,400	22,239	22,894	23,161	21,510	21,231	22,551	261,352
Total	28,834	28,681	28,162	27,159	27,713	29,460	31,150	30,831	31,051	30,034	28,655	30,531	352,261
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	36,845	25,997	23,075	17,115	13,733	13,074	14,347	14,707	16,388	21,717	25,836	28,762	251,596
Total	47,867	35,213	31,901	25,796	22,062	22,241	23,980	24,109	25,191	30,751	35,459	39,034	363,604
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	96,775	95,776	74,191	60,334	52,574	50,269	52,890	58,645	69,922	78,636	110,048	927,250
Residual fuel oil	89,716	82,169	87,251	63,642	51,276	58,221	59,166	61,226	50,654	58,864	61,706	80,396	804,287
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	2,376	2,603	3,014	2,513	2,553	2,393	2,821	2,492	2,554	2,476	2,683	2,705	31,183
Total	7,714	8,800	8,957	7,331	8,753	8,132	8,724	8,428	8,191	8,456	8,321	9,219	101,026
Special naphthas	2,218	2,404	2,069	2,953	2,326	2,682	2,583	2,822	2,785	3,263	2,498	2,603	31,206
Lubricants	4,059	3,429	4,088	4,447	3,975	4,659	4,204	4,044	4,260	4,477	4,062	4,029	49,733
Wax	348	336	406	397	319	407	376	355	443	448	348	423	4,606
Coke	6,684	6,090	6,588	6,448	6,712	6,403	6,467	6,726	6,423	5,817	6,240	6,620	77,218
Asphalt	4,388	4,724	6,252	10,008	14,262	18,779	21,318	20,605	18,759	15,903	10,649	7,827	153,474

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	1,625	1,153	1,429	1,356	1,106	935	1,296	988	1,382	1,017	1,208	1,348	14,843
Total domestic demand	522,670	452,755	475,659	420,892	408,485	417,599	432,855	431,644	415,516	442,672	435,624	507,647	5,364,018
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

[p] Preliminary.
[1] Bureau of Mines data for crude oil and unfinished oils; 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 LRG 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 States [1]

(Million barrels)

State	1966	1967	1968	1969	1970
Eastern States:					
Illinois	362	336	314	272	229
Indiana	48	47	40	41	37
Kentucky	101	94	80	73	61
Michigan	71	63	55	52	46
New York	10	15	13	12	11
Ohio	101	114	132	127	128
Pennsylvania	73	63	59	55	51
West Virginia	57	56	54	53	53
Total	823	788	747	685	616
Central and Southern States:					
Alabama	85	79	73	67	65
Arkansas	181	176	159	127	130
Kansas	726	625	601	566	539
Louisiana [2]	5,408	5,456	5,608	5,689	5,710
Mississippi	374	357	326	360	355
Nebraska	57	63	55	47	41
New Mexico	1,025	926	865	840	761
North Dakota	321	290	287	235	192
Oklahoma	1,518	1,459	1,395	1,390	1,351
Texas [2]	14,077	14,494	13,810	13,063	13,195
Total	23,772	23,925	23,179	22,384	22,339
Mountain States:					
Colorado	344	340	420	401	389
Montana	282	308	345	276	242
Utah	213	201	180	195	182
Wyoming	1,073	1,044	1,101	997	1,017
Total	1,912	1,893	2,046	1,869	1,830
Pacific Coast States:					
Alaska	322	381	373	432	[3] 10,149
California [2]	4,608	4,369	4,341	4,243	3,984
Total [1]	4,930	4,750	4,714	4,675	14,133
Other States [4]	15	21	21	19	83
Total United States	31,452	31,377	30,707	29,632	39,001

[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 reasonable 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	1966	1967	1968	1969	1970 p
Supply:					
Production	3,027,763	3,215,742	3,329,042	3,371,751	3,517,450
Imports [1]	447,120	411,649	472,323	514,114	483,293
Total new supply	3,474,883	3,627,391	3,801,365	3,885,865	4,000,743
Stock changes: [2]					
Domestic crude	+17,863	+7,799	+17,653	−4,668	+10,380
Foreign crude	+239	+2,780	+5,570	−2,298	+760
Unaccounted for [3]	---------	---------	+7,138	−2,561	−7,721
Disposition by use:					
Runs of domestic crude	3,000,789	3,174,004	3,308,044	3,363,602	3,485,332
Runs of foreign crude	446,404	408,590	466,316	516,003	482,171
Exports [4]	1,477	26,541	1,802	1,436	4,991
Transfers:					
Distillate	752	730	712	654	743
Residual	3,551	3,671	4,272	4,334	4,317
Losses	3,808	3,276	4,134	4,241	4,328
Total disposition by use	3,456,781	3,616,812	3,785,280	3,890,270	3,981,882

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 months

(Thousand barrels)

Supply and disposition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1969													
New supply:													
Production	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
Imports [1]	35,442	36,537	45,654	43,568	44,137	40,960	43,209	44,887	42,364	45,042	43,775	48,539	514,114
Total new supply	310,963	286,516	326,369	320,722	334,159	329,902	331,369	325,961	321,216	330,634	324,142	343,912	3,885,865
Change in stocks, end of period:													
Domestic crude	+13,671	−13,127	−4,316	+8,070	+5,586	+4,027	−6,002	−8,417	−2,972	+547	+80	−1,815	−4,668
Foreign crude	−6,381	−1,058	+3,196	+956	+2,481	−754	−1,060	−1,344	−2,221	+1,210	+391	+2,286	−2,298
Unaccounted for [2]	+930	−360	−830	+1,237	+1,033	−1,430	+1,402	−36	−1,287	−2,275	−1,063	+118	−2,561
Disposition by use:													
Runs of domestic crude	262,052	261,730	283,299	269,496	284,561	282,728	294,855	288,523	279,681	281,961	278,253	296,463	3,363,602
Runs of foreign crude	41,791	37,584	42,419	42,583	41,597	41,718	44,202	46,237	44,574	43,705	43,373	46,220	516,003
Exports [3]	-------	220	176	93	216	1	-------	144	83	162	240	101	1,436
Transfers:													
Distillate	55	53	60	54	50	52	54	54	53	57	56	56	654
Residual	371	425	349	365	345	345	353	363	377	361	334	346	4,334
Losses	334	329	356	342	356	355	369	365	354	356	352	373	4,241
Total disposition by use	304,603	300,341	326,659	312,933	327,125	325,199	339,833	335,686	325,122	326,602	322,608	343,559	3,890,270
1970 p													
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

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 States and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1969													
Alabama	676	576	683	669	674	643	638	602	620	648	631	641	7,701
Alaska	5,479	5,165	5,883	6,032	6,526	6,073	5,985	6,279	6,526	6,764	6,556	6,685	73,953
Arizona	231	206	223	209	209	193	196	201	194	189	193	189	2,433
Arkansas	1,546	1,393	1,536	1,526	1,540	1,478	1,479	1,503	1,472	1,541	1,479	1,556	18,049
California:													
South	14,054	12,983	14,152	13,745	14,622	14,126	14,652	14,587	14,064	14,397	13,977	14,320	169,679
Central Coastal	5,051	4,182	4,893	4,981	5,534	5,422	5,833	5,993	5,817	6,110	6,007	6,074	65,897
East Central	11,814	10,722	11,970	11,601	11,918	11,485	11,801	11,706	11,161	11,662	11,370	11,662	138,872
North	76	73	77	78	88	71	69	66	67	60	61	57	843
Total California	30,995	27,960	31,092	30,405	32,162	31,104	32,355	32,352	31,109	32,229	31,415	32,113	375,291
Colorado	2,458	2,284	2,396	2,435	2,425	2,344	2,422	2,374	2,363	2,289	2,231	2,273	28,294
Florida	130	117	138	140	144	146	151	144	140	144	172	165	1,731
Illinois	4,405	4,038	4,452	4,342	4,438	4,184	4,282	4,217	4,166	4,214	3,897	4,089	50,724
Indiana	645	627	694	676	643	612	673	656	663	656	627	669	7,841
Kansas	7,453	6,908	7,513	7,441	7,631	7,359	7,518	7,451	7,364	7,393	7,185	7,500	88,716
Kentucky	1,104	1,004	1,123	1,107	1,104	1,059	1,120	1,052	1,077	1,107	1,005	1,062	12,924
Louisiana:													
Gulf Coast	63,903	58,150	67,425	66,249	69,436	68,557	68,301	62,661	66,360	65,805	68,175	71,051	796,073
Rest of State	4,236	3,764	4,126	4,146	4,158	3,977	4,035	4,042	3,954	4,080	3,965	4,047	48,530
Total Louisiana	68,139	61,914	71,551	70,395	73,594	72,534	72,336	66,703	70,314	69,885	72,140	75,098	844,603
Michigan	1,037	978	1,027	1,041	1,008	985	1,056	1,012	1,020	1,048	976	1,025	12,213
Mississippi	4,988	4,619	5,326	5,211	5,420	5,374	5,627	5,536	5,400	5,680	5,451	5,651	64,283
Missouri	6	5	6	5	6	5	6	6	5	6	5	6	67
Montana	3,922	3,488	3,742	3,575	3,796	3,710	3,810	3,735	3,593	3,620	3,455	3,508	43,954
Nebraska	1,061	967	1,064	1,035	1,045	994	1,011	1,016	983	979	960	991	12,106
Nevada	20	20	21	21	22	20	19	20	17	13	10	20	223
New Mexico:													
Southeastern	10,165	9,199	10,000	9,846	10,187	9,922	10,129	10,013	9,842	10,441	10,081	10,353	120,178
Northwestern	836	774	838	770	728	717	695	681	703	766	762	779	9,049
Total New Mexico	11,001	9,973	10,838	10,616	10,915	10,639	10,824	10,694	10,545	11,207	10,843	11,132	129,227
New York	109	98	103	102	103	102	102	99	110	105	101	122	1,256
North Dakota	1,878	1,752	1,971	1,863	1,557	1,952	1,991	1,983	1,933	1,991	1,885	1,947	22,703
Ohio	995	880	1,005	970	935	911	944	913	903	856	822	838	10,972
Oklahoma	19,295	17,529	18,972	18,658	19,022	18,666	18,826	18,947	18,499	19,000	18,690	18,625	224,729
Pennsylvania	339	340	335	368	371	384	402	373	399	403	388	346	4,448
South Dakota	11	11	11	13	17	14	13	15	13	14	13	13	158
Tennessee	-------	1	-------	1	-------	1	-------	1	7	7	7	7	32

See footnotes at end of table.

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by States and months—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Texas:													
District 01	1,568	1,412	1,548	1,507	1,538	1,484	1,529	1,527	1,486	1,528	1,451	1,523	18,101
District 02	5,732	5,157	5,939	6,061	6,578	6,892	6,600	6,429	6,200	6,442	6,169	6,893	75,092
District 03	12,245	10,952	12,520	12,663	13,583	14,231	13,473	13,200	12,607	13,126	12,504	13,959	155,063
District 04	7,976	7,289	8,128	7,927	8,245	8,110	7,999	7,856	7,512	7,783	7,545	7,935	94,305
District 05	1,412	1,270	1,439	1,441	1,492	1,603	1,494	1,480	1,401	1,481	1,412	1,625	17,550
District 06, except East Texas	4,666	4,190	4,773	4,955	5,311	5,685	5,293	5,125	4,939	5,210	5,061	6,307	61,515
East Texas	4,312	3,820	4,442	4,584	5,075	5,590	5,065	4,959	4,711	4,973	4,741	5,641	57,913
District 07B	3,180	2,831	3,211	3,138	3,242	3,280	3,313	3,253	3,140	3,261	3,137	3,174	38,160
District 07C	4,159	3,739	4,171	3,936	4,029	3,911	3,893	3,888	3,772	3,820	3,734	3,890	46,942
District 08	23,983	21,651	24,514	24,029	25,070	24,852	24,711	24,730	23,903	24,911	24,030	25,472	291,856
District 08A	16,201	14,401	15,805	16,125	17,601	18,471	18,013	17,626	17,548	18,245	17,742	19,789	207,567
District 09	5,052	4,524	4,976	4,856	4,987	4,871	4,863	4,813	4,596	4,724	4,554	4,678	57,494
District 10	2,626	2,379	2,574	2,553	2,605	2,522	2,547	2,545	2,464	2,482	2,416	2,504	30,217
Total Texas	93,112	83,615	94,040	93,775	99,356	101,502	98,793	97,431	94,279	97,986	94,496	103,390	1,151,775
Utah	2,022	1,820	1,966	1,966	2,036	1,945	1,974	2,157	1,875	1,964	1,621	1,949	23,295
Virginia	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1
West Virginia	207	244	257	272	270	257	269	253	271	296	235	273	3,104
Wyoming	12,257	11,447	12,747	12,285	13,053	13,752	13,338	13,349	12,992	13,358	12,878	13,489	154,945
Total United States:													
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
1968	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
Daily average, 1969	8,888	8,928	9,055	9,238	9,356	9,631	9,295	9,067	9,295	9,213	9,346	9,528	9,238
Pennsylvania grade (included in United States total)	906	922	953	1,011	1,002	997	1,042	973	1,031	1,085	964	988	11,874
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	7,223	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	3,954	3,937	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
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 United States total)	948	909	997	1,044	1,025	1,094	1,135	1,090	1,207	1,132	1,098	1,170	12,849

Sources of 1970 data:

Alabama —State Oil and Gas Board of Alabama.
Alaska —Division of Oil and Gas, Alaska Department of Natural Resources.
Arizona —Arizona Oil and Gas Conservation Commission.
Arkansas —Arkansas Oil and Gas Commission.
California —Division of Oil and Gas, Department of Conservation, State of California.
Colorado —Colorado Oil and Gas Conservation Commission.
Florida —Bureau of Geology, Florida Department of Natural Resources.
Illinois —Oil and Gas Section, Illinois State Geological Survey.
Indiana —Petroleum Section, Indiana Geological Survey.
Kansas —Kansas Corporation Commission.
Kentucky —Kentucky Geological Survey.
Louisiana —Louisiana Department of Conservation.
Michigan —Natural Resources Commission, Department of Natural Resources, State of Michigan.
Mississippi —Mississippi State Oil and Gas Board.
Missouri —Missouri Division of Geological Survey and Water Resources.
Montana —Oil and Gas Conservation Commission of the State of Montana.
Nebraska —Nebraska Oil and Gas Conversation 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 —Ohio Oil and Gas Association.
Oklahoma —Oklahoma Corporation Commission.
Pennsylvania —Bureau of Topographic and Geologic Survey, State Planning Board Commonwealth of Pennsylvania.
South Dakota —South Dakota Geological Survey.
Tennessee —Division of Geology, Tennessee Department of Conservation.
Texas —Oil and Gas Division, The Railroad Commission of Texas.
Utah —Utah Oil and Gas Conservation Commission.
Virginia —Division of Mines and Quarries, Department of Labor and Industry, Commonwealth of Virginia.
West Virginia —Oil and Gas Division, West Virginia Department of Mines.
Wyoming —Wyoming State Oil and Gas Commission.

Table 7.—Percentage of total U.S. crude petroleum produced, by States

State	1966	1967	1968	1969	1970
Texas	34.9	34.8	34.1	34.2	35.5
Louisiana	22.3	24.1	24.6	25.0	25.8
California	11.4	11.2	11.2	11.1	10.6
Oklahoma	7.4	7.2	6.7	6.7	6.4
Wyoming	4.4	4.2	4.3	4.6	4.6
New Mexico	4.1	3.9	3.8	3.8	3.6
Kansas	3.4	3.1	2.9	2.6	2.4
Alaska	.5	.9	2.0	2.2	2.4
Mississippi	1.8	1.8	1.7	1.9	1.9
Illinois	2.0	1.8	1.7	1.5	1.2
Montana	1.2	1.1	1.5	1.3	1.1
Colorado	1.1	1.1	1.0	.8	.7
Utah	.8	.7	.7	.7	.7
North Dakota	.9	.8	.7	.7	.6
Arkansas	.8	.7	.6	.5	.5
Kentucky	.6	.5	.4	.4	.3
Michigan	.5	.4	.4	.4	.3
Nebraska	.5	.4	.4	.4	.3
Other States	1.4	1.3	1.3	1.2	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			Estimated reserves
		1969	1970	Total since discovery [2]	
Wilmington	California	89,053	81,842	1,406,358	1,194,455
East Texas	Texas	56,244	71,854	3,944,503	2,057,159
Wasson	do	32,079	46,078	533,784	170,001
Kelly-Snyder	do	33,723	45,798	516,581	671,719
McArthur River	Alaska	31,440	40,382	94,216	209,618
Caillou Island	Louisiana	32,955	37,673	427,512	329,161
Timbalier Bay	do	34,458	35,443	297,936	350,507
Midway Sunset	California	32,916	32,792	1,089,806	560,000
Bay Marchand Block 2	Louisiana	28,763	32,407	305,409	477,534
Slaughter	Texas	18,117	32,005	426,784	97,186
Seeligson (all fields)	do	31,995	30,002	408,199	80,379
Hawkins	do	15,941	29,122	390,491	125,579
Spraberry Trend	do	15,996	27,191	316,818	130,493
Kern River	California	25,550	25,322	526,994	450,000
West Delta Block 30	Louisiana	23,949	23,854	216,666	183,334
Sho-Vel-Tum	Oklahoma	33,483	23,425	864,586	36,537
Tom O'Connor	Texas	17,396	22,904	369,339	177,689
Main Pass Block 41	Louisiana	15,961	22,751	84,221	68,530
South Pass Block 24	do	20,904	22,685	344,829	405,171
South Pass Block 27	do	20,548	22,440	199,177	111,823
Goldsmith	Texas	20,293	21,564	500,835	219,575
Grand Isle Block 43	Louisiana	19,207	21,018	78,826	92,192
Grand Isle Block 16	do	21,112	20,721	137,893	112,172
Dos Cuadras	California	2,827	19,783	22,955	80,217
Garden Island Bay	Louisiana	15,125	18,816	126,934	64,295
Timbalier South Block 135	do	17,342	18,384	89,725	70,275
West Ranch	Texas	15,441	17,972	212,941	160,012
Sooner Trend	Oklahoma	17,244	17,624	135,539	112,376
West Delta Block 73	Louisiana	18,651	17,256	80,641	79,359
Hastings, East and West	Texas	13,051	16,850	413,095	207,667
Vacuum	New Mexico	15,147	16,673	207,568	77,432
Huntington Beach	California	17,598	16,386	846,068	124,129
Panhandle	Texas	17,622	16,237	1,214,741	414,123
Webster	do	11,428	15,597	337,669	112,331
Fairway	do	10,050	13,812	60,282	135,152
Oregon Basin	Wyoming	14,795	13,758	192,615	70,002
Cogdell Area	Texas	10,070	13,575	145,156	92,143
Ship Shoal Block 208	Louisiana	12,610	13,301	46,518	61,858
Elk Basin	Montana, Wyoming	17,533	13,062	343,282	104,496
Conroe	Texas	9,436	12,875	458,498	132,769
Yates	do	9,313	12,809	538,466	762,352
Middle Ground Shoal	Alaska	10,373	12,792	47,480	137,208
Golden Trend	Oklahoma	11,661	12,770	359,955	135,356
Cowden South (Foster, Johnson)	Texas	10,895	12,681	269,430	50,570
Lake Washington	Louisiana	11,623	12,651	176,566	125,197
Ward-Estes North	Texas	14,466	12,629	278,351	100,069
Thompson (all fields)	do	10,030	12,612	309,666	70,035
Swanson River	Alaska	13,132	12,476	114,197	92,580

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 1969	Production 1970	Production Total since discovery [2]	Estimated reserves
Hilight	Wyoming	1,000	12,402	15,421	87,598
La Fitte	Louisiana	11,282	11,936	178,897	41,102
Van and Van Shallow	Texas	8,810	11,906	357,850	74,397
Salt Creek	Wyoming	13,559	11,593	498,195	88,824
Main Pass Block 69	Louisiana	10,866	11,322	149,654	150,346
Headlee and North	Texas	11,115	11,110	68,223	90,163
Dune	do	8,341	10,929	86,626	62,579
Cote Blanche Bay West	Louisiana	10,954	10,533	94,782	64,528
Rangely	Colorado	11,303	10,413	450,243	153,431
San Ardo	California	10,521	10,384	228,014	100,000
Pegasus	Texas	10,252	10,200	127,940	75,060
Ventura	California	8,575	9,905	750,563	61,041
Beverly Hills	do	12,361	9,886	55,295	56,352
Quarantine Bay	Louisiana	7,533	9,813	133,193	37,807
West Bay	do	10,315	9,810	144,344	65,656
Levelland	Texas	7,932	9,743	192,354	58,342
Keystone	do	8,947	9,465	247,196	51,063
Weeks Island	Louisiana	10,535	9,445	182,386	54,614
Cowden North	Texas	9,396	9,428	228,120	84,996
Salt Creek	do	5,901	9,345	79,968	67,774
Empire Abo	New Mexico	8,177	9,162	69,651	30,349
Belridge South	California	9,045	9,107	159,787	100,000
Lake Barre	Louisiana	9,276	8,741	150,699	99,301
McElroy	Texas	8,334	8,510	267,592	74,432
Greater Aneth	Utah	8,638	8,460	228,363	222,754
Bell Creek	Montana	13,939	8,433	39,911	75,125
Seminole and West	Texas	6,283	8,284	159,546	56,021
Coalinga	California	8,575	8,112	603,863	75,000
Diamond M	Texas	8,633	8,093	172,302	322,698
Dollarhide	do	7,319	8,041	115,076	47,086
Old Ocean	do	8,101	8,002	142,897	57,103
Anahuac	do	7,963	7,950	203,184	56,616
Cote Blanche Island	Louisiana	6,140	7,867	50,505	52,279
Old Illinois	Illinois	7,880	7,660	666,030	19,010
Bay St. Elaine	Louisiana	8,525	7,642	120,624	32,376
Carpinteria Offshore	California	11,329	7,634	27,993	87,366
Means and North	Texas	7,894	7,568	116,036	79,106
Kelsey (all fields)	do	8,708	7,455	98,634	27,608
Bayou Sale	Louisiana	8,798	7,298	147,600	52,410
Granite Point	Alaska	9,208	7,154	36,522	138,518
Borregas (all fields)	Texas	9,409	7,139	96,191	47,883
Sand Hills	Texas	9,253	7,001	170,619	26,381

[1] Fields under 7 million barrels not shown for current year.
[2] Includes revisions, if any.

Source: Oil and Gas Journal. All figures are preliminary.

Table 9.—Well completions in the United States, by quarters [1]

	1st Quarter	2d Quarter	3d Quarter	4th Quarter	Total Number	Total Percent
1969:						
Oil	3,240	3,315	3,501	4,312	14,368	44.6
Gas [2]	852	865	1,049	1,317	4,083	12.7
Dry	2,890	2,910	3,255	4,667	13,722	42.7
Total	6,982	7,090	7,805	10,296	32,173	100.0
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

[1] Excludes service wells.
[2] Includes condensate wells.
Note: Data by quarters adjusted to agree with annual totals.

Source: American Association of Petroleum Geologists and American Petroleum Institute for 1969; American Petroleum Institute for 1970. In 1969 some Bureau of Mines data are included in Nevada.

Table 10.—Well completions in the United States, by States and districts [1]

State and district	1969				1970			
	Oil	Gas [2]	Dry	Total	Oil	Gas [2]	Dry	Total
Alabama	10	1	37	48	7	5	33	45
Alaska	38	11	14	63	67	5	40	112
Arizona	9	2	27	38	1	------	11	12
Arkansas	151	40	228	419	100	36	171	307
California	1,543	59	398	2,000	1,697	56	331	2,084
Colorado	158	47	609	814	142	47	521	710
Florida	6	------	7	13	14	------	11	25
Georgia	------	------	2	2	------	------	4	4
Illinois	417	5	458	880	311	5	381	697
Indiana	129	7	231	367	93	4	190	287
Iowa	------	------	------	------	------	------	3	3
Kansas	1,271	184	1,522	2,977	1,044	108	1,269	2,421
Kentucky	296	142	514	952	275	111	423	809
Louisiana:								
North	309	123	416	848	263	157	343	763
South	471	230	763	1,464	497	232	618	1,347
Offshore	372	190	263	825	382	150	306	838
Total Louisiana	1,152	543	1,442	3,137	1,142	539	1,267	2,948
Michigan	73	15	244	332	49	19	215	283
Mississippi	195	16	504	715	211	12	333	556
Missouri	17	------	12	29	10	------	4	14
Montana	186	31	578	795	64	74	465	603
Nebraska	57	1	325	383	39	2	196	237
Nevada	------	------	2	2	------	------	10	10
New Mexico:								
West	58	237	89	384	60	127	42	229
East	503	26	261	790	281	32	186	499
Total New Mexico	561	263	350	1,174	341	159	228	728
New York	112	12	10	134	69	17	13	99
North Dakota	49	------	203	252	48	1	118	167
Ohio	645	395	198	1,238	503	683	164	1,350
Oklahoma	1,604	397	1,112	3,113	1,343	321	1,021	2,685
Pennsylvania	547	277	72	896	441	250	32	723
South Dakota	------	------	56	56	------	------	83	83
Tennessee	4	7	15	26	24	4	22	50
Texas:								
District 01	466	27	291	784	281	18	226	525
District 02	107	90	218	415	83	70	211	364
District 03	410	116	412	938	338	124	373	835
District 04	190	235	522	947	250	197	355	802
District 05	35	36	108	179	23	15	92	130
District 06	292	56	208	556	169	38	132	339
District 07B	398	54	482	934	471	39	432	942
District 07C	231	62	172	465	160	85	169	414
District 08	907	73	247	1,227	865	75	238	1,178
District 08A	374	1	186	561	878	4	164	1,046
District 09	632	50	471	1,153	519	17	308	844
District 10	205	85	93	383	96	74	73	243
Offshore	9	18	87	114	4	18	38	60
Total Texas	4,256	903	3,497	8,656	4,137	774	2,811	7,722
Utah	47	16	111	174	29	10	44	83
Vermont	------	------	1	1	------	------	------	------
Virginia	1	------	9	10	------	------	------	------
West Virginia	135	652	115	902	192	553	119	864
Wyoming	699	57	819	1,575	627	45	727	1,399
Total United States	14,368	4,083	13,722	32,173	13,020	3,840	11,260	28,120

[1] Excludes service wells.
[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute for 1969; American Petroleum Institute for 1970. In 1969 some Bureau of Mines data are included in Nevada.

Table 11.—Producing oil wells in the United States and average production per well per day, by States

State	Producing oil wells			
	1969		1970	
	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels) [1]	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels) [1]
Alabama	[2] 550	38.5	562	35.8
Alaska	183	1,171.2	202	1,190.1
Arizona	29	261.4	28	171.5
Arkansas	6,118	7.9	7,082	7.5
California:				
South	11,178	41.2	10,717	39.3
Central Coastal	5,494	32.5	5,480	40.5
East Central	24,265	15.7	24,181	15.1
North	60	39.8	59	26.8
Total California	40,997	25.0	40,437	25.0
Colorado	1,811	42.6	1,770	37.8
Illinois	26,733	5.1	26,134	4.5
Indiana	[2] 4,094	5.1	[2] 4,055	5.0
Kansas	44,665	5.4	43,490	5.3
Kentucky	[2] 11,843	2.9	[2] 11,659	2.7
Louisiana:				
Gulf Coast	15,745	135.3	[2] 14,944	153.5
Northern	13,648	9.7	12,990	9.7
Total Louisiana	29,393	77.6	[2] 27,934	86.7
Michigan	3,878	8.2	4,311	7.8
Mississippi	2,548	68.4	3,102	63.2
Montana	3,331	35.9	3,243	31.6
Nebraska	1,305	24.5	1,244	24.6
New Mexico:				
Southeastern	15,522	21.3	15,751	20.9
Northwestern	1,566	15.8	1,563	15.2
Total New Mexico	17,088	20.8	17,314	20.4
New York	5,263	.7	5,861	.6
North Dakota	1,987	30.6	1,457	35.0
Ohio	[2] 15,737	1.9	[2] 15,860	1.7
Oklahoma	80,952	7.6	78,019	7.7
Pennsylvania	37,625	.3	36,801	.3
South Dakota	26	16.3	26	16.9
Texas:				
District 01	10,584	4.7	10,572	4.7
District 02	5,695	35.6	5,367	40.7
District 03	12,159	34.5	11,442	39.7
District 04	9,269	27.1	8,754	27.2
District 05	3,092	15.4	2,990	15.5
District 06, except East Texas	5,945	27.8	5,722	38.1
East Texas	15,486	10.1	14,970	13.1
District 07B	13,079	7.8	12,258	8.2
District 07C	8,093	15.7	7,846	15.0
District 08	38,047	20.8	36,964	21.8
District 08A	17,693	31.8	17,648	39.3
District 09	30,424	5.1	29,468	5.0
District 10	13,575	6.1	13,220	5.8
Total Texas	183,141	17.0	177,221	19.0
Utah	843	74.3	889	73.9
West Virginia	[2] 12,849	.7	[2] 12,750	.7
Wyoming	8,978	49.1	[2] 9,280	48.1
Other States:				
Florida	45	106.6	60	156.5
Missouri	164	1.3	126	1.2
Nevada	11	50.9	9	40.8
Tennessee	[2] 35	2.6	[2] 59	18.0
Virginia	5	.5	[2] 5	.5
Total	260	23.4	259	37.2
Total United States	542,227	16.9	530,990	18.0

[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 States of origin and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1969													
Alabama	17.5	26.2	18.0	24.9	19.5	21.5	23.1	20.4	18.2	19.4	18.2	27.7	21.2
Alaska	138.5	203.8	191.8	245.8	158.0	186.6	202.0	202.9	177.1	198.5	240.2	183.3	193.8
Arizona	7.5	6.5	6.7	7.1	7.5	5.6	7.2	6.3	6.5	6.6	4.9	8.4	6.7
Arkansas	42.1	62.7	52.3	50.3	39.2	51.3	51.7	48.5	51.4	49.6	49.5	50.4	49.8
California	890.5	1,086.2	1,010.6	1,001.1	1,133.0	1,006.0	1,083.7	1,008.9	1,077.9	1,045.7	1.012.4	1,058.7	1,034.2
Colorado	74.1	76.5	88.4	65.5	91.2	82.6	69.5	101.8	80.7	74.2	61.2	66.6	77.8
Florida	2.5	8.4	3.5	1.4	11.5	-----	6.4	5.6	1.8	3.9	6.6	4.3	4.7
Illinois	146.5	132.6	143.7	128.8	126.1	142.7	141.3	130.0	142.2	136.0	138.0	150.5	138.3
Indiana	23.2	24.6	21.9	20.9	19.9	21.7	23.2	21.9	14.0	20.1	23.9	26.4	21.8
Kansas	178.9	284.8	254.4	252.0	220.4	249.7	255.1	245.1	228.3	241.5	248.9	238.0	241.0
Kentucky	32.2	39.7	32.2	38.4	36.4	43.1	39.2	33.9	39.5	32.3	49.2	39.2	37.9
Louisiana	2,131.3	2,337.5	2,244.5	2,326.8	2,325.1	2,377.1	2,369.2	2,214.1	2,339.0	2,249.9	2,453.1	2,449.4	2,317.3
Michigan	33.9	31.9	35.5	33.6	34.9	27.9	35.8	35.5	31.0	33.2	31.7	37.5	33.6
Mississippi	163.3	169.7	167.4	163.7	149.4	217.7	171.2	166.4	193.6	195.4	177.2	176.9	175.9
Missouri	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Montana	122.3	126.0	112.5	116.9	120.8	134.0	114.1	134.2	133.2	115.7	112.3	114.2	121.3
Nebraska	37.3	32.5	33.1	36.2	27.1	21.5	41.4	35.4	30.3	24.5	42.8	30.8	32.7
Nevada	.6	.7	.6	.6	.8	.6	.6	.6	.7	.5	.3	.6	.6
New Mexico	327.7	390.4	348.7	343.5	383.6	354.8	364.3	340.5	331.3	365.2	336.9	402.5	357.3
New York	3.5	3.5	3.3	3.4	3.3	3.4	3.3	3.2	3.7	3.4	3.4	3.9	3.4
North Dakota	59.2	61.8	64.7	54.2	29.9	68.8	67.5	66.1	66.6	68.4	62.8	66.9	61.4
Ohio	25.7	34.8	33.1	32.9	32.1	25.7	32.1	28.0	33.1	24.0	28.8	28.2	29.8
Oklahoma	626.9	657.5	638.9	593.9	602.4	626.1	602.5	625.2	609.9	608.0	629.7	580.1	616.4
Pennsylvania	12.2	12.0	13.5	12.5	11.6	11.3	11.9	8.9	15.7	15.2	14.5	16.3	13.0
South Dakota	.4	.4	.4	.4	.6	.5	.4	.5	.4	.5	.4	.4	.4
Tennessee	-----	.0	-----	.0	-----	.0	-----	.0	.2	.2	.2	.2	.1
Texas	2,942.8	3,118.5	3,194.3	2,929.0	3,116.3	3,241.1	3,218.1	3,324.6	3,196.6	3,152.0	3,160.7	3,326.5	3,160.7
Utah	57.1	67.2	60.4	64.8	65.0	60.7	77.0	69.8	64.8	56.8	53.5	60.3	63.1
Virginia	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.0	.0
West Virginia	8.1	7.8	8.3	8.9	8.2	7.9	10.1	9.8	7.0	7.7	9.5	10.2	8.7
Wyoming	340.8	392.2	411.6	411.8	401.4	507.1	467.0	450.1	499.2	446.4	371.9	428.1	427.4
Total domestic crude	8,446.8	9,396.6	9,194.5	8,969.5	9,175.4	9,497.2	9,489.1	9,338.4	9,394.1	9,195.0	9,342.9	9,586.7	9,250.5
Foreign crude	1,349.1	1,342.7	1,369.6	1,420.4	1,343.7	1,390.4	1,428.0	1,491.3	1,486.2	1,413.9	1,446.1	1,483.5	1,414.1
Grand total 1969	9,795.9	10,739.3	10,564.1	10,389.9	10,519.1	10,887.6	10,917.1	10,829.7	10,880.3	10,608.9	10,789.0	11,070.2	10,664.6
Pennsylvania grade (included in total domestic crude above)	33.7	32.3	33.4	32.0	30.5	32.3	32.3	30.5	37.3	33.6	48.3	25.9	33.5
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

Table 13.—Indicated demand for crude petroleum (including lease condensate) in the United States, by States of origin and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1969													
Alabama	541	733	557	747	605	644	716	633	547	600	547	859	7,729
Alaska	4,295	5,705	5,946	7,374	4,898	5,599	6,262	6,289	5,312	6,155	7,207	5,681	70,723
Arizona	233	183	207	213	232	167	224	196	194	205	147	261	2,462
Arkansas	1,305	1,756	1,621	1,508	1,214	1,538	1,602	1,502	1,541	1,537	1,485	1,561	18,170
California	27,605	30,414	31,329	30,033	35,122	30,179	33,595	31,275	32,338	32,417	30,373	32,818	377,498
Colorado	2,297	2,142	2,741	1,966	2,828	2,477	2,154	3,156	2,422	2,301	1,836	2,064	28,384
Florida	77	234	108	42	358	-------	199	174	53	122	196	134	1,697
Illinois	4,542	3,713	4,454	3,865	3,910	4,282	4,381	4,030	4,266	4,215	4,140	4,666	50,464
Indiana	720	690	680	626	616	650	719	678	420	622	715	819	7,955
Kansas	5,546	7,973	7,886	7,559	6,832	7,491	7,909	7,597	6,849	7,486	7,468	7,378	87,974
Kentucky	997	1,112	999	1,151	1,127	1,292	1,216	1,051	1,186	1,000	1,475	1,215	13,821
Louisiana	66,071	65,451	69,581	69,805	72,079	71,313	73,446	68,637	70,171	69,748	73,594	75,932	845,828
Michigan	1,051	893	1,101	1,007	1,083	836	1,108	1,101	931	1,030	952	1,164	12,257
Mississippi	5,064	4,751	5,189	4,912	4,631	6,532	5,307	5,159	5,807	6,057	5,316	5,485	64,210
Missouri	6	5	6	5	6	5	6	6	5	6	5	6	67
Montana	3,790	3,528	3,486	3,508	3,744	4,022	3,537	4,161	3,996	3,586	3,369	3,541	44,268
Nebraska	1,156	911	1,027	1,086	839	646	1,283	1,096	908	759	1,284	955	11,950
Nevada	20	20	19	18	24	17	20	19	21	14	10	18	220
New Mexico	10,159	10,931	10,809	10,304	11,892	10,643	11,293	10,554	9,941	11,322	10,108	12,476	130,432
New York	109	98	103	102	103	102	102	99	110	105	101	122	1,256
North Dakota	1,834	1,731	2,006	1,625	927	2,065	2,092	2,050	1,998	2,120	1,883	2,075	22,406
Ohio	796	975	1,027	986	994	770	995	869	994	745	863	873	10,887
Oklahoma	19,433	18,411	19,805	17,817	18,675	18,784	18,677	19,381	18,293	18,849	18,890	17,982	224,997
Pennsylvania	379	337	420	376	360	339	368	276	471	472	435	504	4,737
South Dakota	11	11	11	13	17	14	13	15	13	14	13	13	158
Tennessee	-------	1	-------	1	-------	1	-------	1	7	7	7	7	32
Texas	91,228	87,317	99,024	87,869	96,605	97,233	99,762	103,063	95,898	97,711	94,822	103,123	1,153,655
Utah	1,770	1,881	1,873	1,945	2,016	1,822	2,387	2,165	1,944	1,762	1,604	1,869	23,038
Virginia	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1
West Virginia	251	217	257	267	255	239	313	305	211	240	286	316	3,157
Wyoming	10,564	10,982	12,759	12,354	12,444	15,213	14,476	13,953	14,977	13,838	11,156	13,270	155,986
Total domestic crude	261,850	263,106	285,031	269,084	284,436	284,915	294,162	289,491	281,824	285,045	280,287	297,188	3,376,419
Foreign crude	41,823	37,595	42,458	42,612	41,656	41,714	44,269	46,231	44,585	43,832	43,384	45,988	516,147
Grand total 1969	303,673	300,701	327,489	311,696	326,092	326,629	338,431	335,722	326,409	328,877	323,671	343,176	3,892,566
Daily average:													
Domestic crude	8,447	9,396	9,194	8,970	9,175	9,497	9,489	9,339	9,394	9,195	9,343	9,587	9,251
Domestic and foreign crude	9,796	10,739	10,564	10,390	10,519	10,888	10,917	10,830	10,880	10,609	10,789	11,070	10,665
Pennsylvania grade (included in total domestic above)	1,044	903	1,035	960	944	968	1,001	946	1,118	1,043	1,448	804	12,214
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

Table 14.—Refinery receipts of domestic

(Thousand

Location of refineries receiving crude oil	Total receipts of domestic crude oil	Intrastate 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	11,442	------	3,024	------	------	------	------	------	------
Florida, Georgia, Virginia	3,166	------	------	------	------	------	------	------	------
New Jersey	96,192	------	------	------	------	------	------	------	------
New York	1,251	------	------	------	------	------	------	485	485
Pennsylvania:									
East	129,418	------	------	------	------	------	------	------	------
West	16,213	4,798	3,674	363	------	3,355	------	491	4,209
West Virginia	2,937	1,575	------	------	------	1,362	------	------	1,362
Total	260,619	6,373	6,698	363	------	4,717	------	976	6,056
District II:									
Illinois	269,622	18,102	------	103	5,350	------	1,786	23,918	31,157
Indiana	183,928	6,460	------	1,274	11,130	5	3,789	33,333	49,531
Kansas	130,356	76,161	------	------	------	------	1,188	17,339	18,527
Kentucky, Tennessee	61,885	4,301	12	14,364	------	132	------	------	14,496
Michigan	35,663	11,159	------	2,618	------	------	------	------	2,618
Minnesota, Wisconsin	5,339	------	------	------	------	------	5,339	------	5,339
Missouri, Nebraska	31,755	------	------	------	1,022	------	556	3,712	5,290
North Dakota	18,142	17,147	------	------	------	------	------	------	------
Ohio:									
East	21,173	4,109	------	1,986	431	------	------	843	3,260
West	115,757	7	------	14,708	------	------	28	3,622	18,358
Oklahoma	164,769	118,560	------	------	2,927	------	------	------	2,927
Total	1,038,389	256,006	12	35,053	20,860	137	12,686	82,767	151,503
District III:									
Alabama	6,409	1,342	------	------	------	------	------	------	------
Arkansas	32,379	15,865	------	------	------	------	------	------	------
Louisiana	430,962	355,361	------	------	------	------	------	29	29
Mississippi	68,102	12,353	------	------	------	------	------	------	------
New Mexico	14,791	14,790	------	------	------	------	------	------	------
Texas	1,041,094	794,407	------	1	2	------	------	804	807
Total	1,593,737	1,194,118	------	1	2	------	------	833	836
District IV:									
Colorado	13,248	2,014	------	------	------	------	------	------	------
Montana	26,373	11,330	------	------	------	------	------	------	------
Utah	40,145	10,236	------	------	------	------	------	------	------
Wyoming	46,720	45,579	------	------	------	------	6	------	6
Total	126,486	69,159	------	------	------	------	6	------	6
District V:									
California	453,335	378,771	------	------	------	------	------	------	------
Other States	19,848	11,367	------	------	------	------	------	------	------
Total	473,183	390,138	------	------	------	------	------	------	------
Total United States	3,492,414	1,915,794	[1] 6,710	35,417	20,862	4,854	12,692	84,576	158,401
Daily average	9,568	5,249	18	97	57	13	35	232	434

[1] Florida, 3,024; New York, 1,455; Virginia, 12; West Virginia, 2,219.
[2] Alaska, 62,659; Arizona, 2,481; California, 4,475; Nevada, 119.

crude oil, by state and district in 1970
barrels)

Interstate receipts from—											
PAD district III					PAD district IV					PAD dist. V, total	Total interstate receipts
Ala., Ark., Miss.	La.	N. Mex.	Texas	Total	Colo.	Mont.	Utah	Wyo.	Total		
388	535	-------	7,495	8,418	-------	-------	-------	-------	-------	-------	11,442
1,321	-------	-------	1,845	3,166	-------	-------	-------	-------	-------	-------	3,166
13,271	54,934	104	27,531	95,840	-------	-------	-------	-------	-------	352	96,192
-------	51	-------	692	743	-------	23	-------	-------	23	-------	1,251
-------	72,699	440	56,279	129,418	-------	-------	-------	-------	-------	-------	129,418
-------	-------	-------	-------	---------	-------	3,532	-------	-------	3,532	-------	11,415
-------	-------	-------	-------	---------	-------	-------	-------	-------	-------	-------	1,362
14,980	128,219	544	93,842	237,585	-------	3,555	-------	-------	3,555	352	254,246
7,305	64,212	18,224	114,349	204,090	4,222	1,380	-------	10,671	16,273	-------	251,520
-------	16,011	19,215	54,231	89,457	1,134	8,223	-------	29,123	38,480	-------	177,468
-------	-------	1,374	13,497	14,871	1,034	842	-------	18,921	20,797	-------	54,195
633	41,086	-------	1,042	42,761	-------	-------	-------	315	315	-------	57,584
-------	-------	-------	13,867	13,867	-------	-------	-------	8,019	8,019	-------	24,504
-------	-------	-------	-------	---------	-------	-------	-------	-------	-------	-------	5,339
-------	-------	8,104	12,710	20,814	-------	-------	-------	5,651	5,651	-------	31,755
-------	-------	-------	-------	---------	-------	995	-------	-------	995	-------	995
-------	10,222	-------	-------	10,222	1,122	-------	-------	2,460	3,582	-------	17,064
3,778	38,001	2,524	49,175	93,478	122	47	-------	3,745	3,914	-------	115,750
-------	-------	4,860	36,453	41,313	1,478	-------	491	-------	1,969	-------	46,209
11,716	169,532	54,301	295,324	530,873	9,112	11,487	491	78,905	99,995	-------	782,383
3,975	1,092	-------	-------	5,067	-------	-------	-------	-------	-------	-------	5,067
-------	2,730	-------	13,784	16,514	-------	-------	-------	-------	-------	-------	16,514
21,804	-------	-------	53,768	75,572	-------	-------	-------	-------	-------	-------	75,601
-------	55,749	-------	-------	55,749	-------	-------	-------	-------	-------	-------	55,749
-------	-------	-------	-------	---------	1	-------	-------	-------	1	-------	1
40	188,044	54,653	-------	242,737	16	-------	3,127	-------	3,143	-------	246,687
25,819	247,615	54,653	67,552	395,639	17	-------	3,127	-------	3,144	-------	399,619
-------	-------	-------	-------	---------	-------	2,298	24	8,912	11,234	-------	11,234
-------	-------	-------	-------	---------	-------	-------	-------	15,043	15,043	-------	15,043
-------	-------	42	-------	42	13,687	159	-------	15,934	29,780	87	29,909
-------	-------	-------	-------	---------	652	483	-------	-------	1,135	-------	1,141
-------	-------	42	-------	42	14,339	2,940	24	39,889	57,192	87	57,327
-------	-------	2,810	-------	2,810	-------	-------	10,940	-------	10,940	60,814	74,564
-------	-------	-------	-------	---------	-------	-------	-------	-------	-------	8,481	8,481
-------	-------	2,810	-------	2,810	-------	-------	10,940	-------	10,940	69,295	83,045
52,515	545,366	112,350	456,718	1,166,949	23,468	17,982	14,582	118,794	174,826	[2] 69,734	1,576,620
144	1,494	308	1,251	3,197	64	49	40	326	479	191	4,319

Table 15.—Crude runs to stills and refinery receipts of crude oil by origin of the crude and method of transportation in 1970

(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	38,035	4	-------	+734	-------	------	-------	-------	-----	11,442	-------	27,331
Florida, Georgia, Virginia	13,317	-----	3,036	−160	-------	------	-------	-------	380	2,786	-------	9,991
New Jersey	160,426	157	-------	−81	-------	------	-------	-------	-----	96,192	-------	64,310
New York	30,090	-----	1,455	−20	-------	------	-------	1,251	-----	-------	28,819	-------
Pennsylvania:												
East	206,881	79	-------	+478	-------	------	-------	-------	-----	129,418	-------	78,020
West	19,187	13	4,798	−55	4,612	186	-------	8,560	1,197	1,658	2,932	-------
West Virginia	2,956	-----	3,794	−19	1,491	84	-------	878	484	-------	-------	-------
Total	[1] 470,892	253	13,083	+877	6,103	270	-------	10,689	2,061	241,496	31,751	179,652
District II:												
Illinois	276,572	80	53,005	−70	18,031	71	-------	251,520	-----	-------	6,960	-------
Indiana	194,613	47	6,563	+115	6,386	74	-------	177,412	56	-------	10,847	-------
Kansas	131,392	45	97,023	−177	74,413	1,748	-------	54,139	56	-------	904	-------
Kentucky, Tennessee	61,607	53	4,312	+225	3,709	266	326	39,822	26	17,736	-------	-------
Michigan	53,396	1	11,682	+65	9,625	1,534	-------	24,504	-----	-------	17,799	-------
Minnesota, Wisconsin	54,919	−1	-------	+83	-------	------	-------	5,339	-----	-------	49,662	-------
Missouri, Nebraska	31,650	-----	7,347	+105	-------	------	-------	31,702	53	-------	-------	-------
North Dakota	18,121	−4	[2] 22,489	+25	17,147	------	-------	995	-----	-------	-------	-------
Ohio:												
East	21,969	16	4,109	−10	2,253	1,856	-------	17,064	-----	-------	802	-------
West	[3] 142,080	47	4,850	+69	-------	7	-------	115,750	-----	-------	[3] 26,439	-------
Oklahoma	164,937	31	203,136	−53	114,929	3,631	-------	46,209	-----	-------	146	-------
Total	1,151,256	315	414,516	+377	246,493	9,187	326	764,456	191	17,736	113,559	-------
District III:												
Alabama	6,341	2	7,448	+66	-------	18	1,324	-------	35	5,032	-------	-------
Arkansas	32,370	13	16,255	−4	15,060	805	-------	16,102	412	-------	-------	-------
Louisiana	430,489	123	900,615	+350	280,299	3,948	71,114	60,508	1,342	13,751	-------	-------
Mississippi	67,706	-----	58,372	+396	10,741	1,612	-------	55,571	-----	178	-------	-------
New Mexico	14,784	11	127,140	−4	12,583	2,207	-------	-------	1	-------	-------	-------
Texas	1,038,498	235	1,251,125	+2,361	762,375	9,767	22,265	130,356	90	116,241	-------	-------
Total	1,590,188	384	2,360,955	+3,165	1,081,058	18,357	94,703	262,537	1,880	135,202	-------	-------
District IV:												
Colorado	14,456	39	25,482	+17	-------	2,014	-------	11,166	68	-------	1,264	-------
Montana	41,363	40	29,312	+283	10,479	851	-------	15,043	-----	-------	15,313	-------
Utah	40,113	−2	24,818	+34	7,618	2,618	-------	28,774	1,135	-------	-------	-------

Wyoming	47,394	4	164,376	−80	44,872	707	-------	1,021	120	-------	598	-------
Total	143,326	81	243,988	+254	62,969	6,190	-------	56,004	1,323	-------	17,175	-------
District V:												
California	508,909	435	383,246	−399	322,558	3,047	53,166	15,668	34	58,862	-------	55,610
Other States [4]	102,932	−35	76,626	+45	11,332	35	-------	---------	-----	8,481	74,313	8,781
Total	611,841	400	459,872	−354	333,890	3,082	53,166	15,668	34	67,343	74,313	64,391
Total United States	3,967,503	1,433	3,492,414	+4,319	1,730,513	37,086	148,154	1,109,354	5,489	461,777	[5] 236,798	244,043
Daily Average	10,870	4	9,568	+12	4,741	102	406	3,039	15	1,265	649	669

[1] Includes 298,094,000 barrels in Delaware River Valley.
[2] Includes 6,000 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 1970, by months

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1969 total
Turned into lines:														
Gasoline:														
Motor	109,934	104,796	116,609	116,962	124,759	123,049	126,333	127,907	115,619	117,189	114,428	118,827	1,416,412	1,354,824
Aviation	342	191	282	403	447	444	583	534	424	349	290	330	4,619	5,658
Total gasoline	110,276	104,987	116,891	117,365	125,206	123,493	126,916	128,441	116,043	117,538	114,718	119,157	1,421,031	1,360,482
Jet fuel:														
Naphtha-type	2,079	2,204	2,320	2,219	2,055	1,704	1,984	2,213	1,964	1,955	2,053	1,729	24,479	27,927
Kerosine-type	14,159	13,269	15,446	12,704	12,892	13,196	14,016	14,158	13,951	13,012	12,962	15,190	164,955	154,321
Total jet fuel	16,238	15,473	17,766	14,923	14,947	14,900	16,000	16,371	15,915	14,967	15,015	16,919	189,434	182,248
Kerosine	8,870	7,320	5,555	4,301	4,674	3,254	3,468	3,985	4,098	5,133	5,189	6,625	62,472	70,110
Distillate fuel oil	60,394	51,119	48,664	42,273	42,615	40,738	41,989	43,680	42,155	43,679	48,406	56,365	562,077	537,765
Natural gas liquids	32,706	28,587	27,994	24,491	24,224	24,034	26,120	29,904	28,374	27,511	27,301	30,384	331,630	296,909
Delivered from lines:														
Gasoline:														
Motor	109,852	102,833	115,785	117,164	122,939	125,483	127,537	128,476	117,489	117,656	115,374	118,354	1,418,942	1,353,041
Aviation	242	281	260	377	435	462	465	538	382	418	286	307	4,453	5,538
Total gasoline	110,094	103,114	116,045	117,541	123,374	125,945	128,002	129,014	117,871	118,074	115,660	118,661	1,423,395	1,358,579
Jet fuel:														
Naphtha-type	2,034	2,268	2,258	2,256	1,994	1,876	1,934	2,096	1,983	1,991	1,978	2,006	24,674	28,044
Kerosine-type	14,314	12,747	15,143	12,800	12,811	13,300	13,795	14,083	13,630	12,803	13,307	14,521	163,254	151,876
Total jet fuel	16,348	15,015	17,401	15,056	14,805	15,176	15,729	16,179	15,613	14,794	15,285	16,527	187,928	179,920

See footnote at end of table.

Table 16.—Transportation of petroleum products by pipelines in the United States, in 1970, by months—Continued

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1969 total
Delivered from line—Continued														
Kerosine	8,781	8,148	6,189	4,148	4,296	3,105	3,023	3,564	3,621	4,700	5,101	6,683	61,359	68,185
Distillate fuel oil	61,587	53,520	53,008	42,260	42,245	38,816	40,360	40,365	40,325	42,040	47,168	58,091	559,785	540,482
Natural gas liquids	33,956	28,367	28,333	25,179	23,676	23,578	25,106	28,704	27,413	26,925	27,335	28,724	327,296	292,763
Shortage or overage:[1]														
Gasoline:														
Motor	(225)	(209)	(96)	(230)	10	(145)	(137)	(56)	(170)	(283)	(75)	23	(1,593)	(1,195)
Aivation	41	15	11	39	10	2	31	26	(3)	-------	1	48	221	176
Total gasoline	(184)	(194)	(85)	(191)	20	(143)	(106)	(30)	(173)	(283)	(74)	71	(1,372)	(1,019)
Jet fuel:														
Naphtha-type	(15)	5	5	10	(10)	(57)	31	20	16	34	(22)	(74)	(57)	39
Kerosine-type	25	145	51	117	163	104	131	141	175	105	182	22	1,361	1,492
Total jet fuel	10	150	56	127	153	47	162	161	191	139	160	(52)	1,304	1,531
Kerosine	230	95	97	109	63	90	91	210	(4)	171	77	84	1,313	1,190
Distillate fuel oil	(83)	129	(232)	(55)	2	129	(24)	(28)	10	(11)	72	(118)	(209)	(714)
Natural gas liquids	171	122	90	(24)	70	92	(16)	87	69	117	209	192	1,179	1,121
Stocks in lines and working tanks at end of month:														
Gasoline:														
Motor	38,330	40,502	41,422	41,450	43,260	40,971	39,904	39,391	37,691	37,507	36,636	37,086	37,086	38,023
Aviation	283	178	189	176	178	158	245	215	260	191	194	169	169	224
Total gasoline	38,613	40,680	41,611	41,626	43,438	41,129	40,149	39,606	37,951	37,698	36,830	37,255	37,255	38,247
Jet fuel:														
Naphtha-type	689	620	677	630	701	586	605	702	667	597	694	491	491	629
Kerosine-type	3,315	3,692	3,944	3,731	3,649	3,441	3,531	3,465	3,611	3,715	3,188	3,835	3,835	3,495
Total jet fuel	4,004	4,312	4,621	4,361	4,350	4,027	4,136	4,167	4,278	4,312	3,882	4,326	4,326	4,124
Kerosine	3,142	2,219	1,488	1,532	1,847	1,906	2,260	2,471	2,952	3,214	3,225	3,083	3,083	3,283
Distillate fuel oil	21,976	19,446	15,334	15,402	15,770	17,563	19,216	22,559	24,379	26,029	27,195	25,587	25,587	23,086
Natural gas liquids	9,396	9,494	9,065	8,401	8,879	9,243	10,273	11,386	12,278	12,747	12,504	13,972	13,972	10,817

[1] Figures in parentheses denote shortage.

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States, 1970, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1969 total
From District I to District II:														
Gasoline:														
Motor	2,750	2,110	2,754	2,997	3,011	2,893	3,256	3,110	2,883	2,835	2,849	2,547	33,995	33,004
Aviation	------	3	------	------	5	9	------	10	9	------	4	------	40	147
Total gasoline	2,750	2,113	2,754	2,997	3,016	2,902	3,256	3,120	2,892	2,835	2,853	2,547	34,035	33,151
Jet fuel:														
Naphtha-type	40	32	18	------	31	33	18	35	36	15	43	41	342	158
Kerosine-type	97	130	73	53	39	61	48	61	72	139	114	133	1,020	921
Total jet fuel	137	162	91	53	70	94	66	96	108	154	157	174	1,362	1,079
Kerosine	123	122	128	49	21	79	61	49	84	92	97	134	1,039	973
Distillate fuel oil	653	577	601	594	471	558	521	559	808	612	714	646	7,314	7,101
Natural gas liquids	------	------	------	------	------	------	------	------	------	------	19	------	19	------
From District II to District I:														
Gasoline (motor)	837	872	933	576	486	823	766	741	711	563	959	977	9,244	9,009
Jet fuel (kerosine-type)	22	35	42	25	35	------	20	1	44	42	20	------	286	59
Distillate fuel oil	23	28	9	20	25	27	35	44	51	10	31	46	349	248
Natural gas liquids	877	654	872	927	772	443	906	893	1,011	1,051	944	1,064	10,414	9,267
From District II to District III:														
Gasoline:														
Motor	1,502	1,476	1,630	1,620	1,715	1,537	1,653	1,634	1,606	1,650	1,603	1,549	19,175	18,633
Aviation	------	------	------	------	------	------	------	------	------	------	------	------	------	51
Total gasoline	1,502	1,476	1,630	1,620	1,715	1,537	1,653	1,634	1,606	1,650	1,603	1,549	19,175	18,684
Jet fuel:														
Naphtha-type	40	25	------	30	------	10	50	30	31	30	30	30	306	854
Kerosine-type	------	------	------	------	------	------	------	------	------	------	------	------	------	79
Total jet fuel	40	25	------	30	------	10	50	30	31	30	30	30	306	933
Distillate fuel oil	296	448	390	416	328	380	232	244	337	268	311	372	4,022	4,504
Natural gas liquids	206	158	207	187	195	203	240	273	223	252	295	252	2,691	2,028
From District III to District I:														
Gasoline:														
Motor	21,470	20,397	24,485	25,610	27,463	27,079	27,222	26,601	24,297	25,931	24,206	23,908	298,669	284,475
Aviation	------	45	------	29	22	62	------	22	67	53	22	31	353	583
Total gasoline	21,470	20,442	24,485	25,639	27,485	27,141	27,222	26,623	24,364	25,984	24,228	23,939	299,022	285,058
Jet fuel:														
Naphtha-type	97	204	173	142	137	215	177	157	135	171	152	136	1,896	1,699
Kerosine-type	4,019	3,513	3,822	3,363	2,867	2,900	3,056	3,195	3,124	3,346	3,422	3,562	40,189	39,051
Total jet fuel	4,116	3,717	3,995	3,505	3,004	3,115	3,233	3,352	3,259	3,517	3,574	3,698	42,085	40,750
Kerosine	2,232	2,124	1,699	696	729	549	633	713	889	1,326	1,699	2,189	15,478	16,582
Distillate fuel oil	16,256	14,211	14,809	11,832	11,675	11,823	12,368	11,854	10,837	11,843	13,658	15,709	156,875	160,203
Natural gas liquids	2,252	1,292	880	511	418	723	1,071	1,208	816	899	1,344	1,595	13,009	12,060

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States, 1970, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1969 total
From District III to District II:														
Gasoline:														
Motor	3,620	3,615	4,643	3,819	4,395	4,418	3,979	3,760	3,958	4,158	3,364	3,472	47,201	46,700
Aviation	100	62	86	104	81	132	187	129	124	81	148	73	1,307	1,767
Total gasoline	3,720	3,677	4,729	3,923	4,476	4,550	4,166	3,889	4,082	4,239	3,512	3,545	48,508	48,467
Jet fuel:														
Naphtha-type	------	------	------	1	49	------	------	------	------	1	------	3	54	1
Kerosine-type	170	195	169	145	203	325	315	290	176	141	323	291	2,743	1,602
Total jet fuel	170	195	169	146	252	325	315	290	176	142	323	294	2,797	1,603
Kerosine	385	331	45	60	128	23	144	135	51	82	171	424	1,979	1,427
Distillate fuel oil	1,872	1,536	873	683	987	965	892	547	1,072	848	1,272	1,165	12,712	11,214
Natural gas liquids	5,308	5,396	4,861	3,663	3,024	2,779	4,028	3,291	3,834	4,537	4,822	5,886	51,429	52,507
From District III to District IV:														
Gasoline:														
Motor	307	268	336	297	318	369	410	408	357	356	310	341	4,077	3,690
Aviation	18	23	22	21	21	22	21	25	21	19	18	18	249	273
Total gasoline	325	291	358	318	339	391	431	433	378	375	328	359	4,326	3,963
Jet fuel (kerosine-type)	335	305	306	290	316	304	306	317	317	328	317	346	3,787	3,589
Kerosine	7	5	4	4	2	3	1	2	4	4	6	7	49	51
Distillate fuel oil	67	41	43	48	47	50	45	46	49	53	37	41	567	518
Natural gas liquids	148	76	101	103	57	40	49	67	85	97	105	142	1,070	1,052
From District III to District V:														
Gasoline (motor)	818	855	970	877	794	657	754	824	772	812	810	952	9,895	11,133
Jet fuel:														
Naphtha-type	299	383	264	307	260	204	243	348	280	302	238	281	3,409	3,474
Kerosine-type	243	216	190	197	198	174	166	173	161	171	186	173	2,248	2,564
Total jet fuel	542	599	454	504	458	378	409	521	441	473	424	454	5,657	6,038
Kerosine	------	------	------	------	------	------	------	------	------	------	------	------	------	26
Distillate fuel oil	215	187	223	197	266	210	267	217	243	256	297	313	2,891	3,087
From District IV to District II:														
Gasoline (motor)	290	172	308	319	354	415	464	488	347	376	343	270	4,146	4,010
Jet fuel (naphtha-type)	------	75	25	26	61	55	17	------	------	------	------	------	259	------
Kerosine	8	8	3	9	2	6	3	9	4	------	4	7	63	91
Distillate fuel oil	276	240	273	283	233	259	281	250	273	308	247	267	3,190	2,352
From District IV to District V:														
Gasoline:														
Motor	854	942	812	893	979	862	870	940	886	893	935	964	10,830	11,741
Aviation	------	------	------	5	------	------	------	------	------	------	------	------	5	------
Total gasoline	854	942	812	898	979	862	870	940	886	893	935	964	10,835	11,714
Jet fuel:														
Naphtha-type	70	92	100	90	87	110	91	97	93	96	70	93	1,089	687
Kerosine-type	70	27	74	73	103	102	52	20	34	24	42	50	671	1,460
Total jet fuel	140	119	174	163	190	212	143	117	127	120	112	143	1,760	2,147
Distillate fuel oil	673	415	501	478	442	342	286	318	404	490	656	558	5,563	5,476

Table 18.—Pipeline tariff rates for crude petroleum and products, January 1

(Cents per barrel)

Origin	Destination	1970	1971
Crude oil:			
West Texas	Houston, Tex	$0.14–$0.16	$0.14–$0.16
Do	East Chicago, Ind	.28	.28
Do	Wood River, Ill	.26	.26
Oklahoma	Chicago, Ill	.22	.22
Do	Wood River, Ill	.19	.19
Eastern Wyoming	Chicago, Ill	.30	.35
Do	Wood River, Ill	.30	.32
Refined products:			
Houston, Texas	Atlanta ,Ga	.2770	.3600
Do	New York, N.Y	.2870	.3100
Tulsa, Okla	Minneapolis, Minn	.6500	.6500
Salt Lake City, Utah	Spokane, Wash	.5000	.5200
Philadelphia, Pa	Rochester, N.Y	.2400	.2400

Source: Interstate Commerce Commission.

Table 19.—Receipts of domestic and foreign crude petroleum at refineries in the United States by mode of transport

(Million barrels)

Method of transportation	1966	1967	1968	1969	1970 p
By water:					
Intrastate	152.0	129.1	136.8	138.0	148.2
Interstate	347.7	428.4	428.8	408.8	461.8
Foreign	320.7	265.3	303.0	314.7	244.0
Total by water	820.4	822.8	868.6	861.5	854.0
By pipeline:					
Intrastate	1,465.8	1,581.1	1,673.0	1,715.1	1,730.5
Interstate	996.2	995.9	1,023.7	1,054.9	1,109.4
Foreign	126.0	146.6	169.2	199.2	236.8
Total by pipeline	2,588.0	2,723.6	2,865.9	2,969.2	3,076.7
By tank cars and trucks:					
Intrastate	38.1	40.0	40.8	41.8	37.1
Interstate	4.5	5.7	6.8	6.0	5.5
Foreign	------	------	------	------	------
Total by tank cars and trucks	42.6	45.7	47.6	47.8	42.6
Grand total	3,451.0	3,592.1	3,782.1	3,878.5	3,973.3

p Preliminary.

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, 1970, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1969 total
Gulf coast to east coast:														
Crude oil	16,745	14,989	18,762	19,598	19,585	17,816	20,717	22,985	19,207	23,835	22,960	18,661	235,860	180,821
Unfinished oils	2,604	2,670	2,906	2,078	2,080	1,700	2,409	2,945	2,462	2,818	2,176	64	26,912	35,361
Gasoline:														
Motor	12,328	12,030	15,335	17,367	14,035	15,277	13,551	10,521	14,118	14,394	14,771	18,900	172,627	141,219
Aviation	199	103	285	325	448	235	210	223	440	221	272	316	3,277	4,737
Total	12,527	12,133	15,620	17,692	14,483	15,512	13,761	10,744	14,558	14,615	15,043	19,216	175,904	145,956
Special naphthas	323	204	364	332	306	499	379	376	465	309	320	371	4,248	5,291
Kerosine	2,125	1,824	1,307	993	1,547	1,291	982	1,258	598	1,323	1,642	1,653	16,543	16,682
Distillate fuel oil	19,197	16,102	14,340	11,850	10,613	11,694	9,393	7,303	8,872	11,556	10,284	16,068	147,272	119,595
Residual fuel oil	1,301	2,062	2,820	1,581	1,374	1,353	1,295	2,915	4,017	1,911	3,017	4,868	28,514	27,326
Jet fuel:														
Naphtha-type	1,303	1,220	1,238	748	1,043	1,454	1,390	1,446	1,474	1,131	822	1,158	14,427	19,544
Kerosine-type	2,411	2,234	2,584	2,545	1,566	1,926	2,382	1,907	2,156	2,508	1,685	2,283	26,187	28,776
Total	3,714	3,454	3,822	3.293	2,609	3,380	3,772	3,353	3,630	3,639	2,507	3,441	40,614	48,320
Lubricating oil	726	475	780	921	990	947	505	802	777	624	737	660	8,944	9,952
Wax	18	36	26	26	26	37	------	27	63	40	23	32	354	282
Asphalt and road oil	238	350	394	438	594	349	307	346	448	372	323	442	4,601	5,350
Liquefied gases	343	374	189	132	140	158	221	243	209	349	152	62	2,572	2,872
Petrochemical feedstocks	196	331	569	466	370	285	188	288	388	130	314	190	3,715	4,156
Other products	86	55	239	156	159	132	130	81	63	162	76	91	1,430	1,824
Grand total	60,143	55,059	62,138	59,556	54,876	55,153	54,059	53,666	55,757	61,683	59,574	65,819	697,483	603,788
West coast to east coast:														
Crude oil	------	------	------	116	------	118	------	18	------	------	------	------	252	------
Unfinished oils	------	------	------	------	------	------	------	------	159	145	153	122	579	------
Gasoline (motor)	151	------	------	------	------	------	------	------	------	------	------	------	151	------
Residual fuel oil	------	------	------	------	------	------	------	------	------	------	------	------	------	87
Jet fuel (kerosine-type)	------	------	------	------	------	------	------	------	------	------	40	------	40	------
Lubricating oil	74	25	75	122	31	87	119	15	120	113	30	83	894	755
Wax	------	------	------	------	------	------	------	------	------	5	------	------	5	3
Other products	------	------	------	------	------	------	------	------	------	------	------	25	25	------
Total	225	25	75	238	31	205	119	33	279	263	223	230	1,946	845
Gulf coast to west coast:														
Crude oil	------	------	------	------	------	------	------	------	------	------	------	------	------	215
Gasoline:														
Motor	9	------	------	------	------	------	------	------	------	271	54	------	334	2,630
Aviation	------	------	------	------	------	------	------	------	------	------	------	------	------	442
Total	9	------	------	------	------	------	------	------	------	271	54	------	334	3,072

Special naphthas	------	------	------	------	17	------	------	------	------	22	------	------	39	91
Kerosine	------	------	------	------	------	------	------	------	------	1	------	91	92	2
Distillate fuel oil	------	------	------	------	------	------	------	------	------	------	18	------	18	1,461
Residual fuel oil	------	------	------	------	------	------	------	------	------	------	------	5	5	3
Jet fuel:														
Naphtha-type	------	------	------	------	------	------	------	------	------	------	------	------	------	3,741
Kerosine-type	------	------	91	192	119	114	------	------	197	24	37	33	807	2,810
Total	------	------	91	192	119	114	------	------	197	24	37	33	807	6,551
Lubricating oil	157	132	132	111	189	19	250	115	180	184	178	------	1,647	1,375
Petrochemical feedstocks	------	17	------	17	------	------	3	25	5	25	8	------	100	195
Other products	------	------	22	------	------	27	13	------	------	7	11	------	80	------
Grand total	166	149	245	320	325	160	266	140	382	534	306	129	3,122	12,965

Table 21.—Barge movements via the Mississippi River of crude oil and products from PAD district III to PAD districts I and II, 1970, by months

(Thousand barrels)

Movements from District III to—	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1969 total
DISTRICT I														
Gasoline:														
Motor gasoline	994	1,043	800	1,161	1,247	1,197	1,661	1,298	1,857	1,566	1,237	1,233	15,294	13,587
Aviation gasoline	10	------	17	19	20	------	28	18	21	------	10	24	167	190
Total	1,004	1,043	817	1,180	1,267	1,197	1,689	1,316	1,878	1,566	1,247	1,257	15,461	13,777
Special naphthas	22	9	24	18	23	17	9	27	21	16	25	9	220	244
Kerosine	171	124	117	20	79	114	177	144	221	133	107	134	1,541	1,458
Distillate fuel oil	233	299	116	162	169	183	208	206	325	202	135	135	2,373	2,318
Residual fuel oil	------	------	------	------	------	------	------	7	------	39	33	111	190	28
Jet fuel (kerosine-type)	51	52	66	18	88	34	52	51	89	114	89	53	757	774
Lubricating oil	117	167	171	147	163	108	222	232	155	199	213	265	2,159	1,909
Wax	9	------	------	3	7	2	2	2	------	2	2	2	31	2
Petrochemical feedstocks	25	32	34	44	71	44	------	36	8	8	60	71	433	659
Other products	14	8	9	------	------	------	12	------	1	------	------	21	65	201
Total	1,646	1,734	1,354	1,592	1,867	1,699	2,371	2,021	2,698	2,279	1,911	2,058	23,230	21,370
DISTRICT II														
Crude oil	1,565	1,439	1,714	1,289	1,563	1,601	1,522	1,594	1,338	1,531	873	1,707	17,736	16,371
Unfinished oils	5	4	11	3	8	4	8	------	4	17	------	9	73	50
Gasoline:														
Motor gasoline	2,390	3,339	3,965	4,120	3,966	2,957	3,146	3,123	3,635	3,760	3,173	3,693	41,267	40,245
Aviation gasoline	10	27	56	46	23	69	104	59	106	21	101	67	689	671
Total	2,400	3,366	4,021	4,166	3,989	3,026	3,250	3,182	3,741	3,781	3,274	3,760	41,956	40,916
Special naphthas	180	212	236	271	155	185	138	150	162	218	194	166	2,267	2,259
Kerosine	247	316	446	305	285	270	317	226	336	169	306	559	3,782	4,261
Distillate fuel oil	700	1,084	1,158	698	830	666	570	408	465	570	581	895	8,625	8,591
Residual fuel oil	879	940	802	1,050	797	286	695	301	851	144	566	474	7,785	5,724
Jet fuel:														
Naphtha-type	------	9	------	9	------	------	9	8	9	18	9	------	71	83
Kerosine-type	602	435	550	355	411	378	284	446	424	298	593	303	5,079	7,502
Total	602	444	550	364	411	378	293	454	433	316	602	303	5,150	7,585
Lubricating oil	148	141	226	213	183	234	231	183	116	367	169	223	2,434	2,982
Wax	------	------	------	3	------	------	------	------	------	------	------	------	3	3
Asphalt and road oil	12	52	130	240	163	314	335	315	256	440	191	92	2,540	2,402
Liquefied gases	171	171	114	114	57	113	57	113	56	113	113	113	1,305	1,273
Petrochemical feedstocks	130	151	126	113	176	102	103	81	105	86	150	54	1,377	1,580
Other products	12	35	70	41	26	48	60	117	55	43	47	51	605	547
Total	7,051	8,355	9,604	8,870	8,643	7,227	7,579	7,124	7,918	7,795	7,066	8,406	95,638	94,544

Table 22.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1966	1967	1968	1969	1970
Crude petroleum:					
At refineries	62,720	72,093	78,718	76,088	80,407
Pipeline and tank farm	153,930	158,797	177,133	172,252	181,580
Producers	21,741	18,080	16,342	16,887	14,380
Total crude petroleum	238,391	248,970	272,193	265,227	276,367
Unfinished oils	89,213	90,201	93,399	97,819	98,989
Natural gasoline, plant condensate, and isopentane	4,563	5,782	5,466	5,704	7,046
Refined products	548,938	599,158	628,514	r611,373	635,459
Grand total	881,105	944,111	999,572	r980,123	1,017,861

Table 23.—Stocks of crude petroleum in the United States by State of origin, and month, 1970

(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	278	347	438	207	352	233	302	474	305	257	490	415	591
Alaska	5,781	5,600	5,020	4,059	4,338	4,050	3,446	5,243	4,667	4,031	4,309	5,078	6,818
Arizona	106	148	142	132	139	187	131	124	121	122	123	73	98
Arkansas	756	778	819	778	711	622	644	611	604	556	663	700	687
California	29,659	30,281	31,409	34,835	33,822	34,866	33,284	29,243	27,280	25,317	24,481	26,875	23,571
Colorado	3,168	3,010	3,100	3,121	3,394	3,767	3,113	2,722	2,560	2,412	2,230	2,689	2,553
Florida	258	179	261	312	292	270	134	249	245	222	318	199	342
Illinois	5,832	5,450	5,628	5,405	6,222	5,825	6,125	5,894	5,470	5,816	5,691	5,446	5,146
Indiana	431	304	382	377	416	389	359	288	323	406	413	509	506
Kansas	6,587	6,398	7,621	7,764	7,654	8,244	7,447	7,378	6,736	6,364	6,064	6,735	7,287
Kentucky	562	645	887	787	849	765	1,013	835	639	777	759	794	836
Louisiana	35,231	34,099	35,466	35,182	37,442	39,469	37,021	35,323	36,667	40,374	41,536	39,702	38,530
Michigan	635	602	683	624	740	684	674	703	699	716	732	632	550
Mississippi	5,278	5,498	5,601	6,017	5,718	5,740	5,221	5,057	4,929	5,028	4,987	5,063	4,671
Montana	4,055	3,829	3,779	3,909	3,711	4,184	4,383	4,421	3,739	3,781	3,242	3,684	4,296
Nebraska	1,048	1,333	1,502	1,127	1,160	894	917	926	824	812	560	787	815
Nevada	3	4	2	1	3	3	2	4	3	3	2	3	4
New Mexico	7,792	8,695	7,946	8,143	8,476	9,190	8,436	8,342	8,144	7,868	7,648	7,582	8,369
New York	30	30	30	30	30	30	30	30	30	30	30	30	30
North Dakota	1,626	1,556	1,599	1,635	1,596	1,682	1,732	1,916	1,953	1,866	1,903	1,527	1,533
Ohio	813	756	703	723	736	829	908	1,022	1,032	1,092	1,188	1,254	1,197
Oklahoma	18,304	17,176	17,329	16,886	18,177	18,013	18,930	18,689	17,559	16,258	16,805	17,430	17,589
Pennsylvania	1,191	1,085	1,132	1,041	1,004	936	888	804	810	839	812	784	811
Texas	98,503	102,345	105,088	105,941	106,078	106,394	105,369	100,623	95,674	101,795	108,783	111,487	110,376
Utah	2,764	2,697	2,790	2,902	2,665	2,633	2,721	2,731	2,785	2,756	2,752	2,767	2,632
West Virginia	967	813	725	618	660	670	677	771	783	767	779	714	673
Wyoming	15,293	15,918	16,317	16,483	17,737	18,606	18,652	16,577	14,913	13,776	14,057	14,486	16,820
Total domestic crude	246,951	249,576	256,399	259,039	264,122	269,175	262,559	251,000	239,494	244,041	251,357	257,445	257,331
Foreign crude located in districts:													
I–IV	11,696	11,970	8,609	9,551	9,287	10,314	11,295	9,592	9,118	7,582	7,957	9,953	12,350
V	6,580	5,541	4,620	6,053	4,628	5,335	6,040	6,262	5,532	7,573	6,165	3,905	6,686
Total foreign crude	18,276	17,511	13,229	15,604	13,915	15,649	17,335	15,854	14,650	15,155	14,122	13,858	19,036
Total crude stocks	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
Pennsylvania grade (included in crude stocks total)	2,573	2,265	2,250	2,061	2,066	2,098	2,158	2,163	2,213	2,238	2,340	2,287	2,219

Table 24.—Stocks of crude petroleum in the United States by locations and month, 1970

(Thousand barrels)

Location	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	1,069	1,116	1,131	1,207	1,217	1,133	1,160	1,205	962	979	950	865	825
Alaska	904	826	490	494	404	494	433	677	524	426	691	1,411	1,255
Arizona	448	491	492	487	492	492	483	477	512	517	519	449	451
Arkansas	1,289	1,351	1,379	1,338	1,254	1,151	1,168	1,136	1,130	1,083	1,192	1,226	1,215
California, Nevada, Oregon, Washington	40,602	40,015	40,121	44,362	41,813	43,152	42,137	39,266	36,804	36,149	34,061	34,833	35,308
Colorado	1,945	1,891	1,825	1,813	2,090	2,083	2,013	1,881	1,801	1,833	1,691	1,845	1,971
Florida, Georgia, South Carolina, Virginia	831	768	686	492	878	1,087	883	1,114	972	731	456	688	628
Hawaii	1,408	1,469	1,276	1,008	1,280	1,206	809	1,459	730	914	858	324	1,170
Illinois	15,950	17,204	18,159	18,887	18,856	19,115	18,864	18,062	17,002	17,402	17,313	16,303	16,990
Indiana	4,268	4,260	4,624	4,556	4,765	4,455	4,910	4,653	4,427	4,037	4,049	4,439	4,663
Iowa, Missouri	6,761	6,320	6,831	6,918	6,637	6,544	6,591	6,738	6,066	6,277	6,061	6,684	6,799
Kansas	10,082	9,963	10,321	9,709	9,885	11,199	11,053	10,796	10,214	9,377	9,880	10,498	10,521
Kentucky, Tennessee	4,456	4,613	4,509	4,300	5,228	4,768	5,205	4,647	4,744	4,433	4,751	4,886	4,811
Louisiana	17,928	18,637	18,475	18,918	20,263	20,327	18,373	16,858	18,221	20,607	20,925	17,834	18,826
Maryland	145	196	235	299	318	214	251	182	206	276	88	139	198
Massachusetts, Delaware, Rhode Island	881	876	697	595	798	764	629	469	666	693	681	827	1,562
Michigan	1,531	1,512	1,675	1,524	1,769	1,537	1,853	1,616	1,364	1,648	1,787	1,861	1,955
Minnesota, Wisconsin	2,264	2,240	2,048	2,199	2,246	2,307	2,452	2,079	1,751	1,802	2,070	2,108	2,479
Mississippi	5,891	5,601	5,897	5,817	5,532	5,557	5,766	5,221	6,105	6,357	5,803	6,088	6,141
Montana	2,476	2,542	2,474	2,562	2,683	3,164	3,292	3,014	2,517	2,626	2,588	2,700	3,136
Nebraska	1,423	1,438	1,710	1,821	1,816	1,648	1,527	1,543	1,619	1,407	1,354	1,599	1,612
New Jersey	6,474	6,131	4,977	5,062	5,470	6,305	5,761	6,570	6,555	4,839	6,490	7,310	6,393
New Mexico	4,246	4,172	4,416	4,374	4,279	4,211	4,206	4,163	4,072	4,060	4,093	4,204	4,247
New York	343	372	325	333	370	307	273	229	275	288	254	267	270
North Dakota	1,268	1,299	1,342	1,357	1,265	1,313	1,400	1,505	1,420	1,331	1,329	1,255	1,288
Ohio	5,779	6,196	6,483	6,796	7,166	7,915	6,961	7,340	6,758	6,830	7,745	7,992	7,454
Oklahoma	19,367	19,113	18,112	19,160	19,784	20,066	19,582	18,965	17,294	16,501	17,668	19,694	20,059
Pennsylvania	9,545	8,922	8,030	8,210	7,595	8,066	9,216	8,491	8,812	8,934	9,752	8,915	9,660
Texas	85,833	87,430	89,870	88,687	90,110	92,092	91,234	87,087	81,905	88,710	92,740	95,511	94,786
Utah	974	966	1,060	1,069	1,048	1,246	1,095	960	996	1,032	987	933	991
West Virginia	673	541	543	551	515	492	518	646	721	708	693	657	614
Wyoming	8,173	8,616	9,415	9,738	10,211	10,414	9,796	7,805	6,999	6,389	5,960	6,958	8,089
Total	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 25.—Stocks of crude petroleum in the United States, by classification, location, and month, 1970

(Thousand barrels)

Classification and location	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	131	195	228	181	193	196	173	145	136	123	94	94	197
Alaska	92	89	89	90	92	186	82	150	140	134	139	181	191
Arkansas	163	269	274	272	252	188	197	196	190	149	138	151	159
California, Nevada, Oregon, Washington	19,725	21,134	19,647	21,853	18,916	20,649	19,851	17,748	17,826	17,109	15,550	17,652	19,510
Colorado	512	511	480	450	528	511	445	388	342	429	358	458	529
Florida, Georgia, South Carolina, Virginia	658	620	586	403	605	834	767	943	729	521	243	524	498
Hawaii	1,408	1,469	1,276	1,008	1,280	1,206	809	1,459	730	914	858	324	1,170
Illinois	3,582	3,838	4,060	3,951	3,966	4,034	4,157	3,611	3,775	3,914	3,788	3,528	3,512
Indiana	1,262	1,247	1,470	1,353	1,486	1,534	1,462	1,388	1,317	1,306	1,220	1,478	1,377
Kansas	1,944	1,956	1,838	1,810	1,998	2,105	2,074	1,928	1,648	1,549	1,891	1,663	1,767
Kentucky, Tennessee	1,016	1,183	1,084	921	1,570	1,306	1,458	1,283	1,288	1,048	1,295	1,265	1,241
Louisiana	5,240	5,344	5,489	5,420	6,281	6,323	5,906	4,894	6,145	6,982	6,748	5,203	5,590
Maryland	145	196	235	299	318	214	251	182	206	276	88	139	198
Massachusetts, Delaware, Rhode Island	881	876	697	595	798	764	629	469	666	693	681	827	1,562
Michigan	829	835	882	807	940	876	827	831	691	870	925	875	894
Minnesota, Wisconsin	1,546	1,358	1,138	1,373	1,415	1,407	1,615	1,283	1,106	1,083	1,319	1,314	1,629
Mississippi	645	708	860	684	683	879	845	745	1,055	1,212	916	1,029	1,041
Missouri	314	295	281	274	306	333	232	234	248	226	222	268	417
Montana	672	665	616	608	765	978	1,018	986	791	747	773	745	955
Nebraska	25	22	25	24	27	20	27	21	15	27	27	25	27
New Jersey	6,474	6,131	4,977	5,062	5,470	6,305	5,761	6,570	6,555	4,839	6,490	7,310	6,393
New Mexico	221	276	310	268	330	297	244	277	234	221	221	215	217
New York	260	276	236	218	300	238	243	199	245	258	224	237	240
North Dakota	283	276	282	266	160	245	317	398	338	248	298	300	308
Ohio	2,020	2,215	2,464	2,283	2,207	2,264	2,015	1,975	1,946	1,975	2,190	2,148	2,079
Oklahoma	1,854	1,828	1,891	1,850	1,967	2,132	2,257	1,979	1,788	1,758	1,789	1,939	1,801
Pennsylvania	7,864	7,368	6,520	6,899	6,448	6,898	8,063	7,420	7,673	7,720	8,486	7,564	8,287
Texas	15,149	15,638	16,430	15,829	16,705	18,079	17,167	17,103	15,958	17,727	17,857	19,158	17,510
Utah	458	486	518	618	526	705	632	493	582	523	479	472	492
West Virginia	98	94	91	97	92	65	90	112	104	105	111	68	79
Wyoming	617	755	696	764	688	749	714	635	512	567	550	586	537
Total at refineries	76,088	78,153	75,670	76,530	77,312	82,520	80,328	76,045	74,979	75,253	75,968	77,740	80,407
Pipeline and tank-farm stocks:													
Alabama	839	828	810	933	931	844	895	967	732	765	764	677	538
Alaska	808	733	397	400	309	296	339	509	366	287	530	1,230	1,064
Arkansas	1,022	964	987	959	895	856	869	838	838	839	947	968	962
California, Arizona	18,207	16,464	18,791	20,924	20,907	20,732	20,334	19,032	17,266	16,784	16,422	16,126	14,812
Colorado	1,310	1,250	1,215	1,228	1,427	1,437	1,433	1,363	1,329	1,274	1,203	1,249	1,312
Florida	163	133	90	60	256	233	101	153	233	186	188	139	109
Illinois	12,062	13,071	13,805	14,647	14,600	14,785	14,423	14,170	12,943	13,211	13,243	12,494	13,203
Indiana	2,972	2,979	3,120	3,169	3,245	2,887	3,414	3,231	3,076	2,697	2,795	2,927	3,252
Iowa, Missouri	6,447	6,025	6,550	6,644	6,331	6,211	6,359	6,504	5,818	6,051	5,839	6,416	6,382
Kansas	7,805	7,673	8,154	7,560	7,565	8,759	8,648	8,568	8,250	7,530	7,697	8,534	8,463

Kentucky, Tennessee	3,383	3,373	3,368	3,322	3,601	3,405	3,690	3,307	3,399	3,328	3,399	3,564	3,513
Louisiana	10,223	10,656	10,556	10,991	11,608	12,036	10,109	9,596	9,762	11,214	11,778	10,199	10,897
Michigan	621	595	711	635	754	586	951	710	598	708	785	915	990
Minnesota, Wisconsin	718	882	910	826	831	900	837	796	645	719	751	794	850
Mississippi	4,942	4,560	4,704	4,800	4,516	4,340	4,599	4,125	4,726	4,826	4,557	4,723	4,796
Montana	1,453	1,520	1,480	1,592	1,525	1,798	1,899	1,680	1,378	1,545	1,481	1,614	1,845
Nebraska	1,300	1,313	1,582	1,694	1,686	1,524	1,396	1,424	1,506	1,282	1,229	1,476	1,487
New Mexico	2,586	2,526	2,663	2,726	2,544	2,483	2,589	2,508	2,473	2,506	2,493	2,613	2,672
New York	53	66	59	85	40	39	-------	-------	-------	-------	-------	-------	-------
North Dakota	845	883	923	946	958	921	940	977	962	948	902	836	861
Ohio	3,684	3,906	3,944	4,438	4,884	5,576	4,871	5,290	4,737	4,780	5,480	5,769	5,300
Oklahoma	16,460	16,256	15,192	16,271	16,791	16,894	16,315	15,992	14,534	13,817	14,859	16,710	17,254
Pennsylvania	1,559	1,432	1,388	1,189	1,025	1,046	1,031	949	1,017	1,092	1,144	1,229	1,251
Texas	64,896	66,196	67,844	67,406	68,116	68,495	68,727	64,821	60,588	65,605	69,386	70,744	71,966
Utah	466	424	473	395	439	473	403	386	333	450	454	406	444
West Virginia	410	282	287	289	258	262	263	369	452	438	417	424	370
Wyoming	7,018	7,314	8,172	8,410	8,974	9,111	8,528	6,627	5,933	5,280	4,852	5,807	6,987
Total	172,252	172,304	178,175	182,539	185,016	186,929	183,963	174,892	163,894	168,162	173,595	178,583	181,580
Lease stocks	16,887	16,630	15,783	15,574	15,709	15,375	15,603	15,917	15,271	15,781	15,916	14,980	14,380
Total stocks:													
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
1969	272,193	279,483	265,298	264,178	273,204	281,271	284,544	277,482	267,721	262,528	264,285	264,756	265,227

Table 26.—Value of crude petroleum at wells in the United States, by States

State	1969 Total value at wells (thousand dollars)	1969 Average value per barrel	1970 Total value at wells (thousand dollars)	1970 Average value per barrel
Alabama	20,793	$2.70	20,627	$2.84
Alaska	214,464	2.90	251,684	3.01
Arizona	7,056	2.90	5,281	2.96
Arkansas	51,079	2.83	51,760	2.87
California	920,060	2.45	945,365	2.54
Colorado	88,277	3.12	78,619	3.18
Illinois	161,302	3.18	141,994	3.25
Indiana	25,013	3,19	23,958	3.20
Kansas	283,891	3.20	277,469	3.27
Kentucky	40,194	3.11	36,461	3.15
Louisiana:				
Gulf Coast	2,635,002	3.31	2,905,343	3.38
Northern	156,267	3.22	156,215	3.30
Total Louisiana	2,791,269	3.30	3,061,558	3.38
Michigan	37,494	3.07	36,246	3.10
Mississippi	187,514	2.92	194,706	2.99
Montana	118,359	2.69	105,403	2.78
Nebraska	36,075	2.98	35,384	3.09
New Mexico:				
Southeastern	378,561	3.15	384,780	3.22
Northwestern	25,880	2.86	25,540	2.94
Total New Mexico	404,441	3.13	410,320	3.20
New York	5,683	4.52	5,397	4.52
North Dakota	63,568	2.80	67,107	3.05
Ohio	36,098	3.29	32,914	3.34
Oklahoma	701,155	3.12	712,419	3.19
Pennsylvania	20,086	4.52	18,500	4.52
South Dakota	362	2.29	374	2.34
Texas:				
Gulf Coast	787,130	3.42	889,724	3.51
East Texas Field	187,638	3.24	241,281	3.32
West Texas	1,715,586	3.14	1,914,593	3.21
Panhandle	95,788	3.17	92,211	3.23
Rest of State	910,186	3.17	966,196	3.23
Total Texas	3,696,328	3.21	4,104,005	3.28
Utah	65,320	2.80	65,603	2.81
West Virginia	11,888	3.83	11,871	3.80
Wyoming	433,846	2.80	469,811	2.93
Other States [1]	5,065	2.47	8,890	2.52
Total United States	10,426,680	3.09	11,173,726	3.18

[1] Florida, Missouri, Nevada, Tennessee, and Virginia.

Table 27.—Posted price per barrel of petroleum at wells in the United States in 1970 by grade, with date of price change

(Dollars)

Date of change	Pennsylvania grade: Bradford and Allegheny districts	Pennsylvania grade: In southwest Pennsylvania	Corning grade	Western Kentucky	Indiana-Illinois	Coldwater, Michigan	Oklahoma-Kansas: 34°–34.9° API	Oklahoma-Kansas: 36°–36.9° API
Jan. 1	4.63	3.92	3.17	3.35	3.35	3.10	3.17	3.25
Nov. 23	----------	----------	3.42	3.60	3.60	3.35	3.42	3.50
	Panhandle, Texas (Carson, Gray, Hutchinson, and Wheeler Counties) 35°–35.9° API	West Texas 30°–30.9° API (sweet)	Lea County, N. Mex. 30°–30.9° API (sour)	South Texas Mirando 24°–24.9° API	East Texas	Conroe, Texas	Texas: 30°–30.9° API	Texas: 20°–20.9° API
Jan. 1	3.16	3.11	2.94	3.40	3.35	3.45	3.20	3.10
Nov. 17	----------	3.36	3.19	3.65	----------	----------	----------	----------
Nov. 23	3.41	----------	----------	----------	3.60	3.70	3.45	3.35
	Louisiana 30°–30.9° API	Caddo-Pine Island, La. 36°–36.9° API	Magnolia Smackover Limestone, Ark. 31°–31.9° API	Elk Basin, Wyo. (including Montana) 30°–30.9° API	California: Coalinga 32°–32.9° API	California: Kettleman Hills 37°–37.9° API	California: Midway Sunset 19°–19.9° API	California: Wilmington 24°–24.9° API
Jan. 1	3.30	3.19	2.82	2.91	3.16	3.41	2.43	2.78
Nov. 23	3.55	3.44	3.07	3.16	----------	----------	----------	----------
Nov. 30	----------	----------	----------	----------	3.41	3.66	2.68	3.03

Source: Platt's Oil Price Handbook.

Table 28.—Wholesale price index, crude petroleum

(1957–59 = 100)

Month	1966	1967	1968	1969	1970
January	96.9	98.2	99.0	99.7	104.5
February	97.0	98.2	99.0	99.9	104.5
March	97.0	98.3	99.0	103.7	104.5
April	97.0	98.3	99.0	104.8	104.5
May	97.2	98.3	99.0	104.7	104.5
June	97.4	98.3	99.3	104.5	104.5
July	97.5	98.4	99.4	104.5	103.3
August	97.7	99.0	99.7	104.5	103.3
September	97.7	99.0	99.7	104.5	103.3
October	98.1	99.0	99.7	104.5	103.3
November	98.1	99.0	99.7	104.5	103.3
December	98.1	99.0	99.7	104.5	111.6
Average	97.5	98.6	99.4	103.7	104.6

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

Table 29.—Average monthly price of petroleum products in the United States, 1969–70

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	1969	11.77	11.75	12.48	12.44	12.29	12.22	12.09	12.28	12.18	12.17	12.25	12.29	12.18
	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
Tank-wagon prices to dealers at 55 cities on first of month	1969	16.86	16.72	17.43	17.49	17.31	17.57	17.37	16.83	17.20	16.67	16.73	17.17	17.11
	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
At service stations (including all taxes)	1969	34.31	34.14	35.09	35.25	35.02	35.40	35.30	34.61	35.10	34.36	34.45	35.03	34.84
	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
Kerosine (cents per gallon):														
No. 1 range at Chicago district	1969	10.93	11.00	10.94	10.75	10.75	10.75	10.68	10.68	10.71	10.89	11.09	11.25	10.87
	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
No. 1 fuel oil at Oklahoma	1969	10.34	10.61	10.60	10.50	10.26	10.25	10.16	10.25	10.33	10.36	10.25	10.58	10.37
	1970	10.66	10.79	10.50	10.31	10.23	10.15	10.25	10.25	10.38	10.54	10.74	11.09	10.49
Kerosine (or No. 1 fuel oil) at New York Harbor	1969	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
	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
Kerosine (or No. 1 fuel oil) at Tampa	1969	11.50	11.50	11.59	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.51
	1970	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.81	12.00	12.00	12.45	11.69
Distillate and diesel fuel oil (cents per gallon):														
No. 2 fuel oil at refineries, Oklahoma	1969	9.59	9.86	9.85	9.75	9.52	9.50	9.41	9.50	9.58	9.61	9.61	9.83	9.63
	1970	9.91	10.40	9.73	9.56	9.45	9.40	9.50	9.52	9.63	9.79	9.99	10.34	9.74
No. 2 fuel oil at New York Harbor	1969	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
	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
Diesel oil, shore plants, New York	1969	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30
	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
Diesel oil for ships (dollars per barrel):														
New York	1969	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63	4.63
	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
New Orleans	1969	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26
	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
San Pedro	1969	4.72	4.72	4.78	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.91
	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
Residual fuel oil (dollars per barrel):														
No. 6 fuel at refineries, Oklahoma	1969	1.74	1.78	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.71
	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
No. 5 fuel oil at New York Harbor	1969	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
	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
Bunker "C" for ships:														
New York	1969	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
	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
New Orleans	1969	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
	1970	2.22	2.22	2.27	2.30	2.39	2.63	2.83	3.07	3.30	[1] 3.30	-----	-----	[1] 2.65
San Pedro	1969	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.90	1.90	1.88
	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
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	[1] 23.00
500 viscosity at 100, 0–10 pour test, 95 V.I.	1970	-----	-----	-----	-----	-----	-----	-----	-----	-----	24.50	24.50	24.50	[1] 24.50
South Texas:														
500 viscosity, No. 2½–3½ color [2]	1969	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
Liquid petroleum gas (propane) (cents per gallon):														
New York Harbor/Philadelphia	1969	7.25	7.25	7.25	6.96	6.75	6.75	6.75	6.75	6.78	7.50	7.54	7.50	7.09
	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
Oklahoma	1969	4.25	4.25	4.25	3.63	3.25	3.25	3.25	3.25	4.07	4.25	4.53	4.75	3.92
	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
Baton Rouge	1969	4.75	4.75	4.75	4.13	3.75	3.75	3.75	3.75	4.57	4.75	4.97	5.25	4.41
	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

[1] Partial average.
[2] No change in price during 1970.

Source: Platt's Oil Price Handbook.

Table 30.—Supply, demand, and stocks of all oils by PAD districts for year 1970

(Thousand barrels)

	PAD districts						
	I	II	III	IV	I–IV	V	United States
Domestic production:							
Crude and lease condensate	11,411	426,777	2,375,205	246,317	3,059,710	457,740	3,517,450
Natural gas plant liquids	8,804	88,596	477,189	12,283	586,872	19,044	605,916
Receipts from other districts	1,282,744	877,649	31,442	16,708	8,898	70,210	---------
Imports:							
Crude oil	211,403	115,613	---------	17,573	344,589	138,704	483,293
Unfinished oils	30,221	---------	913	---------	31,134	8,127	39,261
Refined products	651,494	19,322	20,849	3,193	694,858	29,980	724,838
Other hydrocarbons and hydrogen input	218	225	649	135	1,227	5,011	6,238
Total new supply	2,196,295	1,528,182	2,906,247	296,209	4,727,288	728,816	5,376,996
Unaccounted for crude oil	855	−6,206	607	−2,216	−6,960	−761	−7,721
Processing gain	16,251	34,457	60,565	1,628	112,901	18,151	131,052
Total supply	2,213,401	1,556,433	2,967,419	295,621	4,833,229	746,206	5,500,327
Change in stocks of all oil	+24,265	+21,932	+11,726	−1,876	+56,047	−18,309	+37,738
Total disposition of primary supply	2,189,136	1,534,501	2,955,693	297,497	4,777,182	764,515	5,462,589
Exports:							
Crude oil	18	312	4,439	---------	4,769	222	4,991
Refined products	7,834	4,100	35,438	41	47,413	41,839	89,252
Shipments to other districts	43,959	54,368	2,009,650	161,878	70,210	8,898	---------
Crude losses (estimate for individual districts I–IV)	774	875	1,797	472	3,918	410	4,328
Domestic demand for products:							
Gasoline, total	729,903	741,883	275,805	64,578	1,812,169	319,064	2,131,233
Motor gasoline	725,638	737,223	270,537	63,868	1,797,266	314,083	2,111,349
Aviation gasoline	4,265	4,660	5,268	710	14,903	4,981	19,884
Jet fuel, total	127,586	70,472	34,100	8,355	240,513	111,748	352,261
Naphtha-type	24,228	15,663	15,517	1,265	56,673	34,236	90,909
Kerosine-type	103,358	54,809	18,583	7,090	183,840	77,512	261,352
Ethane (including ethylene)	1,931	9,793	71,403	1	83,128	629	83,757
Liquefied gases	45,477	104,037	185,264	4,620	339,398	24,206	363,604
Kerosine	45,715	30,632	15,780	2,019	94,146	1,828	95,974
Distillate fuel oil	473,483	273,629	69,570	25,790	842,472	84,778	927,250
Residual fuel oil	596,834	72,586	31,688	9,195	710,303	93,984	804,287
Petrochemical feedstocks	8,695	12,567	74,682	340	96,284	4,742	101,026
Special naphthas	6,786	6,867	12,592	164	26,409	4,797	31,206
Lubricants	19,288	13,889	11,208	468	44,853	4,880	49,733
Wax	2,122	1,043	867	64	4,096	510	4,606
Coke	11,487	28,161	28,186	3,239	71,073	6,145	77,218
Asphalt	43,196	53,956	28,881	9,181	135,214	18,260	153,474
Road oil	679	5,479	188	1,874	8,220	1,421	9,641

Still gas for fuel	20,415	46,534	58,626	5,134	130,709	33,196	163,905
Miscellaneous products	2,954	3,318	5,529	84	11,885	2,958	14,843
Total domestic demand	2,136,551	1,474,846	904,369	135,106	4,650,872	713,146	5,364,018
Stocks of all oils:							
Crude oil and lease condensate	19,325	78,631	126,040	14,187	238,183	38,184	276,367
Unfinished oils	18,330	19,179	37,277	2,186	76,972	22,017	98,989
Natural gasoline and plant condensate	299	1,306	4,989	25	6,619	427	7,046
Refined products	205,329	178,645	168,391	13,862	566,227	69,232	635,459
Total	243,283	277,761	336,697	30,260	888,001	129,860	1,017,861

Table 31.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

Product	1968	1969	1970 p
Isopentane:			
Production	2,660	3,457	3,865
Stocks at plants	44	10	7
Used at refineries	2,640	3,491	3,868
Natural gasoline:			
Production	145,214	154,472	161,274
Stocks, end of year:			
At plants	2,584	3,358	4,316
At refineries	1,860	1,557	1,765
Total stocks	4,444	4,915	6,081
Used at refineries	145,492	154,001	160,108
Plant condensate:			
Production	38,494	34,133	31,972
Stocks, end of year:			
At plants	841	547	507
At refineries	137	232	451
Total stocks	978	779	958
Imports	NA	NA	2,258
Used at refineries	38,552	34,332	34,051
Finished gasoline:			
Production:			
At refineries	1,933,827	2,022,407	2,099,911
At gas processing plants	6,211	5,745	5,347
Total gasoline production	1,940,038	2,028,152	2,105,258
Stocks, end of year:			
At refineries	211,256	217,084	214,150
At plants	270	308	198
Total stocks	211,526	217,392	214,348
Imports	21,591	22,709	24,320
Exports	2,083	2,449	1,389
Domestic demand	1,956,000	2,042,546	2,131,233
Motor gasoline:			
Production:			
At refineries	1,902,264	1,995,947	2,080,199
At gas processing plants	6,211	5,745	5,347
Total motor gasoline production	1,908,475	2,001,692	2,085,546
Stocks, end of year:			
At refineries	204,226	210,891	209,057
At plants	270	308	198
Total motor gasoline stocks	204,496	211,199	209,255
Imports	21,591	22,709	24,320
Exports	249	703	461
Domestic demand	1,925,376	2,016,995	2,111,349
Aviation gasoline:			
Production	31,563	26,460	19,712
Stocks, end of year	7,030	6,193	5,093
Exports	1,834	1,746	928
Domestic demand	30,624	25,551	19,884
Jet fuel:			
Production	314,928	321,718	301,913
Stocks, end of year	24,277	28,073	27,610
Imports	38,507	45,539	52,052
Exports	2,092	1,730	2,167
Domestic demand	349,378	361,731	352,261
Naphtha-type:			
Production:			
At refineries	121,165	104,748	84,060
At gas processing plants	277	18	21
Total production	121,442	104,766	84,081
Stocks, end of year:			
At refineries	8,880	8,537	6,618
At plants	24	19	3
Total stocks	8,904	8,556	6,621

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 p
Jet fuel (Naphtha-type)—Continued			
Stocks, end of year—Continued			
Imports	7,117	5,134	7,060
Exports	2,091	1,730	2,167
Domestic demand	126,601	108,518	90,909
Kerosine-type:			
Production	193,486	216,952	217,832
Stocks, end of year	15,373	19,517	20,989
Imports	31,390	40,405	44,992
Exports	1	-------	-------
Domestic demand	222,777	253,213	261,352
Ethane (including ethylene):			
Production:			
At gas processing plants	45,803	63,027	73,434
At refineries	9,446	9,159	9,460
Total production	55,249	72,186	82,894
Stocks, end of year:			
At plants	2,212	2,182	1,319
At refineries	-------	-------	-------
Total stocks	2,212	[1] 2,182	[1] 1,319
Domestic demand:			
Plant ethane	45,706	63,057	74,297
Refinery ethane and/or ethylene	9,446	9,159	9,460
Total domestic demand	55,152	72,216	83,757
Liquefied gases:			
Production:			
At gas processing plants (LPG)	305,459	315,430	326,177
At refineries (LRG):			
For fuel use	71,102	75,659	80,870
For chemical use	37,539	38,703	35,657
Total production at refineries	108,641	114,362	116,527
Total production	414,100	429,792	442,704
Stocks end of year:			
LPG stocks:			
At plants	68,928	51,799	59,276
At refineries	647	571	794
Total LPG stocks	69,575	52,370	60,070
LRG stocks:			
For fuel use	4,225	4,782	5,433
For chemical use	148	268	221
Total LRG stocks	4,373	5,050	5,654
Total stocks	73,948	[2] 57,420	[2] 65,724
Imports	11,647	12,651	19,161
Exports	10,608	12,797	9,650
LPG used at refineries	72,652	72,764	80,307
Domestic demand:			
LPG for fuel and chemical use	221,869	263,402	251,596
LRG for fuel use	71,628	74,447	80,219
LRG for chemical use	37,092	35,561	31,789
Total domestic demand	330,589	373,410	363,604
Propane (including propylene):			
Production:			
At gas processing plants	184,409	195,346	202,494
At refineries:			
For fuel use	56,847	57,022	63,409
For chemical use	17,489	19,721	20,090
Total production at refineries	74,336	76,743	83,499
Total production	258,745	272,089	285,993

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 p
Propane (including propylene)—Continued			
Stocks, end of year:			
Plant propane stocks:			
At plants	44,523	31,375	38,791
At refineries	5	4	84
Total plant propane stocks	44,528	31,379	38,875
Refinery propane and/or propylene stocks:			
For fuel use	2,947	3,083	4,301
For chemical use	73	215	146
Total refinery propane and/or propylene stocks	3,020	3,298	4,447
Total stocks	47,548	34,677	43,322
Imports	5,627	5,251	9,467
Exports	2,542	2,412	2,165
Plant propane used at refineries	1,587	1,632	1,530
Domestic demand:			
Plant propane	178,448	209,702	200,770
Refinery propane and/or propylene:			
For fuel use	57,345	56,886	62,191
For chemical use	17,479	19,579	20,159
Total refinery propane and/or propylene domestic demand	74,824	76,465	82,350
Total domestic demand	253,272	286,167	283,120
Butane (including butylene):			
Production:			
At gas processing plants	78,903	86,471	87,253
At refineries:			
For fuel use	9,584	13,535	13,514
For chemical use	12,441	10,987	8,693
Total production at refineries	22,025	24,522	22,207
Total production	100,928	110,993	109,460
Stocks, end of year:			
Plant butane stocks:			
At plants	16,141	13,330	14,397
At refineries	357	270	414
Total plant butane stocks	16,498	13,600	14,811
Refinery butane and/or butylene stocks:			
For fuel use	936	1,448	912
For chemical use	42	36	35
Total refinery butane and/or butylene stocks	978	1,484	947
Total stocks	17,476	15,084	15,758
Imports	6,020	7,400	9,694
Exports	1,184	3,086	1,349
Plant butane used at refineries	41,526	40,268	43,758
Domestic demand:			
Plant butane	40,064	53,415	50,629
Refinery butane and/or butylene:			
For fuel use	9,785	13,023	14,050
For chemical use	12,478	10,993	8,694
Total refinery butane and/or butylene	22,263	24,016	22,744
Total domestic demand	62,327	77,431	73,373
Butane-propane mixture:			
Production:			
At gas processing plants	12,367	6,711	5,677
At refineries:			
For fuel use	4,671	5,102	3,947
For chemical use	6,494	6,289	5,353
Total production at refineries	11,165	11,391	9,300
Total production	23,532	18,102	14,977

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 p
Butane-propane mixture—Continued			
Stocks, end of year:			
Plant butane-propane mixture:			
At plants	528	240	733
At refineries	12	91	35
Total plant butane-propane mixture stocks	540	331	768
Refinery butane-propane mixture:			
For fuel use	342	251	220
For chemical use	1	------	------
Total refinery butane-propane mixture stocks	343	251	220
Total stocks	883	582	988
Exports	6,882	7,299	6,136
Plant butane-propane mixture used at refineries	2,527	3,013	2,822
Domestic demand:			
Plant butane-propane mixture	3,357	285	197
Refinery butane-propane mixture:			
For fuel use	4,488	4,538	3,978
For chemical use	6,020	3,268	1,438
Total refinery butane-propane mixture	10,508	7,806	5,416
Total domestic demand	13,865	8,091	5,613
Isobutane:			
Production:			
At gas processing plants	29,780	26,902	30,753
At refineries	1,115	1,706	1,521
Total production	30,895	28,608	32,274
Stocks, end of year:			
Plant isobutane:			
At plants	7,736	6,854	5,355
At refineries	273	206	261
Total plant isobutane stocks	8,009	7,060	5,616
Refinery isobutane	32	17	40
Total stocks	8,041	7,077	5,656
Plant isobutane used at refineries	27,012	27,851	32,197
Domestic demand: Refinery isobutane for chemical use	1,125	1,721	1,498
Kerosine (including range oil):			
Production:			
At refineries	100,545	101,738	94,635
At gas processing plants	1,027	1,121	1,077
Total production	101,572	102,859	95,712
Stocks, end of year:			
At refineries	23,190	26,531	27,564
At plants	290	249	284
Total stocks	23,480	26,780	27,848
Imports	190	965	1,451
Exports	613	155	121
Domestic demand	102,934	100,369	95,974
Distillate fuel oil:			
Production:			
At refineries	839,373	846,863	895,656
At gas processing plants	1,308	1,541	1,441
Total production	840,681	848,404	897,097
Crude used directly as distillate	712	654	743
Stocks, end of year:			
At refineries	173,093	171,664	[2] 195,213
At plants	65	50	58
Total stocks	173,158	171,714	195,271

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 p
Distillate fuel oil—Continued			
Imports	48,148	50,883	53,903
Exports	1,547	1,123	936
Domestic demand	874,539	900,262	927,250
Residual fuel oil:			
Production	275,814	265,906	257,510
Crude used directly as residual	4,272	4,334	4,317
Stocks, end of year	65,359	58,395	53,994
Imports	409,928	461,611	557,845
Exports	20,013	16,891	19,786
Domestic demand	668,239	721,924	804,287
Petrochemical feedstocks (excluding LRG): [3]			
Production	95,422	98,356	100,381
Stocks, end of year	2,945	2,845	3,619
Imports: Naphtha-400°	-------	40	5,195
Exports: Other	2,795	3,848	3,776
Domestic demand:			
Still gas	9,844	9,985	12,564
Naphtha-400°	55,618	57,569	57,279
Other	27,474	27,094	31,183
Total domestic demand	92,936	94,648	101,026
Special naphthas:			
Production:			
At refineries	27,643	28,397	30,196
At gas processing plants	473	492	384
Total production	28,116	28,889	30,580
Stocks, end of year:			
At refineries	5,816	6,281	6,184
At plants	13	11	9
Total stocks	5,829	6,292	6,193
Imports	1,399	3,191	2,111
Exports	2,427	2,019	1,584
Domestic demand	27,007	29,598	31,206
Lubricants:			
Production	65,684	65,080	66,183
Stocks, end of year	14,023	14,088	14,712
Imports	33	163	224
Exports:			
Grease	298	257	292
Oil	17,703	16,139	15,758
Total exports	18,001	16,396	16,050
Domestic demand	48,467	48,782	49,733
Wax (1 barrel = 280 pounds):			
Production	5,887	6,049	6,294
Stocks, end of year	1,001	997	993
Imports	17	158	117
Exports	1,588	1,623	1,809
Domestic demand	4,360	4,588	4,606
Coke (5 barrels = 1 short ton):			
Production:			
Marketable coke	45,823	52,006	59,107
Catalyst coke	49,367	50,862	48,764
Total production	95,190	102,868	107,871
Stocks, end of year	6,195	5,198	5,297
Exports	19,497	23,035	30,554
Domestic demand	76,319	80,830	77,218
Asphalt (5.5 barrels = 1 short ton):			
Production	135,460	135,691	146,658
Stocks, end of year	20,055	16,753	15,779
Imports	6,236	4,761	6,201
Exports	429	464	359
Domestic demand	141,151	143,290	153,474
Road oil:			
Production	6,826	9,086	9,393
Stocks, end of year	550	880	632
Domestic demand	7,080	8,756	9,641
Still gas for fuel: Production	149,796	160,363	163,905

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 p
Miscellaneous products:			
Production:			
At refineries	15,711	17,139	14,746
At gas processing plants	3,385	805	924
Total production	19,096	17,944	15,670
Stocks, end of year:			
At refineries	1,931	2,345	2,105
At plants	25	19	15
Total stocks	1,956	2,364	2,120
Exports	1,049	919	1,071
Domestic demand	17,842	16,617	14,843
Unfinished oils (net):			
Input (+) output (−)	+26,152	+34,346	+38,091
Stocks, end of year	93,399	97,819	98,989
Imports	29,350	38,766	39,261

p Preliminary. NA Not available.

[1] Includes underground stocks at plants and refineries, in thousands of barrels. At plants: ethane, 1969, 1,904; 1970, 810; propane, 1969, 24,902; 1970, 31,924; butane, 1969, 10,416; 1970, 10,902; butane-propane mixtures, 1969, 190; 1970, 291; and isobutane, 1969, 6,438; 1970, 4,317. At refineries: (includes LRG): propane, 1969, 2,532; 1970, 2,153; isobutane, 1970, 766; butane, 1969, 932; 1970, 1,679; butane-propane mixtures, 1969, 199; 1970, 127.

[2] Includes 4,276,000 barrels of No. 4 fuel oil. 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 in the United States at end of month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1969												
Gasoline:												
Motor	207,972	216,015	222,595	210,668	202,134	196,461	187,772	183,908	188,804	189,473	202,538	211,199
Aviation	6,492	6,535	6,602	5,969	5,543	5,347	5,303	5,466	5,448	5,562	5,824	6,193
Total	214,464	222,550	229,197	216,637	207,677	201,808	193,075	189,374	194,252	195,035	208,362	217,392
Jet fuel:												
Naphtha-type	8,738	8,840	8,445	8,520	8,654	8,896	9,320	8,880	8,863	9,152	9,058	8,556
Kerosine-type	14,176	16,094	17,123	18,268	19,663	19,515	20,536	21,347	20,003	20,141	20,473	19,517
Total	22,914	24,934	25,568	26,788	28,317	28,411	29,856	30,227	28,866	29,293	29,531	28,073
Ethane	2,121	2,018	1,924	2,123	2,099	2,116	2,188	1,869	1,803	2,061	2,099	2,182
Liquefied gases [1]	56,264	50,476	49,764	55,082	63,549	70,349	76,337	80,574	81,842	77,864	69,414	57,420
Kerosine	19,355	18,586	18,909	20,330	21,989	25,331	27,289	29,735	30,106	30,631	29,429	26,780
Distillate fuel oil	130,609	106,650	96,563	99,826	110,925	132,650	159,081	183,515	197,653	207,986	200,969	171,714
Residual fuel oil [2]	60,957	57,930	55,188	58,213	60,570	60,511	63,144	64,062	63,593	62,225	60,665	58,395
Petrochemical feedstocks	3,096	2,789	2,776	2,410	2,549	2,603	2,848	2,736	3,075	3,095	3,061	2,845
Special naphthas	5,352	5,955	6,231	5,708	6,180	6,075	5,916	5,794	6,024	5,768	5,957	6,292
Lubricants	13,861	13,824	14,019	13,918	13,453	12,784	12,834	12,799	12,679	12,495	13,617	14,088
Wax	977	931	989	1,041	1,067	1,036	988	1,030	988	946	998	997
Coke	6,490	6,495	6,307	6,545	6,591	6,908	6,570	6,175	5,655	6,124	6,184	5,198
Asphalt	21,926	24,360	27,335	28,444	28,303	26,104	23,357	19,502	16,103	13,177	14,002	16,753
Road oil	686	809	1,180	1,279	1,398	1,411	1,302	1,426	1,157	938	868	880
Miscellaneous	1,749	1,780	1,942	1,928	1,657	1,940	2,128	2,127	1,914	1,830	1,984	2,364
Unfinished oils	90,528	93,335	94,411	100,759	105,318	104,081	101,914	97,454	97,818	97,976	95,609	97,819
Total 1969 [2]	651,349	633,422	632,303	641,031	661,642	684,118	708,827	728,399	743,528	747,444	742,749	709,192
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	696,437	720,964	743,000	753,053	765,071	734,448

[1] Includes LRG used for petrochemical feedstocks.
[2] Revised. Excludes 2,000,000 barrels of pitch which were previously included in refinery stocks of residual fuel oil in the Texas Inland Refining District during 1969 and preceding years.

Table 33.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1966	1967	1968	1969	1970 p
INPUT					
Crude petroleum:					
Domestic	3,000,789	3,174,004	3,308,044	3,363,602	3,485,332
Foreign	446,404	408,590	[1] 466,316	[1] 516,003	[1] 482,171
Total crude petroleum	3,447,193	3,582,594	3,774,360	3,879,605	3,967,503
Unfinished oils rerun (net)	34,632	34,237	26,152	34,346	38,091
Total crude and unfinished oils rerun	3,481,825	3,616,831	3,800,512	3,913,951	4,005,594
Natural gas liquids:					
Liquefied petroleum gases	68,403	68,675	72,652	72,764	80,307
Natural gasoline	133,484	138,521	148,132	157,492	163,976
Plant condensate	33,693	37,524	38,552	34,332	34,051
Total natural gas liquids	235,580	244,720	259,336	264,588	278,334
Other hydrocarbons and hydrogen [2]	30	87	3,377	4,213	6,238
OUTPUT					
Gasoline:					
Motor gasoline [3]	1,742,456	1,801,448	1,902,264	1,995,947	2,080,199
Aviation gasoline	41,244	37,074	31,563	26,460	19,712
Total gasoline [3]	1,783,700	1,838,522	1,933,827	2,022,407	2,099,911
Jet fuel:					
Naphtha-type [3]	89,473	109,650	121,165	104,748	84,060
Kerosine-type	125,973	163,535	193,486	216,952	217,832
Total jet fuel [3]	215,446	273,185	314,651	321,700	301,892
Ethane (including ethylene)	(4)	7,028	9,446	9,159	9,460
Liquefied refinery gas:					
For fuel use	60,090	67,589	71,102	75,659	80,870
For chemical use	46,128	36,900	37,539	38,703	35,657
Total liquefied refinery gas	106,218	104,489	108,641	114,362	116,527
Kerosine [3]	100,849	99,061	100,545	101,738	94,635
Distillate fuel oil [3]	784,717	804,429	839,373	846,863	895,656
Residual fuel oil	263,961	275,956	275,814	265,906	257,510
Petrochemical feedstocks:					
Still gas	10,068	9,500	9,844	9,985	12,564
Naphtha-400°	38,446	50,573	55,077	57,389	54,154
Other	25,939	27,355	30,501	30,982	33,663
Total petrochemical feedstocks	74,453	87,428	95,422	98,356	100,381
Special naphthas [3]	29,634	26,912	27,643	28,397	30,196
Lubricants	65,407	64,870	65,684	65,080	66,183
Wax [5]	5,772	5,719	5,887	6,049	6,294
Coke [5]	88,054	90,933	95,190	102,868	107,871
Asphalt [5]	129,579	127,767	135,460	135,691	146,658
Road oil	7,247	6,978	6,826	9,086	9,393
Still gas for fuel	135,459	140,034	149,796	160,363	163,905
Miscellaneous [3]	16,474	14,919	15,711	17,139	14,746
Processing gain (−) or loss (+)	−89,535	−106,592	−116,691	−122,412	−131,052

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Benzol included for 1966–67 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] Included with liquefied refinery gases.
[5] 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 months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
INPUT 1969													
Crude petroleum:													
Domestic	262,052	261,730	283,299	269,496	284,561	282,728	294,855	288,523	279,681	281,961	278,253	296,463	3,363,602
Foreign	41,791	37,584	42,419	42,583	41,597	41,718	44,202	46,237	44,574	43,705	43,373	46,220	[1] 516,003
Total crude petroleum	303,843	299,314	325,718	312,079	326,158	324,446	339,057	334,760	324,255	325,666	321,626	342,683	3,879,605
Unfinished oils rerun (net)	5,055	776	1,647	−3,792	−2,100	4,297	5,038	8,089	3,800	2,757	6,091	2,688	34,346
Total crude and unfinished oils rerun	308,898	300,090	327,365	308,287	324,058	328,743	344,095	342,849	328,055	328,423	327,717	345,371	3,913,951
Natural gas liquids:													
Liquefied petroleum gases	7,102	5,765	5,180	4,328	4,903	4,605	4,733	5,078	5,934	7,698	8,139	9,299	72,764
Natural gasoline	12,556	11,185	12,675	12,938	13,298	13,014	13,841	13,505	13,741	13,673	13,553	13,513	157,492
Plant condensate	3,173	2,834	2,978	2,725	2,775	2,862	2,661	2,947	2,810	2,823	2,874	2,870	34,332
Total natural gas liquids	22,831	19,784	20,833	19,991	20,976	20,481	21,235	21,530	22,485	24,194	24,566	25,682	264,588
Other hydrocarbons	275	291	399	363	321	331	473	379	374	337	349	321	4,213
OUTPUT 1969													
Gasoline:													
Motor gasoline [2]	157,198	149,446	160,671	151,830	164,359	163,213	174,681	176,578	171,640	174,301	172,559	179,471	1,995,947
Aviation gasoline	1,494	1,651	2,693	2,002	2,218	2,363	2,641	2,515	2,205	2,346	2,228	2,104	26,460
Total gasoline [2]	158,692	151,097	163,364	153,832	166,577	165,576	177,322	179,093	173,845	176,647	174,787	181,575	2,022,407
Jet fuel:													
Naphtha-type [2]	7,780	8,077	10,079	9,161	9,729	10,009	10,707	9,090	7,947	7,614	7,175	7,380	104,748
Kerosine-type	16,704	17,286	16,748	18,299	18,083	18,187	18,535	18,516	17,149	18,635	18,448	20,362	216,952
Total jet fuel [2]	24,484	25,363	26,827	27,460	27,812	28,196	29,242	27,606	25,096	26,249	25,623	27,742	321,700
Ethane (including ethylene)	782	679	881	683	732	699	723	773	757	805	798	847	9,159
Liquefied gases:													
LRG for fuel use	5,343	5,454	6,124	5,924	6,660	6,700	7,240	6,752	6,499	6,284	6,309	6,370	75,659
LRG for chemical use	2,959	2,964	3,519	3,638	3,441	3,318	3,363	3,611	3,001	3,074	2,837	2,978	38,703
Total liquefied gases	8,302	8,418	9,643	9,562	10,101	10,018	10,603	10,363	9,500	9,358	9,146	9,348	114,362
Kerosine [2]	11,148	10,932	10,287	7,162	7,015	7,769	7,442	7,516	7,317	7,493	7,936	9,721	101,738
Distillate fuel oil [2]	69,232	66,279	73,879	66,580	67,165	71,137	73,465	70,838	68,811	70,365	72,379	76,733	846,863
Residual fuel oil	27,873	25,126	25,336	23,595	21,239	19,403	19,493	19,250	19,536	19,543	21,439	24,073	265,906
Petrochemical feedstocks:													
Still gas	747	711	909	791	789	877	864	995	794	895	794	819	9,985
Naphtha-400°	4,768	4,253	5,175	4,279	4,810	4,779	4,416	5,174	4,961	5,164	4,636	4,974	57,389
Other	2,187	2,292	2,403	2,389	2,503	2,649	2,806	2,647	2,394	3,046	2,781	2,885	30,982
Total petrochemical feedstocks	7,702	7,256	8,487	7,459	8,102	8,305	8,086	8,816	8,149	9,105	8,211	8,678	98,356

See footnotes at end of table.

Table 34.—Input and output at refineries in the United States, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Special naphthas [2]	1,941	2,291	2,335	2,152	2,600	2,577	2,316	2,436	2,501	2,368	2,410	2,470	28,397
Lubricants:													
Bright stock	361	504	564	503	522	518	630	431	463	451	611	611	6,169
Neutral	2,421	1,849	2,483	2,612	2,779	2,163	2,102	2,279	2,202	2,390	2,726	2,589	28,595
Other grades	1,924	2,078	2,570	2,376	2,376	2,590	2,782	3,062	2,714	2,812	2,486	2,546	30,316
Total lubricants	4,706	4,431	5,617	5,491	5,677	5,271	5,514	5,772	5,379	5,653	5,823	5,746	65,080
Wax:													
Microcrystalline	85	70	123	98	145	96	108	116	100	108	146	82	1,277
Fully refined	219	187	248	239	242	258	188	234	231	242	218	301	2,807
Other	90	149	187	164	187	136	189	184	150	191	171	167	1,965
Total wax [3]	394	406	558	501	574	490	485	534	481	541	535	550	6,049
Coke [3]	7,407	7,411	8,375	8,369	8,445	8,857	9,055	8,759	8,672	8,977	9,135	9,406	102,868
Asphalt [3]	5,527	6,191	8,476	10,235	12,939	14,348	15,154	14,926	15,082	13,464	10,367	8,982	135,691
Road oil	260	170	502	364	782	1,105	1,282	1,814	1,209	895	432	271	9,086
Still gas for fuel	11,906	11,425	12,293	12,640	13,633	13,929	14,355	14,504	14,469	13,422	14,000	13,787	160,363
Miscellaneous products [2]	1,269	1,339	1,390	1,324	1,363	1,598	1,581	1,401	1,415	1,413	1,483	1,563	17,139
Processing gain (−) or loss (+)	−9,621	−8,649	−9,653	−8,768	−9,401	−9,723	−10,315	−9,643	−11,305	−13,344	−11,872	−10,118	−122,412
INPUT 1970 p													
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 p													
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 petrochemical 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
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
Fully refined	206	203	227	252	236	276	235	236	310	194	223	262	2,860
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

[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 1969								
Crude petroleum:								
Domestic	181,420	23,122	204,542	22,711	643,645	23,309	322,552	1,012,217
Foreign	247,029	26,286	273,315	100	[1] 38,093	49,120	143	[1] 87,456
Total crude petroleum	428,449	49,408	477,857	22,811	681,738	72,429	322,695	1,099,673
Unfinished oils rerun (net)	+64,843	+1,268	+66,111	+203	−2,228	−10	+1,167	−868
Total crude and unfinished oils rerun	493,292	50,676	543,968	23,014	679,510	72,419	323,862	1,098,805
Natural gas liquids:								
Liquefied petroleum gases	2,449	9	2,458	127	8,773	2,903	9,390	21,193
Natural gasoline	1,867	4	1,871	4	9,873	725	11,569	22,171
Plant condensate	801	23	824	---	291	413	---	704
Total natural gas liquids	5,117	36	5,153	131	18,937	4,041	20,959	44,068
Other hydrocarbons	350	---	350	---	---	---	215	215
OUTPUT 1969								
Gasoline:								
Motor gasoline [2]	231,200	20,510	251,710	12,086	370,221	39,572	188,928	610,807
Aviation gasoline	831	---	831	---	2,088	---	655	2,743
Total gasoline [2]	232,031	20,510	252,541	12,086	372,309	39,572	189,583	613,550
Jet fuel:								
Naphtha-type [2]	5,104	722	5,826	---	7,234	1,028	9,272	17,534
Kerosine-type	11,716	573	12,289	22	30,144	1,464	10,555	42,185
Total jet fuel [2]	16,820	1,295	18,115	22	37,378	2,492	19,827	59,719
Ethane (including ethylene)	---	---	---	---	---	---	122	122
Liquefied gases:								
LRG for fuel use	12,021	889	12,910	259	10,528	1,427	8,814	21,028
LRG for chemical use	4,720	---	4,720	---	2,552	---	816	3,368
Total liquefied gases	16,741	889	17,630	259	13,080	1,427	9,630	24,396
Kerosine [2]	12,180	1,198	13,378	824	17,078	1,534	4,534	23,970
Distillate fuel oil [2]	124,465	12,342	136,807	5,129	135,896	17,687	78,224	236,936
Residual fuel oil	37,703	4,554	42,257	1,821	43,205	5,890	5,830	56,746
Petrochemical feedstocks:								
Still gas	1,490	---	1,490	---	1,347	---	---	1,347
Naphtha—400°	2,523	---	2,523	---	3,526	---	1,824	5,350
Other	860	557	1,417	---	2,665	---	656	3,321
Total petrochemical feedstocks	4,873	557	5,430	---	7,538	---	2,480	10,018
Special naphthas [2]	734	372	1,106	293	3,821	---	1,385	5,499
Lubricants:								
Bright stock	275	1,202	1,477	---	501	---	802	1,303
Neutral	2,261	1,904	4,165	112	3,787	---	3,497	7,396
Other grades	4,143	764	4,907	---	1,811	---	1,317	3,128
Total lubricants	6,679	3,870	10,549	112	6,099	---	5,616	11,827
Wax:								
Microcrystalline	331	252	583	---	37	---	262	299
Fully refined	1,037	44	1,081	14	228	---	256	498
Other	657	280	937	---	141	---	51	192
Total wax [3]	2,025	576	2,601	14	406	---	569	989
Coke [3]	13,429	147	13,576	96	18,173	3,037	8,641	29,947
Asphalt [3]	27,294	1,676	28,970	1,802	29,921	3,807	13,365	48,895
Road oil	---	585	585	---	3,179	245	1,030	4,454
Still gas for fuel	18,612	2,013	20,625	984	31,016	2,725	13,080	47,805
Miscellaneous products [2]	1,785	155	1,940	14	1,275	122	1,325	2,736
Processing gain (−) or loss (+)	−16,612	−27	−16,639	−311	−21,927	−2,078	−10,205	−34,521

See footnotes at end of table.

in the United States, by districts
barrels)

PAD district III						PAD district IV	PAD district V	United States
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	New Mexico	Total	Other Rocky Mt.	West Coast	
141,656	878,486	469,150	52,675	14,209	1,556,176	128,039	462,628	3,363,602
---------	---------	12	---------	---------	12	12,605	142,615	[1] 516,003
141,656	878,486	469,162	52,675	14,209	1,556,188	140,644	605,243	3,879,605
−713	−30,700	−6,856	+1,237	−6	−37,038	+379	+5,762	+34,346
140,943	847,786	462,306	53,912	14,203	1,519,150	141,023	611,005	3,913,951
7,870	19,435	9,362	1,017	538	38,222	3,539	7,352	72,764
14,459	79,212	20,954	843	605	116,073	1,974	15,403	157,492
28	26,554	2,439	2,987	---------	32,008	271	525	34,332
22,357	125,201	32,755	4,847	1,143	186,303	5,784	23,280	264,588
---------	178	480	---------	---------	658	203	2,787	4,213
87,615	436,493	226,029	26,562	8,244	784,943	72,545	275,942	1,995,947
2,415	7,763	6,206	---------	---------	16,384	508	5,994	26,460
90,030	444,256	232,235	26,562	8,244	801,327	73,053	281,936	2,022,407
9,290	21,765	15,091	1,573	1,741	49,460	3,775	28,153	104,748
9,639	45,987	45,266	---------	50	100,942	4,620	56,916	216,952
18,929	67,752	60,357	1,573	1,791	150,402	8,395	85,069	231,700
132	5,512	2,745	---------	---------	8,389	---------	648	9,159
3,096	14,672	11,729	1,085	333	30,915	1,925	8,881	75,659
292	20,774	6,821	185	---------	28,072	23	2,520	38,703
3,388	35,446	18,550	1,270	333	58,987	1,948	11,401	114,362
1,428	41,710	16,548	1,419	142	61,247	1,991	1,152	101,738
24,365	213,560	108,334	12,807	2,646	361,712	34,318	77,090	846,863
4,304	36,053	11,169	2,606	330	54,462	10,183	102,258	265,906
---------	6,308	7	---------	---------	6,315	146	687	9,985
1,627	40,596	2,307	193	---------	44,723	---------	4,793	57,389
2,975	6,094	13,883	249	106	23,307	305	2,632	30,982
4,602	52,998	16,197	442	106	74,345	451	8,112	98,356
1,006	15,572	510	956	---------	18,044	146	3,602	28,397
---------	1,664	640	---------	---------	2,304	27	1,058	6,169
---------	8,484	5,927	517	---------	14,928	237	1,869	28,595
156	16,951	1,024	1,436	---------	19,567	62	2,652	30,316
156	27,099	7,591	1,953	---------	36,799	326	5,579	65,080
92	203	94	---------	---------	389	6	---------	1,277
---------	539	396	---------	---------	935	51	242	2,807
---------	494	103	---------	---------	597	24	215	1,965
92	1,236	593	---------	---------	1,921	81	457	6,049
2,355	17,598	12,874	2,208	148	35,183	2,960	21,202	102,868
6,577	8,192	9,338	6,164	813	31,084	7,943	18,799	135,691
106	84	---------	---------	---------	190	1,978	1,879	9,086
5,561	34,562	15,930	2,443	566	59,062	4,499	28,372	160,363
971	6,468	1,353	27	---------	8,819	53	3,591	17,139
−702	−34,933	−18,783	−1,671	+227	−55,862	−1,315	−14,075	−122,412

Table 35.—Input and output at refineries in

(Thousand

Item	PAD district I			PAD district II				
	East Coast	Appa-lachian No. 1	Total	Appa-lachian No. 2	Ind., Ill., etc.	Minn., Wis., etc.	Okla., Kans., etc.	Total
INPUT 1970 p								
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 p								
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:								
LRG for fuel use	11,964	1,091	13,055	331	12,636	1,386	8,400	22,753
LRG 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
Fully refined	979	87	1,066	14	280	---	257	551
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

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 districts—Continued

barrels)

PAD district III						PAD district IV	PAD district V	United States
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	New Mexico	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

Table 36.—Percentage yields of refined petroleum products from crude oil in the United States [1]

Finished products	1966	1967	1968	1969	1970 p
Gasoline	44.4	44.0	43.9	44.8	45.3
Jet fuel	6.2	7.5	8.3	8.2	7.5
Ethane (including ethylene)	(2)	(2)	(2)	.2	.2
Liquefied gases	3.0	3.1	3.1	2.9	3.0
Kerosine	2.9	2.7	2.7	2.6	2.3
Distillate fuel oil	22.5	22.2	22.1	21.7	22.4
Residual fuel oil	7.6	7.7	7.2	6.8	6.4
Petrochemical feedstocks	2.1	2.4	2.5	2.5	2.5
Special naphthas	.9	.8	.7	.7	.8
Lubricants	1.8	1.8	1.7	1.7	1.6
Wax	.2	.2	.2	.2	.2
Coke	2.5	2.5	2.5	2.6	2.7
Asphalt	3.8	3.5	3.6	3.5	3.6
Road oil	.2	.2	.1	.2	.3
Still gas	3.9	3.9	4.0	4.1	4.1
Miscellaneous	.5	.4	.4	.4	.3
Shortage	−2.5	−2.9	−3.0	−3.1	−3.2
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 months and refining districts

(Thousand barrels)

	1969						1970 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	157,198	533	2,213	20	207,972	156,448	174,626	432	1,936	23	225,564	162,606
February	149,446	487	1,793	12	216,015	143,671	155,296	404	1,240	31	232,916	149,557
March	160,671	491	2,638	25	222,595	157,195	171,404	426	2,146	32	235,189	171,671
April	151,830	459	1,929	17	210,668	166,128	162,272	400	2,086	50	230,370	169,527
May	164,359	481	1,962	116	202,134	175,220	170,382	453	1,873	36	221,338	181,704
June	163,213	439	1,434	65	196,461	170,694	171,992	447	2,200	41	210,152	185,784
July	174,681	469	2,086	71	187,772	185,854	178,072	473	1,862	40	196,863	193,656
August	176,578	476	1,974	153	183,908	182,739	180,639	459	1,949	47	191,722	188,141
September	171,640	449	1,986	98	188,804	169,081	178,516	443	2,008	29	194,622	178,038
October	174,301	464	1,184	53	189,473	175,227	175,670	451	2,317	43	189,906	183,111
November	172,559	483	1,794	30	202,538	161,741	173,331	469	2,349	45	198,925	167,085
December	179,471	514	1,716	43	211,199	172,997	187,999	490	2,354	44	209,255	180,469
Total	1,995,947	5,745	22,709	703	211,199	2,016,995	2,080,199	5,347	24,320	461	209,255	2,111,349
By refining district:												
East Coast	231,200	---	22,112	5	51,070	689,530	219,511	---	24,006	3	51,937	725,638
Appalachian No. 1	20,510	---			5,478		21,554	---			6,031	
Appalachian No. 2	12,086	---			3,190		11,367	---			3,183	
Indiana, Illinois, Kentucky, etc	370,221	---	126	50	33,698	708,062	394,565	---	65	74	34,666	737,223
Minnesota, Wisconsin, etc	39,572	---			7,103		40,521	---			7,341	
Oklahoma, Kansas, etc	188,928	44			18,905		193,171	26			18,314	
Texas Inland	87,615	892			8,280		91,206	864			9,187	
Texas Gulf Coast	436,493	248			27,918		463,284	212			24,249	
Louisiana Gulf Coast	226,029	1,828	---	302	14,165	260,355	244,268	1,728	---	164	14,084	270,537
Arkansas, Louisiana Inland, etc	26,562	2,733			7,517		26,986	2,517			8,799	
New Mexico	8,244	---			842		8,141	---			719	
Rocky Mountain	72,545	---	---	6	7,880	60,964	73,680	---	---	12	6,117	63,868
West Coast	275,942	---	471	340	25,153	298,084	291,945	---	249	208	24,628	314,083
Total	1,995,947	5,745	22,709	703	211,199	2,016,995	2,080,199	5,347	24,320	461	209,255	2,111,349

p Preliminary.

[1] Includes stocks of gasoline at refineries, bulk terminals, and pipelines.

Table 38.—Production (refinery output) and consumption of gasoline (excluding naphtha) in the United States, by States

(Thousand barrels)

State	1968		1969		1970 p	
	Production	Consumption [1]	Production	Consumption [1]	Production	Consumption [1]
Alabama	(2)	34,006	(2)	36,042	(2)	38,155
Alaska	—	2,235	—	2,449	—	2,430
Arizona	—	18,088	—	20,527	—	22,649
Arkansas	13,325	20,935	14,515	22,092	15,257	23,019
California	[3] 272,049	201,477	[3] 281,936	210,903	[3] 297,236	219,693
Colorado	6,993	22,944	6,736	24,445	7,116	26,523
Connecticut	—	26,408	—	27,638	—	29,026
Delaware	(4)	5,776	(4)	6,024	(4)	6,305
District of Columbia	—	5,575	—	5,670	—	5,705
Florida	—	67,320	—	72,790	—	78,761
Georgia	—	48,285	—	52,149	—	55,206
Hawaii	(3)	5,005	(3)	5,254	(3)	5,439
Idaho	—	8,617	—	9,259	—	9,791
Illinois	136,576	99,696	132,838	103,067	152,576	105,323
Indiana	87,559	55,676	95,955	57,922	97,576	60,045
Iowa	—	35,143	—	36,182	—	36,350
Kansas	[5] 95,898	29,114	[5] 98,123	32,619	[5] 98,674	32,816
Kentucky	[6] 22,348	30,953	[6] 24,509	32,641	[6] 26,837	34,373
Louisiana	222,477	33,027	237,515	34,532	253,357	35,763
Maine	—	10,316	—	10,715	—	11,220
Maryland	—	32,945	—	35,238	—	37,626
Massachusetts	—	45,156	—	47,075	—	49,891
Michigan	26,478	91,128	26,560	95,956	26,804	99,619
Minnesota	22,481	41,094	25,719	43,776	25,788	45,412
Mississippi	[2] 6,368	22,417	[2] 6,767	23,905	[2] 6,312	24,952
Missouri	(5)	51,939	(5)	54,567	(5)	57,016
Montana	21,210	9,560	21,397	9,664	22,233	10,125
Nebraska	(5)	18,962	(5)	19,975	(5)	20,225
Nevada	—	6,726	—	7,054	—	7,693
New Hampshire	—	7,213	—	7,723	—	8,295
New Jersey	79,970	62,572	89,418	64,363	84,232	67,510
New Mexico	8,030	12,297	8,244	12,944	8,141	13,431
New York	11,831	138,401	13,686	150,120	14,396	149,777
North Carolina	—	51,502	—	55,183	—	57,650
North Dakota	[7] 14,638	8,698	[7] 13,853	9,109	[7] 14,733	9,060
Ohio	101,510	100,086	104,533	105,053	103,844	109,519
Oklahoma	90,978	33,786	91,460	35,398	94,936	37,490
Oregon	—	22,766	—	23,874	—	25,336
Pennsylvania	[4] 131,756	97,040	[4] 139,813	100,946	[4] 135,396	103,472
Rhode Island	—	7,596	—	7,942	—	8,240
South Carolina	—	25,687	—	27,346	—	29,066
South Dakota	—	9,822	—	9,899	—	10,143
Tennessee	(6)	39,200	(6)	41,806	(6)	43,259
Texas	511,362	153,876	534,286	149,737	562,122	152,226
Utah	20,590	12,810	21,526	14,021	22,158	14,372
Vermont	—	4,555	—	4,772	—	5,115
Virginia	(8)	45,011	(8)	48,020	(8)	50,862
Washington	(3)	33,836	(3)	35,595	(3)	36,721
West Virginia	[8] 8,965	15,120	[8] 9,624	15,603	[8] 7,571	16,526
Wisconsin	(7)	42,017	(7)	44,210	(7)	46,386
Wyoming	20,435	5,514	23,394	5,760	22,616	6,085
Total	1,933,827	2,009,928	2,022,407	2,109,554	2,099,911	2,191,692

p Preliminary.
[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 months and refining districts

(Thousand barrels)

	1969				1970 p			
	Production	Exports	Stocks (end of period)	Domestic demand	Production	Exports	Stocks (end of period)	Domestic demand
By month:								
January	1,494	33	6,492	1,999	1,442	40	6,251	1,344
February	1,651	98	6,535	1,510	1,252	193	5,887	1,423
March	2,693	146	6,602	2,480	1,574	123	5,604	1,734
April	2,002	111	5,969	2,524	1,585	67	5,354	1,768
May	2,218	143	5,543	2,501	1,631	74	5,058	1,853
June	2,363	107	5,347	2,452	1,335	54	4,745	1,594
July	2,641	181	5,303	2,504	2,034	112	5,081	1,586
August	2,515	88	5,466	2,264	1,894	24	4,654	2,297
September	2,205	308	5,448	1,915	1,880	57	4,703	1,774
October	2,346	220	5,562	2,012	1,577	84	4,559	1,637
November	2,228	93	5,824	1,873	1,828	38	5,040	1,309
December	2,104	218	6,193	1,517	1,680	62	5,093	1,565
Total	26,460	1,746	6,193	25,551	19,712	928	5,093	19,884
By refining districts:								
East Coast	831	21	758	6,323	530	29	745	4,265
Appalachian No. 1	-		68		-		74	
Appalachian No. 2	-		2		-		1	
Illinois, Indiana, Kentucky, etc	2,088	20	1,008	5,083	1,705	32	643	4,660
Minnesota, Wisconsin, North Dakota	-		178		-		193	
Oklahoma, Kansas, etc	655		353		439		192	
Texas Inland	2,415		387		2,058		403	
Texas Gulf Coast	7,763		1,293		5,574		797	
Louisiana Gulf Coast	6,206	1,259	855	7,141	3,672	548	789	5,268
Arkansas, Louisiana Inland, etc	-		-		-		-	
New Mexico	-		12		-		4	
Rocky Mountain	508	1	105	748	443	-	79	710
West Coast	5,994	445	1,174	6,256	5,291	319	1,173	4,981
Total	26,460	1,746	6,193	25,551	19,712	928	5,093	19,884

p Preliminary.

Table 40.—Shipments of aviation fuels

(Thousand barrels)

Product and use	Shipments to PAD districts I	II	III	IV	V	U.S. total
1969						
Aviation gasoline:						
For commercial use:						
Airlines	638	327	195	37	266	1,463
Factory	85	62	38	1	20	206
General aviation	2,581	2,556	1,639	376	1,898	9,050
Total	3,304	2,945	1,872	414	2,184	10,719
For military use	3,934	1,427	5,556	304	3,893	15,114
Jet fuel:						
For commercial use:						
Airlines	83,613	49,504	19,009	6,253	68,898	227,277
Factory	1,606	717	325	------	1,052	3,700
General aviation	3,759	1,803	923	757	1,114	8,356
Total	88,978	52,024	20,257	7,010	71,064	239,333
For military use:						
JP-4	[1] 28,868	16,904	22,537	3,688	[2] 36,872	108,869
JP-5	5,204	60	4,982	------	6,926	17,172
Other	177	162	467	------	379	1,185
Total	34,249	17,126	27,986	3,688	44,177	127,226
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	[3] 20,840	15,290	15,254	2,516	[4] 32,745	86,645
JP-5	6,723	77	3,843	------	7,368	18,011
Other	232	65	540	30	461	1,328
Total	27,795	15,432	19,637	2,546	40,574	105,984

[1] Excludes 93,000 barrels imported directly by the military.
[2] Excludes 1,013,000 barrels imported directly by the military.
[3] Excludes 3,143,000 barrels imported directly by the military.
[4] Excludes 960,000 barrels imported directly by the military.

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, international air carriers (if delivery is made in the United States) and to such other air carriers as supplemental or nonscheduled carriers, air taxis, 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 U.S. Government.

Table 41.—Salient statistics of kerosine in the United States, by months and districts

(Thousand barrels unless otherwise stated)

	1969							1970 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	11,148	3.6	105	111	11	19,355	15,478	10,134	3.0	86	25	3	20,398	16,624
February	10,932	3.6	86	76	5	18,586	11,858	9,052	2.9	71	183	16	17,956	11,732
March	10,287	3.1	88	171	15	18,909	10,208	9,372	2.8	80	48	20	18,499	8,937
April	7,162	2.3	86	---	22	20,330	5,805	7,429	2.3	72	160	12	20,785	5,363
May	7,015	2.2	89	106	23	21,989	5,528	6,966	2.1	77	78	10	22,851	5,045
June	7,769	2.4	92	---	14	25,331	4,505	7,344	2.2	79	299	8	26,254	4,311
July	7,442	2.2	105	56	6	27,289	5,639	6,160	1.8	111	264	17	27,749	5,023
August	7,516	2.2	96	---	5	29,735	5,161	6,436	1.9	100	161	6	29,592	4,848
September	7,317	2.2	98	243	17	30,106	7,270	6,143	1.8	97	3	5	30,295	5,535
October	7,493	2.3	93	34	7	30,631	7,088	8,063	2.4	105	41	11	31,012	7,481
November	7,936	2.4	86	55	22	29,429	9,257	9,127	2.7	101	14	9	31,517	8,728
December	9,721	2.8	97	113	8	26,780	12,572	8,409	2.4	98	175	4	27,848	12,347
Total	101,738	2.6	1,121	965	155	26,780	100,369	94,635	2.3	1,077	1,451	121	27,848	95,974
By refining district:														
East Coast	12,180	2.5	-----	960	14	10,696	47,321	11,273	2.4	-----	1,349	10	11,223	45,715
Appalachian No. 1	1,198	2.4	-----			592		1,143	2.2	-----			628	
Appalachian No. 2	824	3.6	-----			358		879	4.0	-----			385	
Indiana, Illinois, Kentucky, etc.	17,078	2.5	-----	---	8	4,358	30,466	17,488	2.4	-----	-----	5	4,866	30,632
Minnesota, Wisconsin, etc.	1,534	2.1	-----			1,132		1,779	2.4	-----			1,046	
Oklahoma, Kansas, etc.	4,534	1.4	-----			1,434		3,419	1.1	-----			776	
Texas Inland	1,428	1.0	199			232		1,501	1.1	223			242	
Texas Gulf Coast	41,710	4.9	56			3,950		32,097	3.7	47			4,045	
Louisiana Gulf Coast	16,548	3.6	256	---	87	2,394	19,721	19,756	4.1	183	-----	68	2,612	15,780
Arkansas, Louisiana Inland, etc.	1,419	2.6	575			926		1,361	2.4	592			1,195	
New Mexico	142	1.0	35			28		110	0.7	32			26	
Rocky Mountain	1,991	1.4	-----	5	---	372	1,838	2,042	1.4	-----	-----	---	380	2,019
West Coast	1,152	.2	-----	---	46	308	1,023	1,787	.3	-----	102	38	424	1,828
Total	101,738	2.6	1,121	965	155	26,780	100,369	94,635	2.3	1,077	1,451	121	27,848	95,974

p Preliminary.

Table 42.—Salient statistics of distillate fuel oil in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1969								1970 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	69,232	22.4	139	55	7,341	70	130,609	119,246	79,353	23.4	133	59	6,686	29	130,726	127,190
February	66,279	22.1	120	53	5,973	92	106,650	96,292	71,762	23.2	117	55	5,707	69	111,523	96,775
March	73,879	22.6	138	60	7,033	120	96,563	91,077	77,541	23.0	121	67	7,581	74	100,983	95,776
April	66,580	21.6	121	54	3,523	45	99,826	66,970	70,674	22.3	117	61	4,550	133	102,061	74,191
May	67,165	20.7	135	50	2,613	125	110,925	58,739	70,658	21.7	127	55	3,384	105	115,846	60,334
June	71,137	21.6	134	52	2,221	143	132,650	51,676	72,165	21.9	130	85	1,872	18	137,506	52,574
July	73,465	21.3	129	54	2,826	95	159,081	49,948	73,391	21.6	130	46	2,840	175	163,469	50,269
August	70,838	20.7	133	54	4,296	38	183,515	50,849	74,704	21.7	114	57	2,762	47	188,169	52,890
September	68,811	21.0	112	53	3,472	119	197,653	58,191	73,270	21.6	105	65	2,777	67	205,674	58,645
October	70,365	21.4	119	57	2,297	119	207,986	62,386	76,586	22.7	107	67	3,986	112	216,386	69,922
November	72,379	22.1	132	56	3,403	75	200,969	82,912	75,145	22.6	116	68	5,095	36	218,138	78,636
December	76,733	22.2	129	56	5,885	82	171,714	111,976	80,407	22.6	124	58	6,663	71	[2] 195,271	110,048
Total	846,863	21.7	1,541	654	50,883	1,123	171,714	900,262	895,656	22.4	1,441	743	53,903	936	[2] 195,271	927,250
By refining district:																
East Coast	124,465	25.2	-----	-----	47,720	96	68,969	460,055	127,280	26.9	-----	-----	49,410	24	84,356	473,483
Appalachian No. 1	12,342	24.4	-----				3,597		12,938	24.4	-----				3,886	
Appalachian No. 2	5,129	22.3	-----				2,052		5,523	25.0	-----				2,448	
Indiana, Illinois, Kentucky, etc	135,896	20.0	-----	386	1,264	9	23,011	265,204	152,920	21.0	-----	475	2,223	5	30,817	
Minnesota, Wisconsin, etc	17,687	24.4	-----				8,168		18,630	25.5	-----				8,926	273,629
Oklahoma, Kansas, etc	78,224	24.2	-----				12,578		77,962	23.8	-----				15,187	
Texas Inland	24,365	17.3	165				2,047		25,787	17.9	163				1,724	
Texas Gulf Coast	213,560	25.2	119				20,516		228,836	26.4	117				20,183	
Louisiana Gulf Coast	108,334	23.4	395	197	937	231	8,064	64,349	120,587	25.0	409	197	1,192	141	8,409	69,570
Arkansas, Louisiana Inland, etc	12,807	23.8	862				5,118		14,239	25.1	752				3,458	
New Mexico	2,646	18.6	-----				250		2,897	19.5	-----				375	
Rocky Mountain	34,318	24.3	-----	71	------	3	3,216	26,108	34,587	24.2	-----	71	------	2	2,631	25,790
West Coast	77,090	12.6	-----	-----	962	784	14,128	84,546	73,470	11.9	-----	-----	1,078	764	12,871	84,778
Total	846,863	21.7	1,541	654	50,883	1,123	171,714	900,262	895,656	22.4	1,441	743	53,903	936	[2] 195,271	927,250

p Preliminary.
[1] Figures represent crude oil used as fuel on pipelines, which is considered part of the demand for distillate.
[2] Includes No. 4 fuel oil, in thousand barrels; PAD districts I, 3,855; II, 145; III, 273; IV, 3.

Table 43.—Salient statistics of residual fuel oil in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1969							1970 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	27,873	9.0	371	51,384	1,669	60,957	82,361	25,963	7.7	378	55,998	1,474	49,544	89,716
February	25,126	8.4	425	41,230	1,687	57,930	68,121	23,947	7.7	333	56,529	2,116	46,068	82,169
March	25,336	7.7	349	41,374	1,845	55,188	67,956	23,639	7.0	479	58,488	1,103	40,320	87,251
April	23,595	7.7	365	38,834	1,134	58,213	58,635	19,829	6.3	355	47,304	1,375	42,791	63,642
May	21,239	6.6	345	34,220	1,549	60,570	51,898	17,676	5.4	442	36,825	1,794	44,664	51,276
June	19,403	5.9	345	29,094	1,423	60,511	47,478	17,020	5.2	341	43,581	1,349	46,036	58,221
July	19,493	5.7	353	32,289	1,098	63,144	48,404	17,688	5.2	372	44,686	1,730	47,886	59,166
August	19,250	5.6	363	34,105	1,492	64,062	51,308	20,670	6.0	375	41,659	1,223	48,141	61,226
September	19,536	6.0	377	35,100	988	63,593	54,494	19,868	5.9	292	39,119	2,812	53,954	50,654
October	19,543	6.0	361	39,001	1,641	62,225	58,632	20,044	5.9	315	42,927	1,246	57,130	58,864
November	21,439	6.5	334	33,751	1,550	60,665	55,534	22,230	6.7	344	41,777	952	58,823	61,706
December	24,073	7.0	346	51,229	815	58,395	77,103	28,936	8.1	291	48,952	2,612	53,994	80,396
Total	265,906	6.8	4,334	461,611	16,891	[2] 58,395	721,924	257,510	6.4	4,317	557,845	19,786	53,994	804,287
By refining district:														
East Coast	37,703	7.6	------	440,983	1,080	20,780	512,360	30,650	6.5	------	536,968	872	23,666	596,834
Appalachian No. 1	4,554	9.0				332		4,409	8.4				470	
Appalachian No. 2	1,821	7.9				152		1,868	8.4				44	
Indiana, Illinois, Kentucky, etc	43,205	6.4	578	627	1,027	4,483	64,673	47,586	6.6	579	4,207	317	6,520	72,586
Minnesota, Wisconsin, etc	5,890	8.1				675		7,023	9.7				980	
Oklahoma, Kansas, etc	5,830	1.8				988		6,362	1.9				1,262	
Texas Inland	4,304	3.1				187		4,308	3.0				200	
Texas Gulf Coast	36,053	4.3				3,747		36,925	4.3				4,086	
Louisiana Gulf Coast	11,169	2.4	1,785	12,167	5,027	1,256	30,023	15,599	3.3	1,785	11,029	4,211	1,619	31,688
Arkansas, Louisiana Inland, etc	2,606	4.8				145		3,101	5.5				210	
New Mexico	330	2.3				21		409	2.8				4	
Rocky Mountain	10,183	7.2	252	78	10	443	12,442	9,100	6.3	252	52	-------	515	9,195
West Coast	102,258	16.7	1,719	7,756	9,747	25,186	102,426	90,170	14.5	1,701	5,589	14,386	14,418	93,984
Total	265,906	6.8	4,334	461,611	16,891	[2] 58,395	721,924	257,510	6.4	4,317	557,845	19,786	53,994	804,287

p Preliminary.
[1] Represents crude oil used as fuel on leases and for general industrial purposes.
[2] New basis. Excludes 2,000,000 barrels of pitch which were previously included in refinery stocks of residual fuel oil in the Texas Inland refining district during 1969 and preceding years.

Table 44.—Salient statistics of jet fuel in the United States, by months and refining districts

(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
1969															
By month:															
January	7,781	16,704	24,485	454	2,667	3,121	1	------	1	8,738	14,176	22,914	8,400	20,568	28,968
February	8,077	17,286	25,363	590	2,761	3,351	296	------	296	8,840	16,094	24,934	8,269	18,129	26,398
March	10,079	16,748	26,827	821	3,830	4,651	89	------	89	8,445	17,123	25,568	11,206	19,549	30,755
April	9,161	18,299	27,460	190	2,620	2,810	166	------	166	8,520	18,268	26,788	9,110	19,774	28,884
May	9,729	18,083	27,812	602	3,135	3,737	101	------	101	8,654	19,663	28,317	10,096	19,823	29,919
June	10,012	18,187	28,199	267	3,470	3,737	177	------	177	8,896	19,515	28,411	9,860	21,805	31,665
July	10,709	18,535	29,244	259	3,869	4,128	66	------	66	9,320	20,536	29,856	10,478	21,383	31,861
August	9,092	18,516	27,608	505	3,714	4,219	64	------	64	8,880	21,347	30,227	9,973	21,419	31,392
September	7,950	17,149	25,099	726	4,211	4,937	323	------	323	8,863	20,003	28,866	8,370	22,704	31,074
October	7,617	18,635	26,252	186	2,336	2,522	221	------	221	9,152	20,141	29,293	7,293	20,833	28,126
November	7,176	18,448	25,624	256	4,041	4,297	139	------	139	9,058	20,473	29,531	7,387	22,157	29,544
December	7,383	20,362	27,745	278	3,751	4,029	87	------	87	8,556	19,517	28,073	8,076	25,069	33,145
Total	104,766	216,952	321,718	5,134	40,405	45,539	1,730	------	1,730	[2] 8,556	19,517	28,073	108,518	253,213	361,731
By refining district:															
East Coast	5,104	11,716	16,820	1,976	23,031	25,007	3	------	3	686	3,890	4,576	28,771	101,876	130,647
Appalachian No. 1	722	573	1,295							45	333	378			
Appalachian No. 2	-------	22	22							73	190	263			
Indiana, Illinois, Kentucky, etc	7,234	30,144	37,378							700	3,155	3,855			
Minnesota, Wisconsin,				------	1,771	1,771	------	------	------				16,863	53,228	70,091
North and South Dakota	1,028	1,464	2,492							127	703	830			
Oklahoma, Kansas, Missouri, etc	9,272	10,555	19,827							993	967	1,960			
Texas Inland	9,290	9,639	18,929							442	967	1,409			
Texas Gulf Coast	21,765	45,987	67,752							1,437	2,233	3,670			
Louisiana Gulf Coast	15,091	45,266	60,357	------	478	478	244	------	244	840	970	1,810	22,239	13,578	35,817
Arkansas, Louisiana Inland, etc	1,591	-------	1,591							529	477	1,006			
New Mexico	1,741	50	1,791							178	123	301			
Rocky Mountain	3,775	4,620	8,395	------	------	------	------	------	------	328	421	749	2,667	6,223	8,890
West Coast	28,153	56,916	85,069	3,158	15,125	18,283	1,483	------	1,483	2,178	5,088	7,266	37,978	78,308	116,286
Total	104,766	216,952	321,718	5,134	40,405	45,539	1,730	------	1,730	[2] 8,556	19,517	28,073	108,518	253,213	361,731
1970 p															
By month:															
January	6,131	17,733	23,864	531	3,743	4,274	279	------	279	8,221	18,877	27,098	6,718	22,116	28,834
February	6,678	17,358	24,036	417	3,764	4,181	201	------	201	7,962	18,471	26,433	7,153	21,528	28,681
March	6,635	19,718	26,353	89	2,732	2,821	245	------	245	7,361	19,839	27,200	7,080	21,082	28,162
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	4,338	4,925	102	------	102	7,881	22,726	30,607	7,937	22,894	30,831
September	7,499	18,447	25,946	430	4,432	4,862	149	------	149	7,771	22,444	30,215	7,890	23,161	31,051
October	7,103	18,921	26,024	1,225	3,531	4,756	166	------	166	7,409	23,386	30,795	8,524	21,510	30,034
November	7,426	17,168	24,594	512	2,965	3,477	85	------	85	7,838	22,288	30,126	7,424	21,231	28,655
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	7,060	44,992	52,052	2,167	------	2,167	6,621	20,989	27,610	90,909	261,352	352,261
By refining district:															
East Coast	2,606	11,108	13,714	4,493	25,382	29,875	5	------	5	294	4,370	4,664	24,228	103,358	127,586
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				------	1,988	1,988	1	------	1				15,663	54,809	70,472
Dakota	764	1,028	1,792							156	731	887			
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	75	------	75	642	903	1,545	15,517	18,583	34,100
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	301,913	7,060	44,992	52,052	2,167	------	2,167	6,621	20,989	27,610	90,909	261,352	352,261

p Preliminary.
[1] Includes naphtha-type jet fuel produced at natural gas processing plants: Arkansas, Louisiana Inland, etc., 1969: 18; 1970: 21.
[2] Includes naphtha-type jet fuel stored at natural gas processing plants: Arkansas, Louisiana Inland, etc., 1969: 19; 1970: 3.

Table 45.—Salient statistics of lubricants in the United States, by months and refining districts

(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	
1969												
By month:												
January	361	2,421	1,924	4,706	1.5	2	1,165	1,395	4,432	8,034	13,861	3,705
February	504	1,849	2,078	4,431	1.5	2	807	1,504	4,178	8,142	13,824	3,663
March	564	2,483	2,570	5,617	1.7	2	1,408	1,523	4,189	8,307	14,019	4,016
April	503	2,612	2,376	5,491	1.8	3	1,442	1,407	4,134	8,377	13,918	4,153
May	522	2,779	2,376	5,677	1.8	2	1,741	1,301	4,034	8,118	13,453	4,403
June	518	2,163	2,590	5,271	1.6	65	1,915	1,352	3,567	7,865	12,784	4,090
July	630	2,102	2,782	5,514	1.6	2	1,135	1,372	3,597	7,865	12,834	4,331
August	431	2,279	3,062	5,772	1.7	2	1,674	1,194	3,404	8,201	12,799	4,135
September	463	2,202	2,714	5,379	1.6	44	1,459	1,189	3,386	8,104	12,679	4,084
October	451	2,390	2,812	5,653	1.7	1	1,219	1,081	3,486	7,928	12,495	4,619
November	611	2,726	2,486	5,823	1.8	33	1,058	1,277	4,103	8,237	13,617	3,676
December	611	2,589	2,546	5,746	1.7	5	1,373	1,347	4,520	8,221	14,088	3,907
Total	6,169	28,595	30,316	65,080	1.7	163	16,396	1,347	4,520	8,221	14,088	48,782
By refining district:												
East Coast	275	2,261	4,143	6,679	1.4	18	4,049	121	672	2,648	3,441	19,181
Appalachian No. 1	1,202	1,904	764	3,870	7.6			198	291	419	908	
Appalachian No. 2	----	112	----	112	.5			----	61	74	135	
Indiana, Illinois, Kentucky, etc	501	3,787	1,811	6,099	.9	4	725	88	620	998	1,706	13,907
Minnesota, Wisconsin, etc	----	----	----	----	----			----	----	46	46	
Oklahoma, Kansas, etc	802	3,497	1,317	5,616	1.7			108	597	191	896	
Texas Inland	----	----	156	156	.1			----	----	40	40	
Texas Gulf Coast	1,664	8,484	16,951	27,099	3.2			234	1,210	2,400	3,844	
Louisiana Gulf Coast	640	5,927	1,024	7,591	1.6	141	10,289	76	785	312	1,173	10,495
Arkansas, Louisiana Inland, etc	----	517	1,436	1,953	3.6			----	44	334	378	
New Mexico	----	----	----	----	----			----	----	5	5	
Rocky Mountain	27	237	62	326	.2	----	6	3	38	35	76	428
West Coast	1,058	1,869	2,652	5,579	.9	----	1,327	519	202	719	1,440	4,771
Total	6,169	28,595	30,316	65,080	1.7	163	16,396	1,347	4,520	8,221	14,088	48,782
1970 p												
By month:												
January	563	2,416	2,503	5,482	1.6	48	1,267	1,408	4,684	8,200	14,292	4,059
February	575	1,966	2,195	4,736	1.5	2	1,145	1,492	4,561	8,403	14,456	3,429
March	713	2,271	2,473	5,457	1.6	1	1,721	1,426	4,423	8,256	14,105	4,088
April	672	2,354	2,423	5,449	1.7	1	1,299	1,494	4,479	7,836	13,809	4,447
May	556	2,424	2,620	5,600	1.7	1	1,308	1,629	4,530	7,968	14,127	3,975
June	605	2,298	2,439	5,342	1.6	1	1,171	1,597	4,370	7,673	13,640	4,659
July	608	2,444	2,424	5,476	1.6	88	1,726	1,422	4,131	7,721	13,274	4,204
August	722	2,615	2,345	5,682	1.6	----	1,202	1,471	4,422	7,817	13,710	4,044
September	594	2,431	2,604	5,629	1.6	37	1,102	1,474	4,382	8,158	14,014	4,260
October	738	2,453	2,415	5,606	1.7	44	1,543	1,467	4,254	7,923	13,644	4,477
November	611	2,517	2,675	5,803	1.7	1	1,149	1,194	4,545	8,498	14,237	4,062

December	590	2,584	2,747	5,921	1.7	--------	1,417	1,233	4,555	8,924	14,712	4,029
Total	7,547	28,773	29,863	66,183	1.6	224	16,050	1,233	4,555	8,924	14,712	49,733
By refining district:												
East Coast	608	3,393	3,464	7,465	1.6	15	3,983	155	599	2,652	3,406	19,288
Appalachian No. 1	1,168	1,976	673	3,817	7.2			156	272	538	966	
Appalachian No. 2	-------	17	--------	17	0.1			--------	45	81	126	
Indiana, Illinois, Kentucky, etc	553	2,390	3,405	6,348	.9	3	539	96	638	1,049	1,783	13,889
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	10,495	38	680	290	1,008	11,208
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	--------	1,026	274	325	1,043	1,642	4,880
Total	7,547	28,773	29,863	66,183	1.6	224	16,050	1,233	4,555	8,924	14,712	49,733

p Preliminary.

Table 46.—Salient statistics of liquefied gases (excluding ethane) in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

	1969								1970 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	8,302	2.7	26,716	1,600	1,058	7,102	56,264	46,142	9,819	2.9	27,952	1,704	1,044	7,711	40,273	47,867
February	8,418	2.8	25,181	1,194	1,187	5,765	50,476	33,629	9,457	3.1	26,099	1,719	667	6,706	34,962	35,213
March	9,643	3.0	27,455	1,004	1,416	5,180	49,764	32,218	9,683	2.9	28,568	1,564	1,005	6,357	35,514	31,901
April	9,562	3.1	25,993	783	741	4,328	55,082	25,951	9,697	3.1	27,100	1,274	1,011	5,561	41,217	25,796
May	10,101	3.1	26,622	547	789	4,903	63,549	23,111	10,087	3.1	27,939	934	630	5,105	52,380	22,062
June	10,018	3.0	25,196	656	706	4,605	70,349	23,759	9,739	2.9	26,250	767	729	5,283	60,883	22,241
July	10,603	3.1	25,318	661	1,227	4,733	76,337	24,634	10,427	3.0	26,106	854	832	5,821	67,637	23,980
August	10,363	3.0	25,694	621	1,341	5,078	80,574	26,022	9,734	2.9	26,163	1,124	771	5,602	74,176	24,109
September	9,500	2.9	25,360	901	1,144	5,934	81,842	27,415	9,329	2.8	25,910	1,320	725	6,107	78,712	25,191
October	9,358	2.8	27,007	1,373	1,105	7,698	77,864	32,913	9,297	2.8	27,467	2,125	766	7,799	78,285	30,751
November	9,146	2.8	26,646	1,403	983	8,139	69,414	36,523	9,447	2.9	27,604	2,523	715	8,399	73,286	35,459
December	9,348	2.7	28,242	1,908	1,100	9,299	57,420	41,093	9,811	2.8	29,019	3,253	755	9,856	65,724	39,034
Total	114,362	2.9	315,430	12,651	12,797	72,764	57,420	373,410	116,527	3.0	326,177	19,161	9,650	80,307	65,724	363,604
By refining district:																
East Coast	16,741	3.4	4,179	559	25	2,449	4,623	43,029	15,794	3.3	4,774	2,124	13	2,155	5,616	45,477
Appalachian No. 1	889	1.7				9			1,091	2.1				12		
Appalachian No. 2	259	1.1				127			331	1.4				60		
Indiana, Illinois, Kentucky, etc	13,080	1.9	55,114	4,291	817	8,773	20,067	103,199	15,619	2.1	55,632	8,383	295	10,838	21,712	104,037
Minnesota, Wisconsin, etc	1,427	2.0				2,903			1,386	1.9				3,038		
Oklahoma, Kansas, etc	9,630	3.0				9,390			9,151	2.8				11,808		
Texas Inland	3,388	2.4				7,870			3,649	2.5				8,638		
Texas Gulf Coast	35,446	4.2				19,435			31,685	3.7				20,981		
Louisiana Gulf Coast	18,550	4.0	239,569	------	10,762	9,362	31,103	200,586	20,656	4.2	250,429	412	8,053	11,796	37,311	185,264
Arkansas, Louisiana Inland, etc	1,270	2.4				1,017			1,348	2.3				804		
New Mexico	333	2.4				538			534	3.6				717		
Rocky Mountain	1,948	1.4	8,260	2,896	------	3,539	462	4,324	2,291	1.6	8,291	3,130	------	3,562	372	4,620
West Coast	11,401	1.9	8,308	4,905	1,193	7,352	1,165	22,272	12,992	2.0	7,051	5,112	1,289	5,898	713	24,206
Total	114,362	2.9	315,430	12,651	12,797	72,764	57,420	373,410	116,527	3.0	326,177	19,161	9,650	80,307	65,724	363,604

p Preliminary.

Table 47.—Salient statistics of ethane (including ethylene) in the United States, by months and refining districts

(Thousand barrels)

	1969					1970 p				
	At gas processing plants	Production at refineries	Total	Total stocks (end of period)	Domestic demand	At gas processing plants	Production at refineries	Total	Total stocks (end of period)	Domestic demand
By month:										
January	5,081	782	5,863	2,121	5,954	5,953	904	6,857	2,110	6,929
February	4,641	679	5,320	2,018	5,423	5,510	798	6,308	1,998	6,420
March	5,033	881	5,914	1,924	6,008	6,186	895	7,081	2,117	6,962
April	5,119	683	5,802	2,123	5,603	5,757	758	6,515	2,265	6,367
May	5,265	732	5,997	2,099	6,021	6,138	763	6,901	2,249	6,917
June	4,898	699	5,597	2,116	5,580	5,797	817	6,614	2,303	6,560
July	5,105	723	5,828	2,188	5,756	6,151	820	6,971	2,355	6,919
August	5,251	773	6,024	1,869	6,343	6,165	727	6,892	2,179	7,068
September	5,054	757	5,811	1,803	5,877	6,085	800	6,885	1,925	7,139
October	5,600	805	6,405	2,061	6,147	6,551	774	7,325	1,516	7,734
November	5,744	798	6,542	2,099	6,504	6,457	674	7,131	1,360	7,287
December	6,236	847	7,083	2,182	7,000	6,684	730	7,414	1,319	7,455
Total	63,027	9,159	72,186	2,182	72,216	73,434	9,460	82,894	1,319	83,757
By refining district:										
East Coast	-------	-------	-------	} -------	734	-------	-------	-------	} -------	1,931
Appalachian No. 1	734	-------	734			1,931	-------	1,931		
Appalachian No. 2	-------	-------	-------			-------	-------	-------		
Indiana, Illinois, Kentucky, etc	8,121	-------	8,121	} 418	8,596	7,761	-------	7,761	} 582	9,793
Minnesota, Wisconsin, etc	-------	-------	-------			-------	-------	-------		
Oklahoma, Kansas, etc	454	122	576			1,881	316	2,197		
Texas Inland	21,144	132	21,276			23,518	102	23,620		
Texas Gulf Coast	12,647	5,512	18,159			14,365	5,283	19,648		
Louisiana Gulf Coast	16,917	2,745	19,662	} 1,764	62,238	20,276	3,130	23,406	} 737	71,403
Arkansas, Louisiana Inland, etc	1,117	-------	1,117			1,484	-------	1,484		
New Mexico	1,893	-------	1,893			2,218	-------	2,218		
Rocky Mountain	-------	-------	-------	-------	-------	-------	-------	-------	-------	1
West Coast	-------	648	648	-------	648	-------	629	629	-------	629
Total	63,027	9,159	72,186	2,182	72,216	73,434	9,460	82,894	1,319	83,757

p Preliminary.

Table 48.—Salient statistics of petrochemical feedstocks [1] in the United States, by months and refining districts

(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	
1969										
By month:										
January	747	4,768	2,187	7,702	--------	536	1,818	1,278	3,096	7,015
February	711	4,253	2,292	7,256	--------	355	1,799	990	2,789	7,208
March	909	5,175	2,403	8,487	--------	338	1,566	1,210	2,776	8,162
April	791	4,279	2,389	7,459	--------	282	1,293	1,117	2,410	7,543
May	789	4,810	2,503	8,102	--------	423	1,453	1,096	2,549	7,540
June	877	4,779	2,649	8,305	--------	261	1,527	1,076	2,608	7,990
July	864	4,416	2,806	8,086	--------	155	1,603	1,245	2,848	7,686
August	995	5,174	2,647	8,816	--------	297	1,385	1,351	2,736	8,631
September	794	4,961	2,394	8,149	40	349	1,726	1,349	3,075	7,501
October	895	5,164	3,046	9,105	--------	369	1,588	1,507	3,095	8,716
November	794	4,636	2,781	8,211	--------	233	1,457	1,604	3,061	8,012
December	819	4,974	2,885	8,678	--------	250	1,331	1,514	2,845	8,644
Total	9,985	57,389	30,982	98,356	40	3,848	1,331	1,514	2,845	94,648
By refining district:										
East Coast	1,490	2,523	860	4,873	-------		-------	9	9	9,750
Appalachian No. 1	-------	--------	557	557			-------	11	11	
Appalachian No. 2	-------	--------	--------	--------			-------	--------	--------	
Indiana, Illinois, Kentucky, etc	1,347	3,526	2,665	7,538	-------		113	202	315	11,702
Minnesota, Wisconsin, etc	-------	--------	--------	--------			-------	--------	--------	
Oklahoma, Kansas, etc	-------	1,824	656	2,480		1,682	42	23	65	
Texas Inland	-------	1,627	2,975	4,602			5	317	322	
Texas Gulf Coast	6,308	40,596	6,094	52,998			813	616	1,429	
Louisiana Gulf Coast	7	2,307	13,883	16,197	40		-------	325	325	66,478
Arkansas, Louisiana Inland, etc	-------	193	249	442			4	--------	4	
New Mexico	-------	--------	106	106			-------	--------	--------	
Rocky Mountain	146	--------	305	451	--------		-------	11	11	369
West Coast	687	4,793	2,632	8,112	--------	2,166	354	--------	354	6,349
Total	9,985	57,389	30,982	98,356	40	3,848	1,331	1,514	2,845	94,648
1970 p										
By month:										
January	850	4,844	2,623	8,317	365	297	1,892	1,624	3,516	7,714
February	825	5,053	2,617	8,495	415	191	1,820	1,615	3,435	8,800
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	8,753
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	8,724
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	8,191
October	1,131	4,432	2,742	8,305	559	255	1,801	1,894	3,695	8,456

November	968	4,361	2,724	8,053	565	259	1,901	1,832	3,733	8,321
December	1,294	4,925	2,841	9,060	401	356	1,856	1,763	3,619	9,219
Total	12,564	54,154	33,663	100,381	5,195	3,776	1,856	1,763	3,619	101,026
By refining district:										
East Coast	1,764	2,249	610	4,623	-------		-------	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	-------		229	195	424	12,567
Minnesota, Wisconsin, etc	-------	-------	-------	-------			-------	-------	-------	
Oklahoma, Kansas, etc	50	2,204	507	2,761		1,863	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	5,195		-------	310	310	74,682
Arkansas, Louisiana Inland, etc	-------	5	234	239			-------	5	5	
New Mexico	-------	-------	-------	-------			-------	-------	-------	
Rocky Mountain	135	-------	214	349	-------		-------	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	5,195	3,776	1,856	1,763	3,619	101,026

[p] Preliminary.
[1] Produced at petroleum refineries (excluding ethane and liquefied gases).

Table 49.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons) [1]

	1966	1967	1968	1969	1970 [p]
Petroleum asphalt:					
Production	23,560	23,230	24,629	24,671	26,665
Imports (including natural)	1,110	1,172	1,134	866	1,127
Exports	87	77	78	84	65
Stocks (end of period)	3,147	3,265	3,646	3,046	2,869
Apparent domestic consumption	24,377	23,847	25,664	26,053	27,904
Petroleum asphalt shipments:					
Paving	19,648	18,867	20,690	21,333	23,787
Roofing	3,992	3,967	4,767	4,080	3,806
All other	2,798	2,969	2,922	2,743	2,865
Total	26,438	25,803	28,379	28,156	30,458
Road oil:					
Production	1,318	1,269	1,241	1,652	1,708
Stocks (end of period)	167	146	100	160	115
Apparent domestic consumption	1,257	1,290	1,287	1,592	1,753
Road oil shipments	1,045	1,033	1,025	1,116	1,753

[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 months and refining districts

(Thousand short tons) [1]

	1969					1970 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	1,005	46	4	3,987	708	1,235	69	3	3,548	798
February	1,126	61	6	4,429	738	1,217	23	4	3,925	859
March	1,541	32	4	4,970	1,027	1,691	29	4	4,505	1,137
April	1,861	33	4	5,172	1,688	1,968	38	9	4,683	1,820
May	2,352	86	9	5,146	2,455	2,363	82	6	4,529	2,593
June	2,609	84	9	4,746	3,084	2,628	142	5	3,880	3,414
July	2,755	104	11	4,247	3,348	2,922	223	4	3,144	3,876
August	2,714	73	11	3,546	3,477	3,008	137	4	2,539	3,746
September	2,742	134	10	2,928	3,483	2,831	164	7	2,117	3,411
October	2,448	64	6	2,396	3,038	2,724	85	9	2,026	2,891
November	1,885	54	6	2,546	1,783	2,235	76	5	2,395	1,936
December	1,633	95	4	3,046	1,224	1,843	59	5	2,869	1,423
Total	24,671	866	84	3,046	26,053	26,665	1,127	65	2,869	27,904
By refining district:										
East Coast	4,962	798	17	805	7,209	5,428	1,092	18	663	7,854
Appalachian No. 1	305			86		372			85	
Appalachian No. 2	328			88		277			73	
Illinois, Indiana, Kentucky, etc	5,440	27	13	521	9,551	5,554	35	4	473	9,810
Minnesota, Wisconsin, North Dakota	692			63		811			149	
Oklahoma, Kansas, etc	2,430			304		2,669			275	
Texas Inland	1,196			95		1,310			97	
Texas Gulf Coast	1,489			113		1,643			77	
Louisiana Gulf Coast	1,698	41	24	157	4,383	2,207	--------	14	184	5,251
Arkansas, Louisiana Inland, etc	1,121			140		1,205			119	
New Mexico	148			34		178			40	
Rocky Mountain	1,444	--------	5	269	1,480	1,607	--------	2	222	1,669
West Coast	3,418	--------	25	371	3,430	3,404	--------	27	412	3,320
Total	24,671	866	84	3,046	26,053	26,665	1,127	65	2,869	27,904

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]

	1969			1970 p		
	Production	Stocks (end of period)	Domestic demand	Production	Stocks (end of peirod)	Domestic demand
By month:						
January	47,273	124,727	22,546	23,636	139,818	43,818
February	30,909	147,091	8,545	41,455	161,818	19,455
March	91,273	214,546	23,818	90,545	217,454	34,909
April	66,182	232,545	48,183	105,636	250,363	72,727
May	142,182	254,182	120,545	202,364	287,273	165,454
June	200,909	256,546	198,545	226,545	275,818	238,000
July	233,091	236,727	252,910	299,091	233,273	341,636
August	329,818	259,273	307,272	278,727	195,818	316,182
September	219,818	210,364	268,727	186,182	140,364	241,636
October	162,727	170,545	202,546	130,727	101,273	169,818
November	78,545	157,818	91,272	77,454	100,727	78,000
December	49,273	160,000	47,091	45,455	114,909	31,273
Total	1,652,000	160,000	1,592,000	1,707,817	114,909	1,752,908
By refining district:						
East Coast	---	---	105,818	---	---	123,454
Appalachian No. 1	106,364	2,909		121,636	1,091	
Appalachian No. 2	---	---		---	---	
Indiana, Illinois, Kentucky, etc	578,000	42,727	774,364	739,818	31,091	996,182
Minnesota, Wisconsin, North Dakota	44,545	---		44,727	182	
Oklahoma, Kansas, etc	187,273	20,727		184,182	4,727	
Texas Inland	19,273	182		24,545	727	
Texas Gulf Coast	15,273	546		9,636	---	
Louisiana Gulf Coast	---	---		---	---	
Arkansas, Louisiana Inland, etc	---	---	34,364	---	---	34,182
New Mexico	---	---		---	---	
Rocky Mountain	359,636	27,273	362,909	336,182	23,273	340,727
West Coast	341,636	65,636	314,545	247,091	53,818	258,363
Total	1,652,000	160,000	1,592,000	1,707,817	114,909	1,752,908

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 months and refining districts

(Thousand barrels unless otherwise stated)

	1969							1970 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	1,941	0.6	46	288	157	5,352	2,595	2,210	0.7	33	169	114	6,372	2,218
February	2,291	.8	39	37	130	5,955	1,634	2,183	.7	32	217	157	6,243	2,404
March	2,335	.7	42	947	205	6,231	2,843	2,407	.7	37	6	106	6,518	2,069
April	2,152	.7	42	156	236	5,708	2,637	2,621	.8	34	130	157	6,193	2,953
May	2,600	.8	45	273	157	6,180	2,289	2,609	.8	31	6	211	6,302	2,326
June	2,577	.8	43	347	204	6,075	2,868	2,427	.7	31	100	136	6,042	2,682
July	2,316	.7	41	130	129	5,916	2,517	2,511	.7	35	16	106	5,915	2,583
August	2,436	.7	42	266	234	5,794	2,632	2,605	.8	32	-------	99	5,631	2,822
September	2,501	.8	40	526	161	6,024	2,676	2,405	.7	32	153	111	5,325	2,785
October	2,368	.7	39	3	154	5,768	2,512	2,810	.8	30	677	149	5,430	3,263
November	2,410	.7	37	2	142	5,957	2,118	2,627	.8	27	420	118	5,888	2,498
December	2,470	.7	36	216	110	6,292	2,277	2,781	.8	30	217	120	6,193	2,603
Total	28,397	.7	492	3,191	2,019	6,292	29,598	30,196	.8	384	2,111	1,584	6,193	31,206
By refining district:														
East Coast	734	.1	-------	2,190	518	1,380	8,358	709	.2	-------	1,739	369	1,471	6,786
Appalachian No. 1	372	.7	-------			85		331	.7	-------			86	
Appalachian No. 2	293	1.3	-------			37		253	1.1	-------			28	
Indiana, Illinois, Kentucky, etc	3,821	.6	-------	12	252	1,002	7,503	3,080	.4	-------	3	154	941	6,867
Minnesota, Wisconsin, etc	-------	-----	-------			69		-------	-----	-------			78	
Oklahoma, Kansas, etc	1,385	.4	29			180		1,311	.4	28			161	
Texas Inland	1,006	.1	43			136		1,061	.7	40			145	
Texas Gulf Coast	15,572	1.8	-------			2,366		16,835	1.9	-------			2,248	
Louisiana Gulf Coast	510	.1	-------	953	1,081	117	9,924	550	.1	-------	269	908	115	12,592
Arkansas, Louisiana Inland, etc	956	1.8	420			191		1,036	1.8	316			136	
New Mexico	-------	-----	-------			-------		-------	-----	-------			-------	
Rocky Mountain	146	.1	-------	-------	1	33	160	145	.1	-------	10	-------	20	164
West Coast	3,602	.6	-------	36	167	696	3,653	4,885	.8	-------	90	153	764	4,797
Total	28,397	.7	492	3,191	2,019	6,292	29,598	30,196	.8	384	2,111	1,584	6,193	31,206

p Preliminary.

Table 53.—Salient statistics of wax in the United States, by types, months, and refining districts [1]

(Thousand barrels)

	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Microcrystalline	Fully refined	Other	Total			Microcrystalline	Fully refined	Other	Total	
1969											
By month:											
January	85	219	90	394	19	45	167	376	434	977	392
February	70	187	149	406	13	84	152	344	435	931	381
March	123	248	187	558	2	134	164	343	482	989	368
April	98	239	164	501	21	145	163	356	522	1,041	325
May	145	242	187	574	24	167	182	354	531	1,067	405
June	96	258	136	490	14	136	185	380	471	1,036	399
July	108	188	189	485	-------	161	167	337	484	988	372
August	116	234	184	534	13	162	174	360	496	1,030	343
September	100	231	150	481	26	114	188	359	441	988	435
October	108	242	191	541	-------	149	158	299	489	946	434
November	146	218	171	535	13	160	211	320	467	998	336
December	82	301	167	550	13	166	164	360	473	997	398
Total	1,277	2,807	1,965	6,049	158	1,623	164	360	473	997	4,588
By refining district:											
East Coast	331	1,037	657	2,025			29	125	45	199	
Appalachian No. 1	252	44	280	576	12	768	18	11	151	180	2,172
Appalachian No. 2	-------	14	-------	14			-------	4	-------	4	
Indiana, Illinois, Kentucky, etc	37	228	141	406	-------	60	3	19	125	147	945
Minnesota, Wisconsin, etc	-------	-------	-------	-------			-------	-------	-------	-------	
Oklahoma, Kansas, etc	262	256	51	569			49	23	8	80	
Texas Inland	92	-------	-------	92			19	-------	-------	19	
Texas Gulf Coast	203	539	494	1,236			26	55	86	167	
Louisiana Gulf Coast	94	396	103	593	146	697	19	60	41	120	1,024
Arkansas, Louisiana Inland, etc	-------	-------	-------	-------			-------	-------	-------	-------	
New Mexico	-------	-------	-------	-------			-------	-------	-------	-------	
Rocky Mountain	6	51	24	81	-------		1	21	17	39	87
West Coast	-------	242	215	457	-------	98	-------	42	-------	42	360
Total	1,277	2,807	1,965	6,049	158	1,623	164	360	473	997	4,588
1970 p											
By month:											
January	89	206	158	453	26	130	164	380	454	998	348
February	103	203	150	456	18	155	159	343	474	976	336
March	104	227	171	502	13	146	165	321	453	939	406
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	-------	150	177	351	524	1,052	376
August	109	236	164	509	13	132	191	378	518	1,087	355
September	77	310	195	582	-------	156	170	385	515	1,070	443

October	113	194	183	490	13	170	184	340	431	955	448
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	1,809	192	325	476	993	4,606
By refining district:											
East Coast	333	979	564	1,876	1	729	27	138	50	215	2,122
Appalachian No. 1	198	87	289	574			32	1	121	154	
Appalachian No. 2	-------	14	-------	14			-------	2	-------	2	
Indiana, Illinois, Kentucky, etc	27	280	125	432	-------	31	2	14	115	131	1,043
Minnesota, Wisconsin, etc	-------	-------	-------	-------			-------	-------	-------	-------	
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	971	28	60	58	146	868
Arkansas, Louisiana Inland, etc	-------	-------	-------	-------			-------	-------	-------	-------	
New Mexico	-------	-------	-------	-------			-------	-------	-------	-------	
Rocky Mountain	6	47	31	84	-------	-------	2	16	15	33	64
West Coast	-------	323	242	565	-------	78	-------	41	-------	41	509
Total	1,191	2,860	2,243	6,294	117	1,809	192	325	476	993	4,606

p Preliminary.
1 Conversion factor: 280 pounds to the barrel.

Table 54.—Salient statistics of petroleum coke in the United States, by months and refining districts [1]

(Thousand barrels unless otherwise stated)

	1969							1970 p						
	Production							Production						
	Marketable	Catalyst	Total	Yield (percent)	Exports	Stocks (end of period)	Domestic demand	Marketable	Catalyst	Total	Yield (percent)	Exports	Stocks (end of period)	Domestic demand
By month:														
January	3,537	3,870	7,407	2.4	971	6,490	6,141	4,999	4,279	9,278	2.7	1,855	5,937	6,684
February	3,790	3,621	7,411	2.5	1,264	6,495	6,142	4,380	3,835	8,215	2.7	2,197	5,865	6,090
March	4,127	4,248	8,375	2.5	1,341	6,307	7,222	4,508	3,974	8,482	2.5	2,374	5,385	6,588
April	4,389	3,980	8,369	2.7	2,061	6,545	6,070	5,346	3,824	9,170	2.9	2,446	5,661	6,448
May	4,221	4,224	8,445	2.6	1,924	6,591	6,475	4,681	3,957	8,638	2.7	2,756	4,831	6,712
June	4,311	4,546	8,857	2.7	2,139	6,908	6,401	5,590	4,053	9,643	2.9	3,241	4,830	6,403
July	4,243	4,812	9,055	2.6	1,982	6,570	7,411	5,284	4,359	9,643	2.8	2,814	5,192	6,467
August	4,359	4,400	8,759	2.6	2,636	6,175	6,518	4,859	4,232	9,091	2.6	2,301	5,256	6,726
September	4,348	4,324	8,672	2.6	2,337	5,655	6,855	4,807	4,190	8,997	2.7	2,361	5,469	6,423
October	4,684	4,293	8,977	2.7	1,576	6,124	6,932	4,869	3,908	8,777	2.6	3,022	5,407	5,817
November	4,857	4,278	9,135	2.8	2,195	6,184	6,880	4,699	4,015	8,714	2.6	2,701	5,180	6,240
December	5,140	4,266	9,406	2.7	2,609	5,198	7,783	5,085	4,138	9,223	2.6	2,486	5,297	6,620
Total	52,006	50,862	102,868	2.6	23,035	5,198	80,830	59,107	48,764	107,871	2.7	30,554	5,297	77,218
By refining district:														
East Coast	5,612	7,817	13,429	2.7	527	782	12,954	5,029	6,957	11,986	2.6	524	908	11,487
Appalachian No. 1	------	147	147	.2		------		------	151	151	.3		------	
Appalachian No. 2	------	96	96	.4		------		------	39	39	.2		------	
Indiana, Illinois, Kentucky, etc	8,340	9,833	18,173	2.7	2,616	468	27,615	8,458	10,042	18,500	2.6	2,516	380	28,161
Minnesota, Wisconsin, etc	2,181	856	3,037	4.2		86		2,041	1,031	3,072	4.2		166	
Oklahoma, Kansas, etc	4,020	4,621	8,641	2.7		132		5,067	4,114	9,181	2.8		255	
Texas Inland	211	2,144	2,355	1.7		1		519	1,806	2,325	1.6		1	
Texas Gulf Coast	4,357	13,241	17,598	2.1		213		6,525	12,074	18,599	2.1		306	
Louisiana Gulf Coast	7,047	5,827	12,874	2.8	5,915	287	29,178	7,111	6,011	13,122	2.7	8,143	299	28,186
Arkansas, Louisiana Inland, etc	1,514	694	2,208	4.1		822		1,468	745	2,213	3.9		264	
New Mexico	------	148	148	1.1		------		------	117	117	.8		------	
Rocky Mountain	899	2,061	2,960	2.1	------	1,558	2,969	1,321	2,064	3,385	2.4	1	1,703	3,239
West Coast	17,825	3,377	21,202	3.5	13,977	1,349	8,114	21,568	3,613	25,181	4.0	19,370	1,015	6,145
Total	52,006	50,862	102,868	2.6	23,035	5,198	80,830	59,107	48,764	107,871	2.7	30,554	5,297	77,218

p Preliminary.

[1] Conversion factor: 5.0 barrels to the short ton.

Table 55.—Production of miscellaneous finished oils in the United States in 1970, by districts and classes

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils	Petrochemicals	Other products	Total
East Coast	----	----	1,212	348	128	1,688
Appalachian No. 1	6	69	22	4	17	118
Appalachian No. 2	----	----	18	----	----	18
Indiana, Illinois, Kentucky, etc	88	16	524	529	82	1,189
Minnesota, Wisconsin, North Dakota, and South Dakota	----	----	----	122	----	122
Oklahoma, Kansas, etc	287	220	673	----	274	1,454
Texas Inland	151	----	185	930	29	1,295
Texas Gulf	27	274	1,442	3,337	455	5,535
Louisiana Gulf	400	45	----	1,092	202	1,739
Arkansas, Louisiana Inland	133	----	----	6	13	152
Rocky Mountain, New Mexico	----	----	----	31	50	81
West Coast	28	18	1,579	387	267	2,279
Total:						
1970	1,120	642	[1] 5,655	6,786	1,467	15,670
1969	963	942	4,675	8,962	2,402	17,944

[1] Specialty oils include: Hydraulic, 28; insulating, 175; medicinal, 238; rust preventatives, 5; sand-frac, 200; spray oils, 343; and other, 4,666.

Table 56.—Crude, refined, and unfinished oils imported into the United States, by months [1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1969													
Crude petroleum	35,442	36,537	45,654	43,568	44,137	40,960	43,209	44,887	42,364	45,042	43,775	48,539	514,114
Petroleum products:													
Motor gasoline	2,213	1,793	2,638	1,929	1,962	1,434	2,086	1,974	1,986	1,184	1,794	1,716	22,709
Jet fuel:													
Naphtha-type	454	590	821	190	602	267	259	505	726	186	256	278	5,134
Kerosine-type	2,667	2,761	3,830	2,620	3,135	3,470	3,869	3,714	4,211	2,336	4,041	3,751	40,405
Total	3,121	3,351	4,651	2,810	3,737	3,737	4,128	4,219	4,937	2,522	4,297	4,029	45,539
Liquefied gases:													
Butane	780	555	629	452	323	449	458	409	608	856	814	1,067	7,400
Propane	820	639	375	331	224	207	203	212	293	517	589	841	5,251
Total	1,600	1,194	1,004	783	547	656	661	621	901	1,373	1,403	1,908	12,651
Kerosine	111	76	171	---	106	---	56	---	243	34	55	113	965
Distillate fuel oil	7,341	5,973	7,033	3,523	2,613	2,221	2,826	4,296	3,472	2,297	3,403	5,885	50,883
Residual fuel oil	51,384	41,230	41,374	38,834	34,220	29,094	32,289	34,105	35,100	39,001	33,751	51,229	461,611
Petrochemical feedstocks	---	---	---	---	---	---	---	---	40	---	---	---	40
Special naphthas	288	37	947	156	273	347	130	266	526	3	2	216	3,191
Lubricants	2	2	2	3	2	65	2	2	44	1	33	5	163
Wax	19	13	2	21	24	14	---	13	26	---	13	13	158
Asphalt	255	333	175	181	474	464	573	403	734	352	294	523	4,761
Unfinished oils	2,184	3,583	2,723	2,556	2,459	3,060	2,871	3,629	4,164	2,915	3,724	4,898	38,766
Total petroleum products	68,518	57,585	60,720	50,796	46,417	41,092	45,622	49,528	52,173	49,682	48,769	70,535	641,437
Total crude and products	103,960	94,122	106,374	94,364	90,554	82,052	88,831	94,415	94,537	94,724	92,544	119,074	1,155,551
1970 p													
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	512	270	7,060
Kerosine-type	3,743	3,764	2,732	4,567	2,957	3,988	4,546	4,338	4,432	3,531	2,965	3,429	44,992
Total	4,274	4,181	2,821	4,890	4,300	4,902	4,965	4,925	4,862	4,756	3,477	3,699	52,052
Liquefied gases:													
Butane	920	729	716	728	503	454	472	703	690	1,210	1,028	1,541	9,694
Propane	784	990	848	546	431	313	382	421	630	915	1,495	1,712	9,467
Total	1,704	1,719	1,564	1,274	934	767	854	1,124	1,320	2,125	2,523	3,253	19,161
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	5,095	6,663	53,903
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	401	5,195

Special naphthas	169	217	6	130	6	100	16	-------	153	677	420	217	2,111
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	75,500	73,740	77,255	64,017	51,751	58,000	60,503	56,821	54,611	60,706	59,652	71,543	764,099
Total crude and products	119,295	114,854	123,605	99,159	89,219	99,178	99,559	93,336	94,921	97,581	97,467	119,218	1,247,392

p Preliminary.

1 Imports of crude oil, unfinished oils, and plant condensate reported to the Bureau of Mines; 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 countries and receiving districts

(Thousand barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [2]	No. 4 distillate fuel oil [3]	Residual fuel oil	Military jet fuel	Commercial jet fuel	Propane	Butane [4]	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
1969																	
North America:																	
Canada	203,298	444	20	36	2,653	27	2,482	-	48	5,038	7,359	194	200	16	3	-	221,791
Mexico	-	-	-	-	-	-	5,805	-	-	-	-	-	9,776	-	2	-	15,583
Total	203,298	444	20	36	2,653	27	8,287	-	48	5,038	7,359	194	9,976	16	5	-	237,374
Central America and Caribbean:																	
Leeward and Windward Islands	-	-	-	-	-	-	211	-	-	-	-	-	-	-	-	-	211
Netherland Antilles	-	183	1,042	-	14,556	10,755	120,319	1,550	17,872	-	-	2,390	5,963	-	-	-	163,875
Panama	-	331	-	-	287	-	660	48	887	-	-	-	1,772	-	-	-	3,985
Puerto Rico	-	20,709	-	-	5,407	-	-	-	112	-	-	-	-	-	-	40	26,268
Trinidad and Tobago	-	-	953	-	3,360	2,980	61,792	2,307	7,164	-	-	9	2,900	138	-	-	78,623
Virgin Islands	-	825	-	929	6,321	-	24,641	273	-	-	-	-	9,564	-	-	-	42,553
Total	-	22,048	1,995	929	29,931	13,735	207,623	4,178	26,035	-	-	2,399	20,199	138	-	40	315,515
South America:																	
Argentina	-	-	-	-	-	-	342	-	-	-	-	-	-	-	-	-	342
Bolivia	5,596	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,596
Chile	1,464	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,464
Colombia	15,551	-	146	-	530	-	9,052	-	-	-	-	-	146	-	-	-	25,425
Peru	216	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	216
Venezuela	111,722	216	438	-	14,774	11,498	174,689	822	9,518	213	40	1,924	4,874	-	143	-	319,373
Total	134,549	216	584	-	15,304	11,498	184,083	822	9,518	213	40	1,924	5,020	-	143	-	352,416
Europe:																	
Belgium	-	-	-	-	146	-	3,849	-	-	-	-	-	-	2	-	-	3,997
France	-	-	-	-	133	133	3,304	-	-	-	1	-	-	-	-	-	3,438
Germany, West	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	10
Italy	-	-	-	-	1,285	960	24,426	-	1,459	-	-	-	162	-	-	-	27,332
Netherlands	-	-	172	-	610	219	11,174	-	236	-	-	237	483	6	-	-	12,918
Romania	-	-	-	-	565	564	1,016	-	-	-	-	-	-	-	-	-	1,581
Spain	-	-	-	-	-	-	4,424	-	110	-	-	-	-	-	-	-	4,534
U.S.S.R.	-	-	-	-	120	120	620	-	-	-	-	-	-	-	-	-	740
United Kingdom	-	1	-	-	136	136	6,093	25	493	-	-	-	627	1	-	-	7,376
Yugoslavia	-	-	-	-	-	-	252	-	-	-	-	-	-	-	-	-	252
Total	-	1	172	-	2,995	2,132	55,158	25	2,298	-	1	237	1,272	9	10	-	62,178
Middle East:																	
Abu Dhabi	5,051	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,051
Bahrain	-	-	-	-	-	-	1,803	86	526	-	-	-	-	-	-	-	2,415
Iran	15,306	-	302	-	-	-	-	-	957	-	-	-	313	-	-	-	16,878

Kuwait	12,539												1,656				14,195
Neutral Zone	15,864																15,864
Gatar	191																191
Saudi Arabia	12,665		118				3,069										15,852
Total	61,616		420				4,872	86	1,483				1,969				70,446
Africa:																	
Algeria	358						363										721
Angola	424																424
Gabon							402										402
Ivory Coast							527										527
Libya	48,862						291										49,153
Nigeria	17,958																17,958
United Arab Republic	14,778																14,778
Total	82,380						1,583										83,963
Asia:																	
Indonesia	32,271											7					32,278
Japan							5	23	1,023				330				1,381
Total	32,271						5	23	1,023			7	330				33,659
Total imports	514,114	22,709	3,191	965	50,883	27,392	461,611	5,134	40,405	5,251	7,400	4,761	38,766	163	158	40	1,155,551
Imports by PAD districts:																	
District I	269,007	22,112	2,190	960	47,720	27,392	440,983	1,976	23,031	494	65	4,386	28,975	18	12		841,929
District II	88,434	126	12		1,264		627		1,771	2,348	1,943	150	51	4			96,730
District III			953		937		12,167		478			225	1,034	141	146	40	16,121
District IV	12,714			5			78			1,489	1,407						15,693
District V	143,959	471	36		962		7,756	3,158	15,125	920	3,985		8,706				185,078
1970 p																	
North America:																	
Canada	245,258	610	22	135	4,941	510	7,683	45	45	8,849	11,281	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	8,850	11,281	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	9,753	5,201	135,010	2,006	17,140			2,483	6,190			151	174,193
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		1,394	78,943
Virgin Islands		1,235		953	4,390	369	52,453						9,833				68,864
Total	265	23,539	734	1,163	23,970	9,300	261,299	4,556	26,883			2,491	17,921	212		5,195	368,228

See footnotes at end of table.

Table 57.—Crude oil and petroleum products imported into the United States, by countries and receiving districts—Continued

(Thousand barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [2]	No. 4 distillate fuel oil [3]	Residual fuel oil [2]	Military jet fuel	Commercial jet fuel	Propane	Butane [4]	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
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	2,331	13,719	617	285	2,769	9,481	------	116	------	361,206
Total	105,843	168	1,265	73	21,460	13,611	220,842	2,331	13,719	617	285	2,769	9,941	------	116	------	379,429
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
U.S.S.R.	------	------	------	------	------	------	1,081	------	------	------	------	------	------	------	------	------	1,081
United Kingdom	------	------	------	80	------	------	3,486	------	198	------	------	------	------	1	------	------	3,765
Total	------	3	------	80	3,404	2,059	58,251	20	2,386	------	92	83	154	7	------	------	64,480
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
Saudi Arabia	14,538	------	------	------	------	------	465	------	------	------	54	------	------	------	------	------	15,057
Total	61,892	------	90	------	------	------	1,554	106	1,819	------	54	------	1,615	------	------	------	67,130
Africa:																	
Algeria	2,093	------	------	------	127	127	608	------	------	------	240	------	------	------	------	------	3,068
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	------	------	------	240	------	4	------	------	------	46,352
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	2,111	1,451	53,903	25,607	557,845	7,060	44,992	9,467	11,952	6,201	39,261	224	117	5,195	1,247,392
Imports by PAD districts:																	
District I	211,403	24,006	1,739	1,349	49,410	25,607	536,967	4,493	25,382	1,516	608	6,008	30,221	15	1	------	893,118
District II	115,613	65	2	------	2,223	------	4,207	------	1,988	5,249	[4] 5,392	193	------	3	------	------	134,935
District III	------	------	270	------	1,192	------	11,029	------	2,429	412	------	------	913	206	116	5,195	21,762
District IV	17,573	------	10	------	------	------	53	------	------	1,607	1,523	------	------	------	------	------	20,766
District V	138,704	249	90	102	1,078	------	5,589	2,567	15,193	683	4,429	------	8,127	------	------	------	176,811

p Preliminary.
[1] Imports of crude and unfinished oils reported to the Bureau of Mines; imports of refined products compiled from records of the U.S. Department of Commerce.
[2] Includes quantities imported duty free for supply of vessels and aircraft engaged in foreign trade.
[3] Included in distillate fuel oil.
[4] Includes 2,258 thousand barrels of plant condensate.

Table 58.—Petroleum oils, crude and refined, exported from the United States, including shipments to territories and possessions by months [1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1969													
Crude petroleum	------	220	176	93	216	1	------	144	83	162	240	101	1,436
Refined products:													
Gasoline: [2]													
Motor	20	12	25	17	116	65	71	153	98	53	30	43	703
Aviation	33	98	146	111	143	107	181	88	308	220	93	218	1,746
Total gasoline	53	110	171	128	259	172	252	241	406	273	123	261	2,449
Jet fuel (naphtha-type)	1	296	89	166	101	177	66	64	323	221	139	87	1,730
Liquefied gases:													
Butane	116	357	515	76	96	77	305	579	442	132	105	286	3,086
Propane	258	130	219	75	177	112	264	115	126	441	296	199	2,412
Butane-propane mix	684	700	682	590	516	517	658	647	576	532	582	615	7,299
Total liquefied gases	1,058	1,187	1,416	741	789	706	1,227	1,341	1,144	1,105	983	1,100	12,797
Kerosine	11	5	15	22	23	14	6	5	17	7	22	8	155
Distillate fuel oil	70	92	120	45	125	143	95	38	119	119	75	82	1,123
Residual fuel oil	1,669	1,687	1,845	1,134	1,549	1,423	1,098	1,492	988	1,641	1,550	815	16,891
Petrochemical feedstocks	536	355	338	282	423	261	155	297	349	369	233	250	3,848
Special naphthas	157	130	205	236	157	204	129	234	161	154	142	110	2,019
Lubricants	1,165	807	1,408	1,442	1,741	1,915	1,135	1,674	1,459	1,219	1,058	1,373	16,396
Wax	45	84	134	145	167	136	161	162	114	149	160	166	1,623
Coke	971	1,264	1,341	2,061	1,924	2,139	1,982	2,636	2,337	1,576	2,195	2,609	23,035
Asphalt	20	30	36	25	61	65	59	40	40	34	31	23	464
Miscellaneous	46	58	90	108	69	72	92	83	74	91	63	73	919
Total refined	5,802	6,105	7,208	6,535	7,388	7,427	6,457	8,307	7,531	6,958	6,774	6,957	83,449
Total crude and refined	5,802	6,325	7,384	6,628	7,604	7,428	6,457	8,451	7,614	7,120	7,014	7,058	84,885
1970 p													
Crude petroleum	93	------	70	94	------	302	97	11	------	1,962	1,616	746	4,991
Refined products:													
Gasoline: [2]													
Motor	23	31	32	50	36	41	40	47	29	43	45	44	461
Aviation	40	193	123	67	74	54	112	24	57	84	38	62	928
Total gasoline	63	224	155	117	110	95	152	71	86	127	83	106	1,389
Jet fuel (naphtha-type)	279	201	245	194	165	94	259	102	149	166	85	228	2,167
Liquefied gases:													
Butane	30	39	31	105	54	91	210	182	158	165	145	139	1,349
Propane	463	105	384	315	102	177	91	108	106	105	89	120	2,165
Butane-propane mix	551	523	590	591	474	461	531	481	461	496	481	496	6,136

Total liquefied gases	1,044	667	1,005	1,011	630	729	832	771	725	766	715	755	9,650
Kerosine	3	16	20	12	10	8	17	6	5	11	9	4	121
Distillate fuel oil	29	69	74	133	105	18	175	47	67	112	36	71	936
Residual fuel oil	1,474	2,116	1,103	1,375	1,794	1,349	1,730	1,223	2,812	1,246	952	2,612	19,786
Petrochemical feedstocks	297	191	173	555	380	307	221	362	420	255	259	356	3,776
Special naphthas	114	157	106	157	211	136	106	99	111	149	118	120	1,584
Lubricants	1,267	1,145	1,721	1,299	1,308	1,171	1,726	1,202	1,102	1,543	1,149	1,417	16,050
Wax	130	155	146	162	172	161	150	132	156	170	105	170	1,809
Coke	1,855	2,197	2,374	2,446	2,756	3,241	2,814	2,301	2,361	3,022	2,701	2,486	30,554
Asphalt	19	25	21	49	31	28	25	24	37	49	25	26	359
Miscellaneous	83	78	105	95	93	117	54	103	97	86	71	89	1,071
Total refined	6,657	7,241	7,248	7,605	7,765	7,454	8,261	6,443	8,128	7,702	6,308	8,440	89,252
Total crude and refined	6,750	7,241	7,318	7,699	7,765	7,756	8,358	6,454	8,128	9,664	7,924	9,186	94,243

[p] Preliminary.
[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
1969															
North America:															
Bahamas	------	54	4	------	------	45	486	13	1	86	(1)	------	1	(1)	690
Canada	30	302	364	13	15	1,066	7,302	1,811	127	838	119	3,403	520	137	16,047
Mexico	1	103	71	20	1	r 461	1,811	620	126	7,997	270	554	38	26	r 12,099
Trinidad and Tobago	220	(1)	11	(1)	------	------	------	14	(1)	------	6	------	1	1	253
Other	------	5	43	------	1	26	892	578	24	33	106	42	16	22	1,788
Total	251	464	493	33	17	r 1,598	10,491	3,036	278	8,954	501	3,999	576	186	r 30,877
South America:															
Argentina	------	(1)	4	------	(1)	------	(1)	603	(1)	923	5	------	18	1	1,554
Brazil	------	(1)	243	------	------	------	101	1,257	9	617	46	121	36	106	2,536
Chile	------	------	1	------	1	------	1	211	3	29	28	(1)	2	9	285
Colombia	------	3	4	2	(1)	1	------	72	(1)	------	82	------	1	21	186
Peru	------	(1)	(1)	------	------	4	600	122	(1)	(1)	10	------	1	3	740
Other	------	37	24	(1)	2	32	21	174	31	1	54	126	3	23	528
Total	------	40	276	2	3	37	723	2,439	43	1,570	225	247	61	163	5,829
Europe:															
Belgium-Luxembourg	(1)	(1)	35	------	1	------	------	535	3	27	11	915	55	22	1,604
France	------	(1)	68	------	(1)	(1)	81	74	30	13	43	452	694	5	1,460
Germany, West	------	94	128	------	17	23	(1)	282	1	(1)	324	1,230	151	19	2,269
Italy	------	498	16	------	1	31	889	290	4	(1)	71	1,402	197	34	3,433
Netherlands	------	272	227	------	1	299	(1)	280	(1)	(1)	22	1,700	614	20	3,435
Norway	------	(1)	(1)	------	------	------	------	23	1	------	2	915	2	1	944
Spain	------	1	3	------	------	------	105	28	5	968	20	722	371	14	2,237
Sweden	------	(1)	2	------	------	------	(1)	139	3	------	10	378	196	8	736
United Kingdom	430	107	1,196	(1)	38	1	1,266	587	1	701	49	311	123	41	4,851
Other	------	88	1	98	(1)	145	1	126	3	22	31	350	10	12	887
Total	430	1,060	1,676	98	58	499	2,342	2,364	51	1,731	583	8,375	2,413	176	21,856
Africa:															
Congo (Kinshasa)	------	(1)	2	------	------	------	(1)	20	1	------	1	------	1	1	26
South Africa, Republic of	------	------	86	------	(1)	------	338	295	5	2	54	34	24	36	874
Other	------	112	13	------	6	42	142	282	10	------	44	268	9	21	949
Total	------	112	101	------	6	42	480	597	16	2	99	302	34	58	1,849
Asia:															
India	------	(1)	2	------	1	------	------	1,894	------	1	8	71	2	14	1,993
Indonesia	------	(1)	(1)	------	------	------	------	200	1	------	(1)	------	(1)	11	212
Japan	755	5	479	------	32	75	2,665	2,732	4	513	78	9,509	106	116	17,069

Philippines	------	(1)	18	------	5	------	------	461	1	------	14	------	4	18	521
Turkey	------	------	2	------	------	------	------	540	(1)	------	(1)	------	5	15	562
Other	------	117	101	193	1	22	12	1,566	14	(1)	40	75	43	64	2,248
Total	755	122	602	193	39	97	2,677	7,393	20	514	140	9,655	160	238	22,605
Oceania:															
Australia	------	1	59	------	5	------	2	216	1	5	57	450	579	49	1,424
French Pacific Islands	------	75	(1)	------	23	130	51	7	(1)	1	------	------	(1)	------	287
New Zealand	------	(1)	17	------	(1)	------	(1)	35	1	4	11	------	6	38	112
Other	------	(1)	(1)	------	------	------	(1)	2	3	(1)	------	------	(1)	------	5
Total	------	76	76	------	28	130	53	260	5	10	68	450	585	87	1,828
Grand total	1,436	1,874	3,224	326	151	2,403	16,766	16,089	413	12,781	1,616	23,028	3,829	908	r 84,844
Shipments from the United States to territories and possessions:															
Puerto Rico	------	123	18	------	(1)	2	1	282	70	16	17	33	18	13	593
Virgin Islands	------	76	------	------	------	16	137	19	------	4	1	------	1	(1)	254
Other [2]	------	489	1	1,527	3	380	------	12	2	------	------	------	------	------	2,414
Total	------	688	19	1,527	3	398	138	313	72	20	18	33	19	13	3,261
Exports from Puerto Rico to foreign countries	------	46	1,227	------	(1)	1,048	134	5	13	3	2	------	(1)	(1)	2,478
Total net shipments from the United States	1,436	2,516	2,016	1,853	154	r 1,753	16,770	16,397	472	12,798	1,632	23,061	3,848	921	r 85,627
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)	264	2	1	366	2,876	159	35	3,834
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

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
Europe—Continued															
Spain	------	(1)	5	------	------	------	274	93	9	------	42	701	238	6	1,368
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	3,149	69	359	756	12,590	2,423	235	24,530
Africa:															
Congo (Kinshasa)	------	------	2	------	(1)	------	------	24	1	(1)	2	------	1	2	32
South Africa, Republic of	(1)	5	63	------	1	------	173	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	1,557	9	(1)	58	180	44	54	2,001
Total	223	5	454	(1)	13	130	8,902	6,046	13	513	152	12,763	88	254	29,556
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	15,712	399	9,932	1,783	30,515	3,754	1,061	92,861
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 the United States	4,991	1,368	1,585	2,093	124	899	19,786	16,089	357	9,955	1,808	30,557	3,776	1,073	94,461

r Revised.
[1] Less than ½ unit.
[2] Data reported by shippers to the Bureau of Mines.

Table 60.—Crude petroleum: World production, by countries

(Thousand 42-gallon barrels)

Country	1968	1969	1970 [p]
North America:			
Canada	379,396	410,814	461,177
Cuba [e]	[r] 1,062	[r] 821	800
Mexico	142,257	149,661	156,530
Trinidad and Tobago	66,904	57,418	51,047
United States	3,329,042	3,371,751	3,517,450
South America:			
Argentina	[r] 125,492	130,086	143,428
Bolivia	14,974	14,759	8,820
Brazil	58,785	63,969	60,923
Chile	[r] 13,696	13,350	12,432
Colombia	63,435	76,776	79,594
Ecuador	1,815	1,567	1,444
Peru	[r] 27,056	26,330	26,272
Venezuela	1,319,340	1,311,832	1,353,420
Europe:			
Albania	7,573	8,767	9,995
Austria	[r] 18,999	19,236	19,515
Bulgaria	[r] 3,468	2,373	2,438
Czechoslovakia	[r] 1,390	1,424	[e] 1,424
France	[r] 19,528	18,207	16,825
Germany, East	219	365	438
Germany, West	[r] 57,652	56,886	54,427
Hungary	[r] 13,787	13,383	14,780
Italy	[r] 10,260	9,309	9,575
Netherlands	[r] 14,645	13,792	13,080
Poland	[r] 3,524	3,257	3,146
Romania	[r] 101,059	101,067	102,067
Spain	[r] 925	1,386	1,457
U.S.S.R.	[r] 2,272,153	2,412,899	2,594,550
United Kingdom	591	562	607
Yugoslavia	18,473	19,991	21,140
Africa:			
Algeria	[r] 330,922	345,436	371,767
Angola	5,401	17,456	36,499
Congo (Brazzaville)	[r] 342	173	137
Gabon	33,630	36,421	39,292
Libya	[r] 951,345	1,134,452	1,209,314
Morocco	674	438	335
Nigeria	[r] 51,907	197,204	395,836
Tunisia	24,539	27,942	34,296
United Arab Republic [1]	[r] 62,208	89,601	119,165
Asia:			
Bahrain	27,598	27,774	27,973
Brunei	[r] 44,653	45,624	50,233
Burma	5,634	6,433	6,388
China, mainland [e]	[r] 72,000	106,000	146,000
India	43,552	51,726	52,596
Indonesia	[r] 219,864	271,001	311,628
Iran	[r] 1,039,367	1,232,155	1,397,460
Iraq	[r] 548,705	555,241	569,726
Israel [e] [1]	[r] 14,689	18,042	31,798
Japan	[r] 5,490	5,538	5,656
Kuwait [2]	964,069	1,021,615	1,090,040
Malaysia (Sarawak)	[r] 1,557	3,278	6,299
Mongolia [e]	90	90	90
Oman	87,854	119,710	121,210
Pakistan	3,305	3,460	3,400
Qatar	[r] 124,266	129,746	132,456
Saudia Arabia [2]	1,113,717	1,173,896	1,387,266
Syrian Arab Republic	[r] 9,955	16,771	29,356
Taiwan	421	581	638
Thailand	26	16	70
Trucial States:			
Abu Dhabi	181,756	218,798	252,179
Dubai	----------	3,800	31,321
Turkey	22,235	25,774	24,776
Oceania:			
Australia	13,877	15,805	65,149
New Zealand	2	3	467
Total	[r] 14,093,150	15,214,038	16,689,617

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Estimates of Israeli production from Sinai peninsula oilfields included with Israel rather than with United Arab Republic.

[2] Data for both Kuwait and Saudi Arabia include those countries' half share of production from the former Kuwait-Saudi Arabia Neutral Zone.

Phosphate Rock

By Richard W. Lewis [1]

The domestic phosphate rock industry continued to pare costs in 1970, by improving operational efficiencies. Some of the more costly operations were closed, and output was increased at the more efficient facilities. Most producers' annual reports showed some financial improvement over that of 1969, and the outlook was optimistic. However, the financial gains resulted from the sales of phosphatic fertilizers and not from phosphate rock, which had the lowest average value per ton on record. In 1970 domestic sales of phosphate rock for agricultural use recorded an 11-percent increase over that for 1969. However, curtailed use of phosphorus in detergents in 1970 resulted in a substantial reduction in phosphate rock demand for industrial purposes. The producers in the Western States, reported an 8-percent decrease in rock sold or used for industrial use.

Tennessee producers cut production by 3 percent, but managed to sell or use essentially the same quantity as in 1969.

Florida and North Carolina suffered a decline of 17 percent in industrial demand, but this was offset by an increase of 11 percent for agricultural uses. In 1970 agricultural use represented 98 percent of the total domestic demand for Florida and North Carolina phosphate rock.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Mine production	112,960	128,973	148,336	121,712	125,514
Marketable production	39,044	39,770	41,251	37,725	38,739
Value	$261,092	$265,947	$250,692	$208,689	$203,218
Average per ton	$6.69	$6.69	$6.08	$5.53	$5.25
Sold or used by producers	36,443	37,835	37,319	36,730	37,923
Value	$245,182	$251,163	$228,347	$204,409	$199,629
Average per ton	$6.73	$6.64	$6.12	$5.57	$5.26
Imports for consumption	178	139	116	140	136
Value	$4,256	$3,261	$2,679	$3,554	$3,790
Average per ton	$23.91	$23.46	$23.09	$25.42	$27.87
Exports [1]	9,248	10,072	12,099	11,336	10,895
P_2O_5 content	2,803	3,290	3,917	3,685	3,528
Value	$65,952	$69,479	$75,653	$62,288	$55,799
Average per ton	$7.13	$6.90	$6.25	$5.49	$5.12
Consumption, apparent [2]	27,373	27,902	25,336	25,534	27,164
World: Production	83,194	85,914	92,577	90,063	93,858

[1] From table 6.
[2] Measured by sold or used plus imports minus exports.

DOMESTIC PRODUCTION

Phosphate rock producers, expecting a greater demand in 1970, increased their output of marketable rock 3 percent. However, the value of production decreased 3 percent from that of 1969, and averaged only $5.25 per ton. Production from Florida and North Carolina accounted for nearly 81 percent of the total domestic output; the Western States, 11 percent; and Tennessee, including a small quantity from Alabama, 8 percent.

Phosphate rock was produced in nine

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States in 1970, and Florida continued to produce more than the combined output of the other eight States. Land-pebble phosphate rock was produced in Florida by Agrico Chemical Co., American Cyanamid Co., Borden Chemical Division of Borden Inc., Cities Service Co., W. R. Grace & Co., International Minerals & Chemical Corp. (IMC), Mobil Chemical Co., Occidental Chemical Co., Swift Agricultural Chemicals Inc., and U.S.S. Agri-Chemicals. Soft phosphate rock was produced in Florida by Howard Phosphate Co., Kellogg Co., Loncala Phosphate Co., Soil Builders, Inc., and Sun Phosphate Co. Other phosphate rock was produced in Alabama by Monsanto Co.; in California, by Cuyama Phosphate Corp.; in Idaho, by Monsanto Co., J. R. Simplot Co., and Stauffer Chemical Co.; in Montana, by Cominco American, Inc.; in North Carolina, by Texas Gulf Sulphur Co.; in Tennessee, by Hooker Chemical Corp., Mobil Chemical Co., Monsanto Co., Stauffer Chemical Co., Tennessee Valley Authority (TVA), and M. C. West, Inc.; and in Utah and Wyoming, by Stauffer Chemical Co.

American Cyanamid Co. increased the capacity of its Chicora mine to 3.0 million tons per year, and later in the year, changed the name to the Haynsworth mine. The washer and flotation plants were enlarged to handle the increased mine production.

CF Chemicals, Inc., at Bonnie, Fla. converted a triple superphosphate unit to a third diammonium phosphate (DAP) pro-

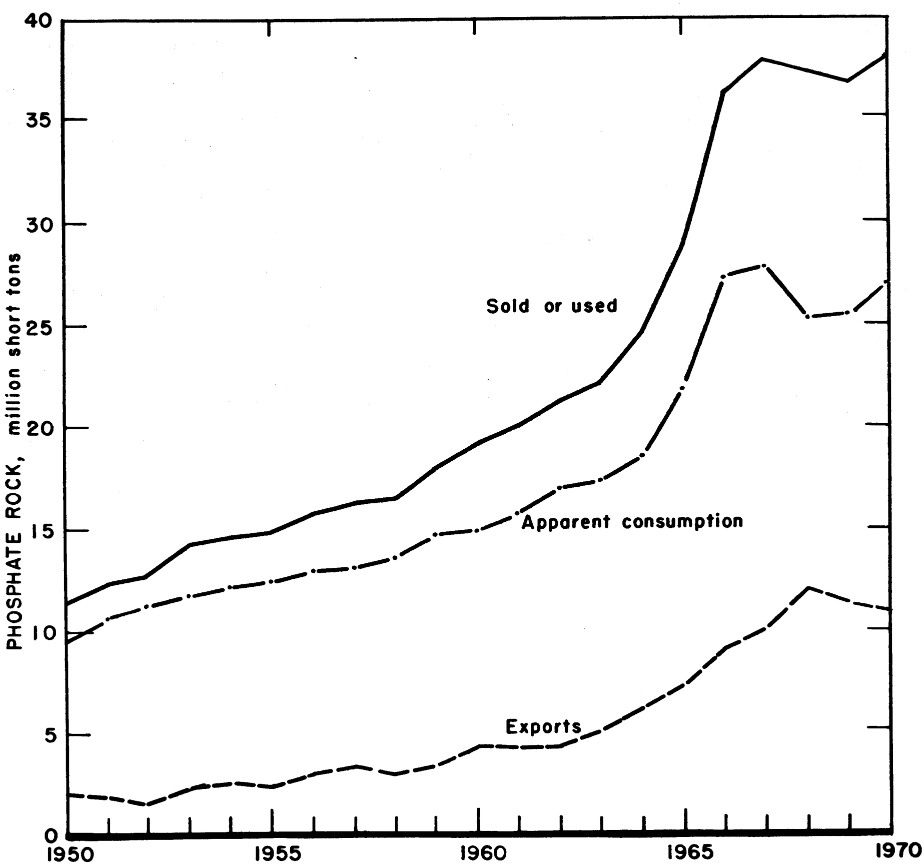

Figure 1.—Phosphate rock (sold or used), apparent consumption, and exports.

duction facility. The firm also constructed a fully automated 50,000-ton-capacity DAP warehouse.

Continental Oil Co. began operating its new soluble silicofluorides plant in April, at South Pierce, Fla. The plant has an output capacity of 4,500 tons per year of magnesium, zinc, and ammonium silicofluorides for use in the chemical detergent, glass, and building materials industries. The plant replaced two smaller, less efficient plants.

Plans for a major expansion of phosphoric acid facilities at Green Bay, Fla., were announced by Farmland Industries, Inc. The new facility will include two large sulfuric acid units and a Swenson phosphoric acid reactor.

Mobil Oil Corp. had a new washer under construction near Nichols, Fla. The new operation will permit the firm to fully use its existing processing facilities and raise phosphate rock production capacity from 3.2 million tons to 4.4 million tons per year. The company closed two economically marginal phosphorus furnaces, one at Mt. Pleasant, Tenn., and the other at Charleston, S.C. Sharply rising costs for electrical power and other raw materials were stated as the causes for the closure.

Monsanto Co. continued to be the leading producer of elemental phosphorus. A multimillion dollar phosphoric acid unit under construction in St. Louis, Mo., was near completion. This was to be a replacement for an obsolete unit at the same location. According to Monsanto's annual report, the initial phase of a $55 million, 3-year capital expenditure program to combat pollution at its U.S. plants was undertaken. During 1970, $12 million went into capital expenditures for pollution control, and a similar amount was spent in the operation of already installed antipollution equipment.

Occidental Chemical Co. (Oxychem), together with The Garrett Research and Development Co., both subsidiaries of Occidental Petroleum Corp., continued development work on a process for the disposal of slimes after additional phosphate recovery. Garrett was developing a process for recovering anhydrous hydrofluoric acid from the fluorine waste from Oxychem's north Florida phosphate operations. In November Oxychem completed a new facility for producing defluorinated phosphate feed supplements. The plant at White Springs, Fla., has an annual capacity of 100,000 tons and replaces a 25,000-ton defluorination plant in Houston, Tex., which was closed in January.

Olin Corp.'s new multimillion dollar defluorination plant in Pasadena, Tex., started production. The plant uses an Olin-developed process and has an annual capacity of over 75,000 tons. The total output will be used as an additive in the manufacture of animal and poultry feed.

Stauffer Chemical Co. shut down two of five electric furnaces at its elemental phosphorus plant at Mt. Pleasant, Tenn. The closure reduces the production capacity of the plant by about 30 percent. Stauffer increased production at its surface mine at Leefe, Wyo.

Swift Agricultural Chemicals Inc. ac-

Table 2.—Production of phosphate rock in the United States, by States

(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
1969									
Florida [1]	111,178	15,711	92	28	29,838	9,575	29,930	9,603	$160,777
Tennessee [2]	5,648	1,080	533	128	2,741	730	3,274	858	18,888
Western States [3]	4,886	1,253	3,539	905	982	318	4,521	1,223	29,024
Total	121,712	18,044	4,164	1,061	33,561	10,623	37,725	11,684	208,689
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

[1] Includes North Carolina.
[2] Includes Alabama.
[3] Includes California, Idaho, Montana, Utah, and Wyoming.
[4] Data may not add to totals shown because of independent rounding.

quired a major portion of the assets of the Agricultural Chemicals Division of Mobil Oil Corp. The marketing and administrative organizations of the two companies were integrated to open new sales territories in the Northeast and west Texas.

Texas Gulf Sulphur Co. (TGS) combined its potash and phosphate operations to form an Agricultural Division, which is headquartered in Raleigh, N.C. Superphosphoric acid production at the TGS Lee Creek mine in North Carolina was expanded upon the completion of a new plant.

CONSUMPTION AND USES

Apparent consumption of phosphate rock was 6 percent greater in 1970, accelerating the upward trend that started in 1969, after the exceptionally low demand in 1968.

The quantity of phosphate rock sold or used by producers in the United States for the production of phosphoric acid (wet process) increased 22 percent; for ordinary superphosphate the increase was 18 percent. However, the quantities of marketable rock used in the production of elemental phosphorus, triple superphosphate, and for direct application to the soil decreased 4 percent, 21 percent, and 27 percent, respectively. The decline in the use of phosphate rock for electric-furnace elemental phosphorus was believed to be due to decreasing demands for phosphorus detergents and increasing power costs. Cutbacks in triple superphosphate production were attributed to the large stock inventories held over from 1968 and 1969, the years when the demand for fertilizers was depressed.

The total quantity of phosphate rock (P_2O_5 content) sold or used by producers for agricultural uses increased 10 percent, but a 4-percent decline was reported for industrial uses.

Table 3.—Florida phosphate rock sold or used by producers, by kinds

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
	Hard rock				Soft rock			
1966	49	17	$437	$8.92	45	9	$293	$6.51
1967	--------	--------	--------	--------	36	7	266	r 7.39
1968	--------	--------	--------	--------	30	6	224	7.47
1969	--------	--------	--------	--------	30	6	221	r 7.37
1970	--------	--------	--------	--------	24	5	168	7.00
	Land pebble				Total [1]			
1966 [2]	28,043	9,077	$184,075	$6.56	28,137	9,103	$184,805	$6.57
1967 [2]	29,796	9,646	193,283	6.49	29,832	9,654	193,548	6.49
1968 [2]	29,571	9,504	173,190	5.86	29,601	9,510	173,413	5.86
1969 [2]	28,835	9,307	155,197	5.38	28,865	9,313	155,418	5.38
1970 [2]	30,268	9,713	153,471	5.07	30,292	9,717	153,639	5.07

r Revised.
1 Data may not add to totals shown because of independent rounding.
2 Includes North Carolina.

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
1966	3,076	799	$23,497	$7.64
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

1 Includes Alabama.

Table 5.—Phosphate rock sold or used by producers in the United States, by grades and States

(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
1969								
Below 60	48	11	2,261	582	2,856	697	5,165	1,291
60 to 66	1,570	472	880	253	261	75	2,710	799
66 to 70	11,827	3,694	44	14	572	176	12,443	3,884
70 to 72	1,822	590	8	3	799	256	2,629	848
72 to 74	8,101	2,682	--------	--------	184	62	8,285	2,744
Plus 74	5,497	1,864	--------	--------	--------	--------	5,497	1,864
Total [4]	28,865	9,313	3,193	851	4,672	1,266	36,730	11,431
1970								
Below 60	38	8	1,828	464	2,865	719	4,731	1,192
60 to 66	1,735	497	1,240	365	231	69	3,206	932
66 to 70	12,442	3,861	114	35	418	131	12,974	4,027
70 to 72	3,155	1,016	2	1	933	297	4,090	1,313
72 to 74	8,377	2,781	--------	--------	--------	--------	8,377	2,781
Plus 74	4,544	1,554	--------	--------	--------	--------	4,544	1,554
Total [4]	30,292	9,717	3,184	864	4,447	1,217	37,923	11,798

[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.
[2] Includes North Carolina.
[3] Includes Alabama.
[4] Data may not add to totals shown because of independent rounding.

Table 6.—Phosphate rock sold or used by producers, by uses and States

(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
1969								
Domestic:								
Agricultural	17,501	5,629	-------	-------	1,039	328	18,540	5,958
Industrial	553	166	3,193	851	3,107	772	6,853	1,789
Total	18,054	5,795	3,193	851	4,146	1,100	25,393	7,747
Exports	10,811	3,519	-------	-------	525	166	11,336	3,685
Total [3]	28,865	9,313	3,193	851	4,672	1,266	36,730	11,431
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	10,319	3,347	-------	-------	576	180	10,895	3,528
Total [3]	30,292	9,717	3,184	864	4,447	1,217	37,923	11,798

[1] Includes North Carolina.
[2] Includes Alabama.
[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 uses

(Thousand short tons and thousand dollars)

Use	1969			1970		
	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
Domestic:						
Phosphoric acid (wet process)	9,839	3,113	$53,081	11,992	3,772	$63,151
Electric furnace phosphorus	6,758	1,759	39,794	6,456	1,709	34,097
Triple superphosphate	3,934	1,289	21,970	3,090	995	17,515
Ordinary superphosphate	3,524	1,150	18,799	4,154	1,366	20,877
Direct application to the soil	157	44	848	114	30	596
Nitraphosphate; Stock and poultry feed; Fertilizer filler; Other fertilizers; Other uses	1,181	392	7,630	1,222	399	7,595
Total	25,393	7,747	142,122	27,028	8,271	143,831
Exports	11,336	3,685	62,288	10,895	3,528	55,799
Grand total [1]	36,730	11,431	204,409	37,923	11,798	199,629

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

STOCKS

Yearend stocks of marketable phosphate rock as reported by producers showed an increase of 6 percent over that of 1969. Because of numerous inventory adjustments, however, data are not comparable with those of 1969.

Table 8.—Producer stocks of marketable phosphate rock, December 31

(Thousand short tons)

Source	1969		1970	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida [1]	11,626	3,653	12,995	4,071
Tennessee [2]	218	49	210	43
Western States	1,853	574	1,361	352
Total	13,697	4,276	14,566	4,466

[1] Includes North Carolina.
[2] Includes Alabama.

PRICES

Prices for various grades of Florida land-pebble phosphate rock as quoted by the Oil, Paint and Drug Reporter are shown in table 9. There were no changes from those quoted for 1969. There were no published prices for marketable rock produced in the other States because their production is not generally marketed, but is used captively by the producers.

Actual prices of Florida and North Carolina phosphate rock are not quoted because they are usually agreed upon through direct negotiation between buyer and seller. The published prices are used as a basis for negotiation; the final selling price is generally somewhat lower. Price cutting and special discounts on contracts continued during the year and the average value reported by producers dropped to a record low of $5.07 per ton.

Table 9.—Prices of Florida land-pebble, unground, washed and dried phosphate rock, in bulk, carlots, at mine, in 1970

(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: Oil, Paint and Drug Reporter.

FOREIGN TRADE

According to the Bureau of Census, the total quantity of phosphate rock exported increased 3 percent over that of 1969. This quantity was 843,000 tons more than that reported by the producers. This would indicate considerable foreign trade activity by other than producers. The average export value per ton for Florida phosphate rock dropped to a new low of $5.12 f.o.b. plant, more than 6 percent less than in 1969. Japan, Canada, West Germany, and Italy were the major importers of U.S. phosphate rock.

In addition to the exports of marketable phosphate rock (table 10) and superphosphates (table 11), the United States also exported ammonium phosphates, reported in table 5 of the Nitrogen chapter, and mixed fertilizers containing phosphates. Data on the latter are not available.

Phosphate rock imported chiefly for use as animal feed supplement came from the Netherlands Antilles, 73 percent; Mexico, 23 percent; and Canada, 4 percent. Mexico began shipping triple superphosphate to Gulf Coast ports in an effort to tap the U.S. market. Fertilizantes Fosfatados Mexicanos, S.A. (FFM) purchases Florida phos-

Table 10.—U.S. exports of phosphate rock, by grades and countries

(Thousand short tons and thousand dollars)

Grade and destination	1969		1970	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Australia	112	$1,011	--------	--------
Austria	139	974	81	$579
Belgium-Luxembourg	414	3,116	396	2,516
Brazil	259	2,312	464	3,933
Canada	1,713	13,967	1,674	12,474
Chile	7	42	44	339
Colombia	20	120	41	263
El Salvador	13	83	15	92
France	312	2,174	376	2,518
Germany, West	1,189	8,005	1,430	9,060
India	307	2,254	494	3,212
Italy	1,359	9,305	1,407	9,840
Japan	2,048	17,259	2,083	17,696
Korea, Republic of	604	4,131	537	3,707
Mexico	766	5,010	794	4,603
Netherlands	319	2,097	507	3,428
New Zealand	16	161	13	95
Norway	17	134	--------	--------
Peru	8	55	9	74
Philippines	183	1,280	113	744
Spain	345	2,567	133	950
Taiwan	78	524	132	1,029
United Kingdom	119	1,151	34	321
Uruguay	11	99	26	262
Yugoslavia	--------	--------	22	982
Other	49	358	98	763
Total	10,407	78,189	10,923	79,480
Other phosphate rock: [1]				
Afghanistan	5	363	--------	--------
Belgium-Luxembourg	([2])	20	1	56
Brazil	([2])	22	([2])	29
Canada	726	6,301	563	7,646
Colombia	([2])	11	1	67
Costa Rica	--------	13	1	27
France	([2])	6	([2])	7
Germany, West	46	385	33	261
Iran	6	553	1	440
Japan	2	20	6	81
Mexico	56	439	108	843
Netherlands	21	167	4	27
Norway	89	711	89	641
Paraguay	--------	--------	3	180
Other	11	218	5	113
Total	962	9,229	815	10,418
Grand total	11,369	87,418	11,738	89,898

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.
[2] Less than ½ unit.

phate rock and converts it into triple superphosphate using Mexican sulfur. Most of the production is for export. FFM has an advantage of backhaul transportation cost to the United States because the same vessels that carry phosphate rock from Florida to its plant at Coatzacoalcos, Veracruz, take triple superphosphate to New Orleans.

There was an 87-percent increase in quantity of ammonium phosphate imported for fertilizer use. All imported ammonium phosphate came from Canada.

The quantity of dicalcium phosphate imported in 1970 was more than double that in 1969; 91 percent of the total came from Belgium-Luxembourg.

Table 11.—U.S. exports of superphosphates (acid phosphates), by countries

(Thousand short tons and thousand dollars)

Destination	1969		1970	
	Quantity	Value	Quantity	Value
Argentina	6	$260	15	$664
Australia	5	179	(1)	5
Belgium-Luxembourg	11	350	21	748
Brazil	138	5,917	192	6,993
Canada	50	2,706	90	4,177
Chile	127	4,270	132	4,313
Colombia	48	1,796	31	1,198
Costa Rica	5	226	5	176
Dominican Republic	7	271	5	189
Ecuador	4	258	4	183
France	38	1,385	23	676
Germany, West	20	713	2	93
Hong Kong	--------	--------	2	115
Indonesia	33	1,397	1	55
Iran	--------	--------	12	414
Italy	20	729	13	427
Jamaica	4	93	5	267
Japan	30	1,148	50	1,549
Korea, Republic of	2	131	--------	--------
Malaysia	18	823	(1)	1
Mexico	1	101	12	100
Nansei and Nanpo Islands	1	36	--------	--------
Netherlands	91	3,871	18	652
Nicaragua	6	328	1	20
Pakistan	20	899	39	1,838
Poland and Danzig	24	866	52	1,674
Singapore	11	516	3	158
Spain	29	1,176	--------	--------
Turkey	34	1,150	--------	--------
Uruguay	35	1,244	--------	--------
Venezuela	3	119	3	103
Vietnam, South	--------	--------	24	1,156
Yugoslavia	11	386	--------	--------
Other	15	578	19	701
Total	847	33,922	774	28,645

[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	1969		1970	
	Quantity	Value	Quantity	Value
Phosphates, crude and apatite	140	$3,554	136	$3,790
Phosphatic fertilizers and fertilizer materials	83	3,976	110	5,679
Ammonium phosphates, used as fertilizers	245	16,625	457	25,086
Bone ash, bone dust, bone meal and bones ground, crude, or steamed	4	298	7	451
Manures, including guano	--------	--------	(1)	3
Basic slag	(1)	(1)	--------	--------
Dicalcium phosphate	14	605	33	1,534

[1] Less than ½ unit.

WORLD REVIEW

The addition of new phosphoric acid production facilities throughout the world in 1968–70 was detailed in a two-part article published in 1970. The first part[2] dealt with increased capacity in Europe and the Americas; the second part[3] dealt with expansion in the rest of the world.

World phosphoric acid production capacity, in terms of P_2O_5 content, totaled 12,957,000 tons. During 1968–69, 42 new plants came on stream and the productive capacity of 38 established plants was increased. An additional 15 new plants were scheduled to come on stream in 1970.

[2] Journal of World Phosphorus and Potassium. New Phosphoric Acid Capacity. No. 45, January–February 1970, pp. 11–14.

[3] Journal of World Phosphorus and Potassium. New Phosphoric Acid Capacity. No. 47, May–June 1970, pp. 18–19.

Table 13.—Phosphate rock: World production, by countries

(Thousand short tons)

Country [1]	1968	1969	1970 [p]
North America:			
United States	41,251	37,725	38,739
Mexico	29	36	52
Netherlands Antilles [2]	103	125	[e] 120
South America:			
Argentina (guano)	(3)	1	NA
Brazil:			
Apatite	159	[e] 165	[e] 165
Phosphate rock	3	[e] 3	[e] 3
Chile (guano)	[r] 25	19	[e] 19
Colombia	--------	13	[e] 17
Peru (guano)	[r] 85	[e] 22	[e] 20
Venezuela	[e] 66	[e] 66	34
Europe:			
France (phosphatic chalk)	26	34	[e] 34
Poland [e]	105	110	110
U.S.S.R.:			
Apatite (marketable concentrate, 39 percent P_2O_5)	[r] 10,700	11,600	12,000
Sedimentary rock (marketable concentrate, 19 to 25 percent P_2O_5)	[r] 8,800	9,650	10,470
Africa:			
Algeria	[r] 404	463	[e] 630
Morocco	11,587	11,753	12,565
Senegal:			
Aluminum phosphate	[r] 177	181	144
Calcium phosphate	[r] 1,224	1,141	1,100
Seychelles Islands (guano) [2]	3	12	[e] 12
South Africa, Republic of	[r] 1,725	1,851	1,857
Togo	1,515	1,624	1,662
Tunisia	3,796	2,960	3,325
Uganda (apatite)	157	[e] 160	241
United Arab Republic	1,588	728	[e] 770
Asia:			
China, mainland [e]	1,100	1,200	1,300
Christmas Island (Indian Ocean) [2]	1,247	1,297	[e] 1,300
India:			
Apatite	7	10	17
Phosphate rock	--------	76	165
Israel	856	1,088	1,102
Jordan	[r] 1,281	1,198	1,323
Korea, North (apatite) [e]	[r] 330	330	330
Turkey	--------	2	--------
Vietnam, North:			
Apatite [e]	1,100	1,300	1,100
Phosphate rock [e]	55	55	55
Oceania:			
Australia	6	20	[e] 22
Nauru Island [2]	2,485	2,423	[e] 2,425
Ocean Island [2]	582	622	[e] 630
Total	[r] 92,577	90,063	93,858

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

[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 estimates of output levels.

[2] Exports.

[3] Less than ½ unit.

Angola.—The Companhia dos Fosfatos de Angola, S.A.R.L. (COFAN) confirmed the existence of high-quality phosphate deposits in commercial quantities. Reserves at the firm's Cabinda concession have been estimated at 15 million tons. Before the deposits can be developed, however, an economic method of transportation must be found. Cabinda has no deep water harbors and the Continental Shelf is shallow and wide.

Australia.—A press release on November 19, 1970 announced that a new fertilizer company, Consolidated Fertilizer Ltd., had been formed and registered in Brisbane. The new firm is jointly owned by Imperial Chemical Industries of Australia and New Zealand, Ltd. (ICIANZ), The Dow Chemical Co., and Swift and Co. and was formed to be a vehicle for the proposed merger of these three companies' investments in the fertilizer industry.[4]

Broken Hill South Ltd. confirmed the existence of substantial phosphate rock at four new sites in Northwest Queensland.[5] Samples of previously discovered deposits were obtained for beneficiation testing at a pilot plant at the Australian Mineral Development Laboratories.

Colombia.—A new plant to process about 9.6 million tons of phosphate rock per year was scheduled to go on stream in mid-1971. Located at Turmeque in the Department of Boyacá, the plant is a project of the Institute of Industrial Development. The experience gained there will aid the Institute with similar projects at four other locations.

Hungary.—A contract was awarded to Wellman-Lord, Inc., to construct a large nitrophosphate fertilizer plant in Hungary. The plant is reported to be the largest of its kind in the world and the first in Eastern Europe to use the Norsk-Hydro nitrophosphate process.

India.—Production of phosphate rock continued to accelerate, but the output was still well below engineering capacity. Imports of P_2O_5 fertilizers reached a peak in 1967–68 and have declined since Indian production began to supply a larger share of the home market. Large-scale mining and production operations have been proposed that could raise annual production of phosphate rock considerably in the next few years. If long-range goals for the utilization of phosphatic fertilizer are realized, increased production and imports will be necessary to meet the additional requirements.

A new plant for the production of complex fertilizers was under construction at Manali.[6] The facility, owned by Madras Fertilizers, Ltd., was designed to produce 634,000 tons of complex fertilizers from imported raw materials.

Japan.—Nippon Chemical Industrial Company was negotiating a long-term supply contract with Albright and Wilson, Ltd., a British chemical group, for bulk phosphorus. The phosphorus would be shipped from Long Harbour, Newfoundland, to Japan in special phosphorus bulk carrier ships. Albright and Wilson owns two such ships, each capable of carrying 5,000 tons of molten phosphorus.[7]

Mexico.—The Government-owned Guanos y Fertilizantes de Mexico, S.A. (Guanomex), absorbed two smaller fertilizer companies, Montrose Mexicana and Lerma Industrial, S.A., and thus strengthened its domination of the domestic market. Guanomex, in an agreement with the Government of Guatemala, will build a fertilizer plant at San Marios, on the Mexican border. About half the output of this plant will be exported to southern Mexico.

Fertilizantes Fosfatados Mexicanos, S.A. (FFM) continued developing export markets for its production of phosphoric acid and granulated triple superphosphate. Contracts were reported to have been signed with firms in Australia, India, Ecuador, and Chile. Storage tank terminals for phosphoric acid were being designed for installation at Santos, Brazil, and Rijeka, Yugoslavia. Late in 1969, FFM signed a contract to deliver an undisclosed quantity of each of its products to Guanomex.

Morocco.—The phosphate industry in Morocco continued to suffer from high production costs and increasing competition from major world producers. To become more competitive, the Office Chérifien des Phosphates (OCP) invested heavily in new equipment and conducted studies of current processing operations to

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[4] U.S. Embassy, Melbourne, Australia. State Department Airgram A–134, Nov. 27, 1970, pp. 1–4.
[5] Phosphorus & Potassium (London). New Plants and Projects. No. 47, May–June 1970, p. 14.
[6] Phosphorus & Potassium (London). Madras Fertilizers' Manali Complex. No. 48, July–August 1970, pp. 15–16.
[7] Oil, Paint and Drug Reporter. Phosphorus for Japan Arranged in A & W Pact. V. 197, No. 15, Apr. 13, 1970, pp. 3, 30.

resolve major technical problems. In spite of the competition, phosphate exports rose substantially.

The development of the phosphate resources at Ben Guerir reportedly was abandoned, and instead, OCP planned to concentrate on Grand Daoui, a newly developed mining operation within the Khouribga zone of deposits. West German credits (amounting to about $12 million) will be used to finance the project.

Nauru.—On June 30, 1970, the British Phosphate Commissioners (BPC) formally transferred its phosphate operations on Nauru to the Nauru Phosphate Corp. BPC will continue to sell most of the phosphate. Nauru has exported nearly all of its production to Australia and New Zealand, but has sold some to Japan, and it is hopeful of gaining a share of the large Japanese market.

Senegal.—Compagnie Sénégalaise des Phosphates de Taiba completed important modifications of its calcium phosphate production facilities near Thiés and added new equipment. Production capacity was raised to about 1.5 million short tons per year. An article describing the Taiba phosphate mine and beneficiation operation was published.[8]

Spanish Sahara.—Construction of a phosphate preparation plant to treat the production from the deposit at Bu-Craa should be completed in 1971. The plant initially will treat 5 million tons per year of phosphate rock containing about 65 percent tricalcium phosphate to produce about 3.3 million tons of concentrate containing 75 to 80 percent tricalcium phosphate. Expansion plans for the future call for an annual production of 10 million tons of concentrate. The concentrate will be transported to the Atlantic port of El Aiún by a conveyor belt system, the longest of its kind in the world. A pier built to accommodate deep draft cargo vessels of 100,000 deadweight tons has been completed. Fosfatos du Bu Craa, S.A., of Madrid has been formed to operate the venture.[9]

Tunisia.—A major expansion program for the phosphate rock industry in Tunisia envisions an increase in mining capacity to 5 million tons in 1972 and to 8 million tons in 1976.[10] The program calls for three new mines, a new phosphoric acid and fertilizer complex, and major new facilities at Gabes for shipping rock and derived products. Reserves of phosphate rock in Tunisia exceed 1.2 billion tons, approximately one-third of which is minable.

Turkey.—Geologists of the Turkish Mineral Research and Prospection Institute reported the discovery of a large high-grade phosphate deposit at Yayladag, near Antakya.

United Arab Republic (U.A.R.).—An agreement between the United Arab Republic and the Soviet Union for the construction of a phosphate plant at Kena, using loans from the U.S.S.R., was ratified in August. Production is scheduled to begin by 1973. When in full operation, capacity will be 120,000 tons per year, half of which will be exported to the U.S.S.R. to repay the loans.

Exploration of phosphate rock deposits in the Abu Tartour Mountains and between Kharga and Dukhla is continuing.

According to reports, under construction was an elemental phosphorus plant that will use electric power from the new Aswan Dam of Upper Egypt. The plant is being built with Soviet aid and will have Soviet furnaces and other equipment. It is expected that over 50 percent of the phosphorus output will be shipped to Soviet Black Sea ports in repayment for the financing.[11]

TECHNOLOGY

Beneficiation techniques used to process Florida phosphate rock were described in an article which noted that although the basic flowsheet has remained nearly unchanged for the past 2 decades, there have been many refinements of the process in recent years.[12] The principal changes have been an increase in the size of plants and equipment, the use of cyclones to facilitate

[8] Phosphorus & Potassium (London). The Taiba Phosphate Rock Mine. No. 47, September–October 1970, pp. 26–30.

[9] Mining Journal. Spanish Sahara Project. V. 276, No. 7064, Jan. 8, 1971, p. 23.

[10] Phosphorus & Potassium (London). Major Expansion Planned by Tunisian Phosphate Industry. No. 46, March–April 1970, pp. 23–25.

[11] European Chemical News. U.S.S.R. Aids U.A.R. Phosphate Project. V. 18, No. 456, Oct. 30, 1970, p. 14.

[12] Aparo, S. J. Improving Techniques Get More Out of Florida Phosphate. Min. Eng. v. 22, No. 5, May 1970, pp. 76–77.

the removal of slimes, improvement of flotation reagents, and innovations to the flotation of coarse phosphate.

A process to produce totally water-soluble P_2O_5 from phosphate rock, using only nitric acid for digestion, was described.[13] The process successfully uses solvent extraction to remove calcium present in the form of calcium nitrate, and produces P_2O_5 in the form of pure crystalline monoammonium phosphate, instead of phosphoric acid.

Hot briquetting of phosphate ore for use as furnace feed in the production of elemental phosphorus and phosphoric acid was described in an article that detailed the various methods used and the comparative costs involved.[14]

A new method for production of phosphoric acid for the food industries was introduced by Toyo Soda Manufacturing Co., Ltd., Tokyo, Japan.[15] The new process employs a unique extraction technology that is flexible enough to economically produce either food-grade or technical-grade phosphoric acid.

Modifications of the wet process for manufacturing phosphoric acid by Japanese manufacturers were detailed.[16] Two of the modifications outlined resulted in a higher phosphoric acid yield and a higher quality gypsum byproduct.

A process was developed by The Garrett Research and Development Co., subsidiary of Occidental Petroleum Corp., Los Angeles, Calif., to reduce problems encountered in producing superphosphoric acid.[17] The process reportedly produces a high-quality superphosphoric acid with a 55- to 59-percent conversion (the ratio of polyphosphoric acids to the total P_2O_5 content) at 71 to 74 percent P_2O_5. A submerged combustion dip-tube arrangement (U.S. Patent 3,276,443) and a scrubbing train (U.S. Patent 3,276,510) are two significant units in the design that distinguishes the system from others.

The wet process incorporating an isothermal reactor for the production of phosphoric acid was described.[18] The addition of the reactor was designed to reduce capital and operational costs, permit the use of coarser rock grinds, improve P_2O_5 recovery efficiency, and produce more uniform gypsum crystals.

Another article described the use of a special reactor unit in the wet-process for the manufacture of phosphoric acid which promised to lower capital, operating, and maintenance costs.[19] This process, called the Kellogg-Lopker process, is supposed to reduce rock grinding requirements, scaling, and sludge buildup and to increase the rate of filtration.

Swift Agricultural Chemicals Inc. of Chicago developed a process for the production of monoammonium phosphate that was said to reduce both investment and operating costs.[20]

The Bureau of Mines Tuscaloosa Metallurgy Research Laboratory continued research on developing a beneficiation process for the economic recovery of phosphate values from Florida pebble containing excessive silica and dolomite. Flotation concentrates, containing 32 to 33 percent P_2O_5 were obtained with about 80-percent phosphate recovery. Additional study is required to improve the method and to recover more of the fine phosphate lost when the pebble (plus 14 mesh) is ground to 28 to 35 mesh for flotation. Research to develop new or to improve current beneficiation methods for recovering phosphate concentrates from low-grade siliceous and calcareous Tennessee phosphates was continued. The Laboratory scientists were also studying possibilities of improving the disposal of Florida phosphate slimes.

The Albany Metallurgy Research Center of the Bureau of Mines directed research toward improving the flotation of carbonate gangue from unaltered phosphate rock. Liberation of the phosphate was the major problem encountered in the treatment.

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[13] Phosphorus & Potassium (London). Production of Water-Soluble P_2O_5 by Nitric Acid Attack. No. 46, March–April 1970, pp. 32–34.

[14] Phosphorus & Postassium (London). Hot Briquetting of Phosphorus Furnace Feed. No. 48, July–August 1970, pp. 19–21.

[15] Japan Chemical Review. Phosphoric Acid Purification Process. June 1970, p. 57.

[16] Japan Chemical Review. NKK Process Phosphoric Acid Plant. June 1970, p. 56.

———. Wet-Process Phosphoric Acid Manufacture by the Central-Prayon Process. June 1970, p. 64.

[17] Stern, D. R., and J. D. Ellis. Processing Problems Pared for Superphosphoric Acid. Chem. Eng. v. 77 No. 6, Mar. 23, 1970, pp. 98–101.

[18] Rushton, W. E. Isothermal Reactor Improves Phosphoric-Acid Wet Process. Chem. Eng. v. 77, No. 4, Feb. 23, 1970, pp. 80–82.

[19] Bostwick, L. E. Loop System Slashes Costs for Making Phosphoric Acid. Chem. Eng. v. 77, No. 8, Apr. 20, 1970, pp. 100–103.

[20] Chemical Age. Swift Develops Low Cost Process for MAP. V. 100, No. 2645, Mar. 27, 1970, p. 9.

The process involves fluosilicic acid depression of the phosphate minerals and a fatty acid emulsion flotation of the carbonate gangue minerals. At the Albany Research Center, scientists were engaged in developing a two-stage acidulation process for treating phosphate rock to produce phosphoric acid. It would allow for the recovery of a fluorine product and a high-purity gypsum product.

Platinum-Group Metals

By Francis C. Mitko [1]

The platinum shortage of the late 1960's reversed itself sharply in 1970, and a market oversupply was reflected in falling prices and consumption. Prices of all platinum-group metals, except osmium and ruthenium, continued the slide begun in 1969, and platinum dealer prices fell below producer prices in the third quarter for the first time. Dealer's prices of all platinum-group metals except osmium were below producer's prices at yearend. Consumption, measured by sales to consuming industries, declined 2 percent for platinum-group metals.

Of particular importance to long-run demand, was the passage of the Clean Air Act of 1970 which set strict standards for automobile exhaust emissions in 1975. If the automobile manufacturers decide to meet the 1975 emission standards by using platinum catalysts, the sales of platinum in the United States would be boosted considerably.

World output of the metals increased 23 percent as production in the Republic of South Africa expanded in anticipation of large sales to the automotive industry particularly in the United States, and perhaps worldwide. However, the major South African producers cut back expansion plans in late 1970 when the market was slow to materialize. Canadian production increased from the low levels caused by strikes in 1969. U.S. production declined 19 percent, although refinery output of new metal was up.

U.S. exports declined 17 percent; imports were up 16 percent. Stocks declined 29 percent, and production of secondary metal was down 6 percent.

Legislation and Government Programs.—The Clean Air Act of 1970 set automotive emission standards for 1975 and 1980 as follows (based on cold start) in maximum permissible grams per mile:

	Carbon monoxide	Hydrocarbons	Nitrogen oxides
1975	11.0	0.50	0.90
1980	4.7	.25	.45

These standards were 90-percent below emission levels common for automobiles in 1970. Automobile manufacturers stated that technology did not exist to meet the hydrocarbon and nitrogen oxide standards simultaneously. Two companies, Universal Oil Products Corp. (UOP) and Engelhard Minerals & Chemicals Corp. announced development of platinum-based catalytic mufflers in 1970 that would at least control the hydrocarbon and carbon monoxide

[1] Economist, Division of Nonferrous Metals.

Table 1.—Salient platinum-group metals statistics

(Troy ounces)

	1966	1967	1968	1969	1970
United States:					
Mine production [1]	51,423	16,365	14,793	21,586	17,885
Value	$3,106,993	$1,428,863	$1,500,603	$2,094,607	$1,520,958
Refinery production:					
New metal	73,615	29,663	12,305	17,875	21,395
Secondary metal	103,321	365,799	329,455	371,659	349,126
Exports (except manufactures)	205,456	279,852	395,157	501,064	413,766
Imports for consumption	1,352,256	1,321,278	1,773,984	1,225,851	1,423,090
Stocks Dec. 31: Refiner, importer, dealer	1,129,604	869,211	802,711	1,077,478	765,936
Consumption	1,675,795	1,334,296	1,376,911	1,357,344	1,335,467
World: Production	3,039,449	3,175,309	3,393,749	3,431,155	4,215,922

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.

emissions. Both mufflers require nonleaded gasoline. It is interesting to note that nine cars met the 1975 emission standards in the Clean Air Race of 1970 from Cambridge, Mass., to Pasadena, Calif. (sponsored by Wayne State University, Detroit, Mich.), and one, using nonleaded gasoline and four platinum catalytic mufflers, even met the 1980 standards.

Table 2.—Government inventory of platinum-group metals, December 31, 1970

(Troy ounces)

Metal	National stockpile	Supplemental stockpile	Objective
Iridium	[1] 17,072	---------	17,000
Palladium	502,152	747,680	1,300,000
Platinum	[2] 400,036	49,999	555,000

[1] Excludes 184 ounces nonstockpile grade.
[2] Includes 32,006 ounces reserved for upgrading.

At yearend, the national stockpile contained 502,152 ounces of palladium, an increase of 167,883 ounces over stocks at yearend 1969. Out of an original 200,000-ounce contract for upgrading the platinum in the stockpile, entered March 17, 1969, all but 32,006 ounces had been upgraded by the close of the year. There is no longer an objective for ruthenium; disposal of 2,500 ounces of ruthenium from the supplemental stockpile was completed in 1970.

The Bureau of Mines began a study of secondary recovery of platinum-group metals in the United States. Although the main purpose is to find areas in which platinum is lost and which might be recovered with further research, it is anticipated that the final report will be a complete and detailed study of the secondary recovery industry.

DOMESTIC PRODUCTION

Refinery output of new platinum metals increased 20 percent, but production of the secondary metals declined 6 percent. Domestic output is derived as a byproduct of copper refining and from the dredging of Alaskan placers.

Toll refining of platinum-group metals decreased 23 percent in 1970 to a total of 1,721,870 ounces. Used materials accounted for 84 percent of toll refining, and the balance was virgin materials. The total amounts in troy ounces treated on toll in 1970 were as follows, with the corresponding 1969 amounts in parentheses: Platinum, 1,079,736 (1,207,559); palladium 569,711 (945,106); rhodium, 56,746 (73,139); iridium, 5,659 (9,186); osmium, 958 (2,197); and ruthenium, 9,060 (8,609).

Table 3.—New platium-group metals recovered by refiners in the United States by sources

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1966	30,048	31,367	3,979	1,533	5,650	1,038	73,615
1967	20,296	8,262	754	151	189	11	29,663
1968	6,302	5,358	454	95	90	6	12,305
1969:							
From domestic sources: Crude platinum; gold and copper refining	8,702	8,224	570	135	70	11	17,712
From foreign crude platinum	------	163	------	------	------	------	163
Total	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

Table 4.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1966	49,563	50,009	402	728	2,434	185	103,321
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	118,221	207,582	1,927	121	13,394	7,881	349,126

CONSUMPTION AND USES

Overall sales of platinum-group metals to consuming industries decreased 2 percent to 1,335,467 ounces. The chemical, petroleum, and electrical industries accounted for 82 percent of the total platinum-group metals consumed in 1970, compared with 77 percent in 1968 and 1969.

Platinum sales increased slightly to 516,008 ounces owing entirely to a threefold increase in purchases by the petroleum industry. Platinum sales to all other industries fell. The bulk of platinum sales in 1970 were distributed among petroleum refiners (35.1 percent), manufacturers of organic and inorganic chemicals (28.5 percent), and electrical and electronic equipment manufacturers (17.1 percent).

Palladium sales declined 3 percent despite substantial increases in sales to the petroleum and glass industries, and slight increases in sales for dental and medical uses. Market declines were in sales of palladium to the chemical industry (down 28,507 ounces), to the electrical industry (down 11,169 ounces), and for miscellaneous uses (down 11,739 ounces). Most palladium sales however, were to the electrical industry (56.9 percent), and the chemical industry (25.3 percent).

Iridium sales declined 23 percent, despite slight increases in sales for glass, electrical, and dental and medical uses. There were no sales of iridium to the petroleum industry, and sales for chemical, jewelry, and miscellaneous uses declined 620, 1,109, and 447 ounces, respectively. Sales of osmium increased 16 percent, and sales of ruthenium increased 24 percent; sales of rhodium declined 2 percent, compared with those in 1969. Rhodium, iridium, and ruthenium are used primarily as alloys with platinum or palladium.

In the chemical industry one of the major uses for platinum (alloyed with 10 percent rhodium) is as a catalyst in nitric acid production for use in fertilizers and explosives. In 1970, Engelhard Minerals announced a new precious-metal catalyst system referred to as "Random Pack" for the production of nitric acid by oxidation of ammonia. The Random Pack system apparently uses 60-percent less platinum with no loss in catalyst efficiency. It can be used with a Degussa palladium-gold alloy catchment gauze, or "getter", which could capture 27 to 29 percent of the platinum lost to volatilization in the nitric acid manufacturing process. Union Carbide Corp. and Engelhard formed a new organization Metal Anode Associates, to produce and market platinum-coated titanium anodes for the electrolysis of brine.[2]

The emphasis on controlling air pollution resulted in several new developments in the use of platinum by the petroleum industry. Most proposed catalytic devices for controlling automotive exhaust emissions require unleaded gasoline. Because achieving high-octane levels without the use of lead requires greater treatment of petroleum feedstocks, platinum usage in petroleum refining increased in 1970. However, application of a new platinum-rhenium catalyst to refining, requiring much less platinum, is expected to offset the demand for this purpose. The city of Chicago had UOP platinum-based Purzaust converters installed on 50 of the city's automobiles as part of its 18-month clean air test program. Engelhard Minerals also negotiated to install their platinum-based system on 50 of Chicago's cars.[3]

More uses were found for platinum-iridium alloys in crucibles for growing crystals for lasers, optical modulators, and other scientific applications. Platinum is also used for fiberglas spinnerettes.

Platinum and palladium alloy pastes were used increasingly in ceramic hybrid microcircuits, and surface coatings on electronic components. The platinum, especially in combination with gold, produces a highly conductive film that resists high temperatures. Platinum and palladium were also used in furnace windings, thermocouples, and many other electrical applications. Engelhard produced a fuel cell using a platinum metal catalyst to produce electrical energy in the 20- to 2,000-watt power range by the electrochemical combination of atmospheric oxygen and hydrogen from ammonia. Platinum and chromium were used to give razor blades a hard, corrosion-resistant edge. The Pacemaker, developed by Medtronic, Inc., used platinum electrodes to stimulate the heart

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[2] American Metal Market. New Forms of Platinum Flow From Researchers. V. 77, No. 171, Sept. 8, 1970, p. 14A.

[3] Metals Week. Mounting the Attack on Auto Exhaust. V. 41, No. 39, Sept. 28, 1970, p. 22.

muscle.[4] Testing continued on the previously unrecognized ability of platinum compounds to inhibit leukemia and sarcoma malignancies in mice.[5]

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
1966	690,787	894,212	10,993	1,836	69,688	8,279	1,675,795
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:							
Chemical	175,436	214,508	6,171	873	18,060	8,696	423,744
Petroleum	58,602	1,337	1,328	-----	2,341	9	63,617
Glass	63,350	3,891	232	-----	10,839	------	78,312
Electrical	112,589	430,258	2,154	5	10,788	2,057	557,851
Dental and medical	22,266	52,326	709	555	339	218	76,413
Jewelry and decorative	36,161	21,837	2,941	-----	5,622	1,915	68,476
Miscellaneous	47,174	34,581	683	39	2,155	4,299	88,931
Total	515,578	758,738	14,218	1,472	50,144	17,194	1,357,344
1970:							
Chemical	147,029	186,001	5,551	992	26,445	13,825	379,843
Petroleum	181,014	15,494	------	-----	59	156	196,723
Glass	34,577	21,147	408	-----	7,138	------	63,270
Electrical	88,146	419,089	2,224	2	9,054	2,554	521,069
Dental and medical	19,794	54,426	717	661	51	260	75,909
Jewelry and decorative	30,093	17,507	1,832	-----	5,343	3,115	57,890
Miscellaneous	15,355	22,842	236	52	805	1,473	40,763
Total	516,008	736,506	10,968	1,707	48,895	21,383	1,335,467

Table 6.—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
1966	459,669	574,651	20,677	2,559	57,737	14,311	1,129,604
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	346,935	333,256	13,330	1,868	47,766	22,781	765,936

STOCKS

During the year, stocks of all platinum-group metals held by refiners, importers, and dealers declined, a total of 29 percent. Individual declines in percent were as follows: Platinum, 6; palladium, 45; iridium, 8; osmium, 35; rhodium, 14; and ruthenium, 8.

Yearend stocks of platinum and palladium held in the New York Mercantile Exchange depositories totaled 19,550 and 32,700 ounces, respectively. This is an increase of 12,450 ounces of platinum but a decrease of 84,800 ounces of palladium during the year.

PRICES

The producer's price remained at $130 to $135 per ounce throughout the year for platinum, $200 to $225 per ounce for osmium, and $50 to $55 per ounce for ruthenium. Palladium prices fell $1 to $36—$38 per ounce; iridium prices declined, $10 to $150—$155 per ounce; and rhodium dropped $15 to $205—$210 per ounce.

Declines in dealer's prices more clearly reflected the general slump in the nation's economy. The dealer's prices for all plati-

[4] American Metal Market. New Forms of Platinum Flow From Researchers. V. 77, No. 39, Sept. 28, 1970, pp. 5A, 7A.

[5] Platinum Metals Review. Some Biologic Effects of Platinum Compounds. V. 15, No. 2, Apr. 7, 1971, p. 42.

num-group metals except osmium were below producer's prices at the end of 1970. Platinum fell from between $177 and $179 per ounce to between $122 and $125 per ounce during the year. Palladium fell from between $35.50 and $36 per ounce to $35 and $35.50 per ounce. Rhodium fell from between $215 and $220 per ounce to between $202 and $205 per ounce, and iridium fell from between $160 and $162 per ounce to between $145 and $148 per ounce. Osmium remained at $220 to $225 per ounce and ruthenium stayed at $45 per ounce.

The future market for platinum declined, with the Mercantile Exchange quotations for April delivery of platinum falling from between $165 and $167.50 per ounce on January 5, 1970, to between $121.50 and $122 per ounce at yearend, but March quotes for delivery of palladium rose from between $32.50 and $33.50 per ounce to between $33.40 and $33.75 per ounce during the same period.

FOREIGN TRADE

Exports of platinum increased 21 percent, but those of the remaining platinum-group metals decreased 48 percent. Platinum accounted for 65 percent of platinum-group exports in 1970. Exports to West Germany accounted for 34 percent of the platinum, and 44 percent of the remaining group metal exports in 1970; Japan received 19 percent of the platinum and 14 percent of the remaining group metals, and the United Kingdom received 23 percent of the platinum and 2 percent of the remaining group metals. The total export values for platinum and remaining group metals were $32,978,000 and $10,034,000 respectively, for a grand total of $43,012,000 in 1970. This compared with $46,711,000 in 1969. New export classifications, established January 1, 1970, were used in compiling table 7.

U.S. imports of platinum-group metals increased 16 percent in quantity to 1,423,090 troy ounces and 12 percent in value to $104,871,000.

Imports from most countries dropped. Those from Belgium-Luxembourg were down by 66,353 ounces and those from Canada, by 49,796 ounces. However, higher imports from the Republic of South Africa, up 108,839 ounces, the U.S.S.R., up 204,259 ounces, the United Kingdom, up 44,225 ounces; Mexico, up 1,436 ounces; and Japan, up 14,860 ounces; resulted in a net increase in total group metal imports in 1970. The United Kingdom accounted for 45.8 percent of total imports of platinum-group metals, the U.S.S.R. for 34.7 percent, and the Republic of South Africa for 8.1 percent.

Table 7.—U.S. exports of platinum-group metals, by countries

Year and destination	Platinum and platinum-group ores, concentrates, waste and scrap, and sweepings		Platinum, unworked or partly worked		Platinum-group metals unworked or partly worked, n.e.c.	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1969:						
Argentina	------	------	------	------	318	$14
Australia	------	------	------	------	2,159	90
Belgium-Luxembourg	36,038	$1,572	4,758	$600	6,167	222
Brazil	------	------	252	48	1,751	120
Canada	140	1	586	83	13,650	563
France	196	32	11,812	1,401	7,108	485
Germany, West	4,282	935	60,204	10,958	134,171	6,824
Hong Kong	------	------	771	124	39	2
Italy	------	------	7,941	994	23,533	1,388
Japan	407	86	22,551	4,099	32,642	2,742
Mexico	------	------	429	63	3,591	160
Netherlands	------	------	19,794	2,975	14,661	896
Switzerland	266	145	2,850	166	29,912	1,904
United Kingdom	31,768	3,044	18,111	2,980	5,751	850
Other	125	7	288	43	2,042	95
Total	73,222	5,822	150,347	24,534	277,495	16,355

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:[1]												
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

[1] New classifications established Jan. 1, 1970.

Table 8.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)
1968	1,773,984	$125,692
1969 [r]	1,225,851	93,899
1970	1,423,090	104,871

[r] Revised.

Table 9.—U.S. imports for consumption of platinum-group metals, by countries

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)
1969:												
Australia	205	$34	------	------	7,622	$867	------	------	------	------	------	------
Belgium-Luxembourg	494	89	5,447	$767	73,564	1,350	------	------	731	$30	114	$34
Canada	165	26	10,874	1,375	19,580	1,254	2,497	$438	27,994	r 1,230	12,654	2,995
Colombia	18,951	3,192	8,735	1,501	2,598	323	------	------	------	------	------	------
France	------	------	147	25	3	(1)	------	------	------	------	------	------
Germany, West	120	15	4,822	593	(1)	1	------	------	1,849	73	245	42
Japan	------	------	------	------	1,720	448	1	(1)	8,112	345	------	------
Mexico	44	13	------	------	4,907	182	------	------	------	------	------	------
Netherlands	------	------	847	141	2,574	169	------	------	25,410	1,457	978	236
Norway	3,345	618	1,755	328	------	------	------	------	3,225	115	300	34
South Africa, Republic of	------	------	125	21	5,503	414	------	------	------	------	179	27
Spain	------	------	------	------	------	------	------	------	------	------	------	------
Switzerland	------	------	3,457	430	------	------	------	------	6,196	293	249	60
U.S.S.R.	3,253	895	------	------	------	------	------	------	3,778	150	2,620	622
United Kingdom	40,433	4,733	236,585	28,484	933	32	3,440	589	171,569	6,697	20,738	4,565
Other	550	126	------	------	8,049	382	------	------	525	20	------	------
Total	67,560	9,741	272,794	33,665	r 127,053	5,422	5,938	1,027	249,389	r 10,410	38,077	8,615
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	300	84	1,655	222	128	16	------	------	2,509	85	959	175
Japan	1,141	198	7,639	1,094	10,225	1,501	------	------	502	18	------	------
Mexico	37	5	------	------	6,374	120	------	------	------	------	------	------
Netherlands	25	3	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	6,448	456	------	------	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	437	------	------	------	------	------	------
Total	28,937	3,828	346,069	39,585	64,096	6,578	8,459	1,239	270,134	9,896	38,626	7,541

See footnotes at end of table.

Table 9.—U.S. imports for consumption of platinum-group metals, by countries—Continued

Year and country	Unwrought				Semimanufactured								Total	
	Ruthenium		Other platinum-group metals		Platinum		Palladium		Rhodium		Other platinum-group metals			
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1969:														
Australia	------	------	------	------	------	------	------	------	------	------	------	------	7,827	$901
Belgium-Luxembourg	------	------	88	$14	94	$24	------	------	5	$1	------	------	80,537	2,309
Canada	------	------	------	------	577	30	------	------	------	------	200	$8	74,541	r 7,356
Colombia	------	------	1,200	184	------	------	------	------	------	------	------	------	31,484	5,200
France	------	------	3,669	607	------	------	------	------	------	------	------	------	3,819	632
Germany, West	------	------	------	------	4,119	545	------	------	------	------	------	------	11,155	1,269
Japan	------	------	15	1	------	------	13,767	$555	------	------	------	------	23,615	1,349
Mexico	------	------	------	------	24	6	------	------	------	------	------	------	4,975	201
Netherlands	------	------	------	------	------	------	------	------	------	------	------	------	29,809	2,003
Norway	------	------	38	8	2,225	428	r 2,613	91	------	------	------	------	r 13,501	1,622
South Africa, Republic of	------	------	487	82	367	45	------	------	------	------	------	------	6,661	589
Spain	------	------	------	------	------	------	16,076	563	------	------	------	------	16,076	563
Switzerland	------	------	1,906	92	359	45	2,229	92	------	------	------	------	14,396	1,012
U.S.S.R.	------	------	------	------	10,206	1,970	266,097	9,857	3,233	407	978	161	290,165	14,062
United Kingdom	7,540	$390	3,729	638	40,278	4,925	82,001	3,122	149	36	275	21	607,670	54,232
Other	26	1	470	70	------	------	------	------	------	------	------	------	9,620	599
Total	7,566	391	11,602	1,696	58,249	8,018	r 382,783	14,280	3,387	444	1,453	190	r 1,225,851	r 93,899
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	2,168	73	506	71	4	4	10,331	882
Japan	------	------	------	------	14,408	627	------	------	3,760	233	800	104	38,475	3,775
Mexico	------	------	------	------	------	------	------	------	------	------	------	------	6,411	125
Netherlands	------	------	------	------	------	------	------	------	------	------	------	------	10,021	1,002
Norway	------	------	------	------	1,748	275	2,100	70	------	------	------	------	11,676	1,036
South Africa, Republic of	------	------	------	------	------	------	1,952	69	160	11	------	------	115,500	13,508
Switzerland	247	10	7	(1)	1,017	153	27	1	------	------	(1)	(1)	1,671	203
U.S.S.R.	------	------	------	------	30,524	5,312	389,031	13,659	------	------	------	------	494,424	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	695
Total	20,816	984	9,242	495	124,867	16,323	503,822	17,532	4,986	428	3,036	442	1,423,090	104,871

r Revised.
[1] Less than ½ unit.

WORLD REVIEW

Total world production of platinum-group metals was up 23 percent in 1970, primarily as a result of completion of 1970 expansion plans by Rustenburg Platinum Mines Ltd., and by Impala Platinum Ltd., both of the Republic of South Africa. Production by the U.S.S.R. was also assumed to have risen. Canadian production recovered from the long strike in 1969. Columbia, Ethiopia, and Japan each produced small amounts of the platinum metals. Drilling during the year indicated fairly high platinum values on the Northwest Oil and Minerals Co. property in western Australia and on the Georgia-Kaolin Co. property near Kerikeri, North Auckland, New Zealand, but the sampling has been insufficient to support the elaborate claims that were made for the finds.

Canada.—The Canadian output of platinum-group metals increased by 49 percent to 461,200 ounces. The production in 1969 was low because of a 130-day strike at the International Nickel Co. of Canada Ltd. (INCO). The effects of the strike were still being felt in early 1970. Most of Canada's production comes as a byproduct of nickel mining and refining in the Sudbury district of Ontario. Canada is the world's third largest producer of platinum-group metals. INCO operated 12 mines, four mills, and two smelters for the treatment of platinum-bearing nickel-copper ores in the Sudbury area. Matte from the smelters was refined at the company refinery at Port Colborne, Ontario, and the precious-metal sludges shipped to the company refinery at Acton, England, for processing. INCO was developing four mines near Sudbury, and a fifth at Shebandowan, Ontario, in 1970. Falconbridge Nickel Mines Ltd. operated eight mines, four mills, and one smelter in the Sudbury area. Nickel-copper matte containing precious metals was shipped from the smelter to the company refinery at Kristiansand, Norway, for refining. Precious-metal sludges were shipped to the United States for refining by Engelhard Minerals.

Consolidated Canadian Faraday Ltd. at Gordon Lake, Ontario, shipped nickel-copper concentrates to INCO at Sudbury for treatment. Dumbarton Mines, in the Bird River area of Manitoba started production in 1969 and shipped ore to the mill of Consolidated Canadian Faraday. Renzy Mines in Hainault Township, Quebec, started production from its mine and mill in 1969 and shipped its concentrates to Falconbridge for smelting.[6]

Colombia.—Production of platinum-group metals by Colombia decreased 5 percent to 26,358 ounces. The largest producer in the country, International Mining Corp., operated five dredges in the Choco district and a newly acquired, 8-cubic-foot dredge in the Nariño district.

[6] Northern Mines (Toronto). Platinoids Surplus for a While With Expanding Production. No. 37, Dec. 3, 1970, p. 11.

Table 10.—Platinum-group metals: World production, by countries

(Troy ounces)

Country [1]	1968	1969	1970 [p]
Canada:			
Platinum and platinum-group metals	485,891	310,404	461,200
Colombia:			
Placer platinum	22,280	27,805	26,358
Ethiopia:			
Placer platinum	349	343	273
Japan:			
Palladium from refineries	3,651	3,877	4,610
Platinum from refineries	2,785	3,140	3,296
South Africa, Republic of:			
Platinum-group metals from platinum ores [e]	850,000	950,000	1,500,000
Osmiridium from gold ores (sales) [e]	14,000	14,000	2,800
U.S.S.R.:			
Placer platinum and from platinum-nickel copper ores [e]	2,000,000	2,100,000	2,200,000
United States:			
Crude placer platinum and byproduct metals recovered largely from domestic gold and copper refining	14,793	21,586	17,385
Total	3,393,749	3,431,155	4,215,922

[e] Estimate. [p] Preliminary.
[1] In addition to the countries listed, New Guinea also produces platinum but production is less than ½ unit.

South Africa, Republic of.—For the eighth consecutive year, output of platinum-group metals expanded. Certain phases of the expansion plans announced in earlier years by Rustenburg Platinum and Impala Platinum were completed in 1970, and output increased 56 percent to 1,502,800. However, when dealer's prices began to drop below producer's prices in late 1970, further expansion plans were curtailed. Rustenburg announced plans in early 1970 to increase its production from the anticipated 1.1-million-ounce annual rate in 1970, to about 1.3 million ounces per year by mid 1972. Part of this expansion was to come from opening the company's Union Section on Middellaagte and Amandebult farms at a cost of $28 million. By yearend these plans had been deferred, with the new north section only prepared to the pre-shaft-sinking stage.

Impala announced in early 1970 that its Bafokeng mine, which was then producing approximately 150,000 ounces per year and expected to produce at 180,000 ounces per year at yearend, would be developed to 250,000 ounces per year in 1971, and 300,000 ounces per year in 1972. Late in 1970, Impala announced that it had already reached an annual rate of 250,000 ounces and were deferring further expansion plans. Impala sells platinum-group metals through Ayreton Metals, a subsidiary, and sells copper and nickel on the free market.

Western Platinum Ltd. (Lonrho Ltd. of London, 51 percent; Falconbridge Nickel Mines of Toronto, 24.5 percent; and Superior Oil Co. of Houston, Tex., 24.5 percent) announced in 1970 that they would open two mines in the Merensky Reef. One mine at Middelkraal was developed to an inclined depth of 1,810 feet in 1970 and was expected to produce 50,000 to 60,000 ounces per year. The first concentrator was near completion with a capacity of 60,000 ounces per year. Milling was scheduled to begin in April 1971.

Western Platinum's second mine, at Wonderkop, was planned for a depth of 2,000 to 4,000 feet and an output initially set at 200,000 ounces per year. Later plans called for a combined target of 430,000 ounces per year by 1974–75 from the two mines and for 20 percent of their revenue to come from sales of nickel. Western Platinum planned to send the matte to Falconbridge Nickel's refinery at Kristiansand, Norway, for recovery of the copper and nickel. The precious-metals-bearing residues would then be returned to South Africa for refining.

Atok Investments, (Pty) Ltd., continued work on its Middlepunt farm property in the Lydenburg area. The company, owned by Anglo-Transvaal Consolidated Investment Co., Ltd., United States Steel Corp., and Middle Witwatersrand Ltd. contracted to sell through their exclusive sales agent, Leonard J. Buck, Inc., of New York.

Other areas with active exploration in 1970 were on the Der Brochen farm in the Rustenburg area (by the Rand Mines group, Anglo-American, and General Mining) and an open pit mine in the Groblersdal District of Transvaal (by a corsortium led by Klockner-Werke of West Germany, with an 11.7-percent interest held by Sherritt Gordon Mines Ltd. of Canada).

TECHNOLOGY

The Chemical and Metallurgical Division of Sylvania Electrical Products, Inc. marketed a coated molybdenum heating coil that is supposed to provide cost savings of 40 percent over platinum and platinum-rhodium coils. The coils were designed for use in an oxidizing environment where high-temperature heat sources are required, such as in sealing of glass diodes and for home and industrial gas dryers.[7]

Permanent cathodic protection systems using platinized electrodes developed by Engelhard Minerals over 15 years ago found significant new uses in the control of corrosion in metal, chemical, petroleum, sewage disposal, and water supply industries. Of particular interest was its use in protecting the world's largest floating drydock, built at Bethlehem Steel's San Francisco shipyard. The drydock was designed to hold 150,000-ton tankers, and uses a Capac cathodic protection system.[8]

Expanded platinum-clad tantalum anodes, trademarked Permanode[R], for gold

[7] American Metal Market. Coated Moly Coils Produce Savings Over Platinum-Type. V. 77, No. 104, June 2, 1970, p. 15.

[8] American Metal Market. Platinum-Columbium Anodes Protect Floating Dry-Dock. V. 77, No. 24, Feb. 4, 1970, p. 9.

and rhodium electroplating were introduced by Sel-Rex Corp. The new anodes reportedly offer the same performance and life, at lower cost, as the solid platinum anodes they are to replace.[9]

An ion-exchange resin capable of recovering up to 100 percent of the gold and other precious metals dissolved in acid solution was described in Haifa, Israel, by Herbert Bernstein, Technical Director of the Technion Research and Development Foundation, Ltd. The resin, known as Srafion NMRR, was first discovered in 1964 by Gabriella Schmuckler of Technion's Department of Chemistry and has since been developed further by her. The resin has the ability to discriminate between noble and base metals. The gold, platinum, and related metals collect on the resin, from which they may be removed by roasting or eluting, while the common metals pass throug the ion-exchange column without collecting or seriously interfering with collection of gold.[10] The resin is further described in a Bureau of Mines publication.[11]

A new concept was used to develop a miniaturized gas chromatograph-mass spectrometer-computer system measuring 7 by 9 by 11 inches for use on the Viking Lander Mars Probe, which is expected to land on Mars in 1975. The concept uses the selective permeability of hydrogen through a palladium transmodulator. The concept could potentially be used to make an integrated-circuit gas chromatograph in which all components could be laid down on a small chip 1 by 2 centimeters.[12]

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[9] American Metal Market. Platinum-Clad Tantalum Mesh Anodes Available. V. 77, No. 25, Feb. 5, 1970, p. 14.

[10] Secondary Raw Materials. New Process to Recover Precious Metals Developed by Technion Research. V. 8, No. 12, December 1970, pp. 51, 52.

[11] Green, Thomas E., and S. L. Law. Properties of an Ion Exchange Resin With High Selectivity for Gold. BuMine Rept. of Inv. 7385, 1970, 9 pp.

[12] Chemical & Engineering News. Palladium May Lead to Thumbnail-Scale GC. V. 48, No. 35, Aug. 24, 1970, p. 33.

Potash

By Donald E. Eilertsen [1]

A hike of $5 per ton in average sales value, record apparent consumption and import tonnages, and sharp declines in sales and export tonnages were some of the highlights for potash materials in the United States in 1970. World production of potash (K_2O) exceeded 20 million tons for the first time.

Legislation and Government Programs.—No action was taken by the 91st Congress, 2d Session, on three bills concerning the imports of potassium chloride. The legislative proposals were: (1) S.344, a bill to impose annual quotas on the quantity of potassium chloride or muriate of potash which may be imported into the United States; (2) S.2883 and (3) H.R. 14941, identical bills to provide for the imposition of a duty on excessive imports of potassium chloride or muriate of potash.

No special dumping duties were assessed during 1970 on Canadian, French, and West German potassium chloride which, according to findings of the U.S. Department of the Treasury and U.S. Tariff Commission late in 1969, had been sold in the United States at less than fair prices.

Table 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Production of potassium salts, marketable	5,701	5,649	4,769	4,918	4,853
Approximate K_2O equivalent	3,320	3,299	2,722	2,804	2,729
Value	$122,210	$105,313	$75,664	$73,572	$98,123
Sales of potassium salts by producers	5,377	5,363	5,091	5,340	4,703
Approximate K_2O equivalent	3,133	3,126	2,913	3,069	2,669
Value at plant	$116,340	$100,566	$81,620	$78,062	$92,373
Average value per ton	$21.64	$18.75	$16.03	$14.62	$19.64
Imports for consumption of potash materials	2,544	2,929	3,658	3,978	4,418
Approximate K_2O equivalent	1,491	1,708	2,172	2,340	2,612
Value	$71,821	$73,649	$78,077	$67,094	$101,337
Exports of potash materials	1,053	1,175	1,336	1,259	1,047
Approximate K_2O equivalent	621	693	748	709	572
Value	$38,159	$39,896	$43,467	$37,773	$36,940
Apparent consumption of potassium salts [1]	6,868	7,117	7,413	8,059	8,074
Approximate K_2O equivalent	4,003	4,141	4,337	4,700	4,709
World: Production, marketable:					
Approximate K_2O equivalent	16,059	17,353	17,867	18,810	p 20,443

p Preliminary.
[1] Measured by sold or used plus imports minus exports.

DOMESTIC PRODUCTION

Production of marketable potassium salts, potassium monoxide (K_2O) equivalent, was 2.7 percent less than in 1969 and 17.8 percent below the record established in 1966. The decline from 1969 was caused mainly by reduced outputs of potash in Michigan and Utah. The general decline in production since 1966 has been attributed mostly to the large quantities of potassium muriate imported from Canada. New Mexico accounted for 87.6 percent of the national output of K_2O equivalent.

[1] Physical scientist, Division of Nonmetallic Minerals.

The average grade of crude potassium salts mined in New Mexico was 18.1 percent K_2O, compared with 18.4 percent in 1969.

Thirteen firms in five States produced marketable potassium salts. They were Duval Corp., International Minerals & Chemical Corp., Kerr-McGee Corp., National Potash Co., Potash Co. of America, Southwest Potash Corp., and United States Potash & Chemical Co., all in New Mexico; Kerr-McGee Corp., formerly American Potash & Chemical Corp., in California; Marquette Cement Manufacturing Co. in Maryland; The Dow Chemical Co. in Michigan; and Texas Gulf Sulfur Co., Kaiser Aluminum & Chemical Corp., and Great Salt Lake Minerals & Chemicals Corp. (GSL), all in Utah.

The Dow Chemical Co. discontinued the recovery of potassium salts from brine in Michigan at midyear.

Texas Gulf Sulphur Co. announced in July that it was discontinuing conventional underground mining of potash at its Cane Creek mine near Moab, Utah, and converting to solution mining, the conversion to be completed by mid-1971. The mine will be flooded with water, and brine containing both potash and salt will be withdrawn through drilled wells. Solar evaporation of the brine in specially constructed ponds will concentrate the salts, which will be processed in the existing facilities.

The new facilities of GSL for producing a variety of products from solar-evaporated brine from the North Arm of Great Salt Lake came on stream about October. The plant, located near Little Mountain, Utah, is scheduled to produce 240,000 tons of potassium sulfate, 150,000 tons of sodium sulfate, and up to 500,000 tons of magnesium chloride annually. Approximately 2 years are required for the brine to pass through the vast complex of solar evaporation ponds covering 20 square miles. Each year 10 million tons of salts will be precipitated, of which approximately 2.5 million tons will be processed into marketable products.[2]

Searles Lake Chemical Co., a subsidiary of Occidental Petroleum Corp., was constructing facilities to produce potassium sulfate, borax, sodium borate, and soda ash from Searles Lake (California) brines. Production is expected in the latter part of 1972.

[2] Engineering and Mining Journal. Utah Company Gets Set To Tap Mineral Wealth of Great Salt Lake. V. 171, No. 4, April 1970, pp. 67–70.

Table 2.—Marketable potassium salts produced and sold or used in the United States, in 1970, by product

(Thousand short tons and thousand dollars)

Muriate of potash, 60 percent K_2O minimum	Production			Sold or used		
	Gross weight	K_2O equivalent	Value [1]	Gross weight	K_2O equivalent	Value
January–June 1970:						
Standard	813	496	$12,887	960	585	$14,661
Coarse	595	364	11,333	583	357	11,280
Granular	441	268	9,057	396	241	8,078
Total [2]	1,848	1,128	33,277	1,939	1,182	34,018
Other potassium salts [3]	662	279	15,765	672	292	15,703
Total [2]	2,511	1,407	49,043	2,611	1,475	49,722
July–December 1970:						
Standard	753	459	13,603	818	498	14,337
Coarse	540	330	10,851	482	295	9,699
Granular	462	281	10,037	332	202	7,153
Total [2]	1,755	1,071	34,491	1,632	995	31,189
Other potassium salts [3]	587	252	14,589	460	200	11,463
Total	2,342	1,323	49,080	2,092	1,195	42,652
Grand total [2]	4,853	2,729	98,123	4,703	2,669	92,373

[1] Derived from reported value of "Sold or used."
[2] Data may not add to totals shown because of independent rounding.
[3] Figures for refined muriate and manure salts are included with potassium sulfate and potassium-magnesium sulfate to avoid disclosure of company confidential data.

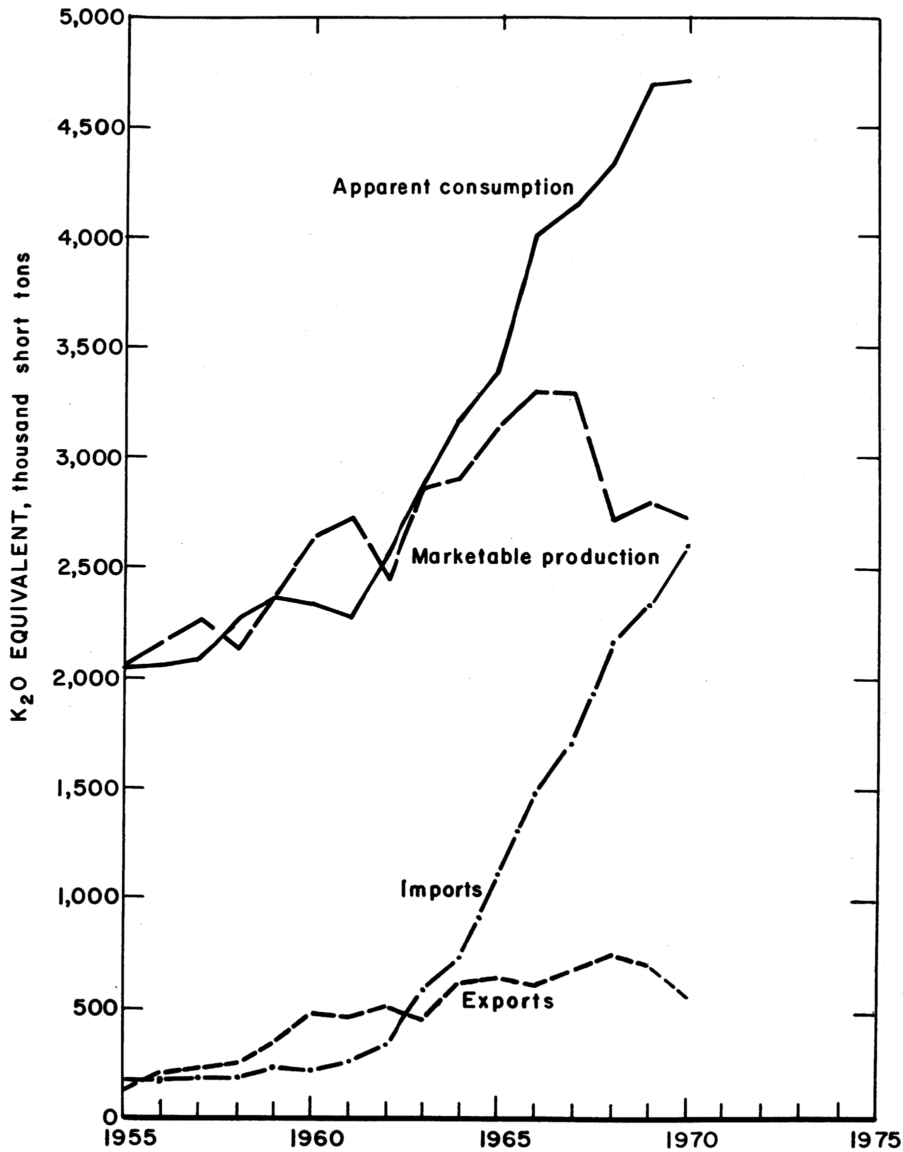

Figure 1.—Marketable production, apparent consumption, exports, and imports of potassium salts measured in K_2O equivalent.

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
1969:								
January–June	7,962	1,472	2,117	1,194	$31,742	2,591	1,466	$37,641
July–December	7,558	1,389	2,014	1,133	30,293	1,842	1,055	27,222
Total [3]	15,519	2,861	4,131	2,327	62,034	4,433	2,521	64,863
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

[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.

CONSUMPTION AND USES

Apparent consumption of potassium salts in the United States, measured by the quantity sold or used by domestic producers plus imports minus exports (K_2O equivalent), was the largest ever reported.

Deliveries of domestic and imported potash salts for agricultural and chemical purposes in the United States, totaling 4.5 million tons of K_2O equivalent, were the second largest ever reported, or 2.8 percent below the record of 1969. Deliveries for agricultural purposes accounted for 95.5 percent of the total. Illinois, Iowa, Indiana, and Ohio received 33 percent of the deliveries for agriculture, while New York continued to be the leading recipient of potash for chemical purposes.

Potassium chemicals have a large number of uses, including applications in ceramics, explosives, glass, medicines, photography, gold and silver recovery, scintillation, and textiles.

Table 4.—Deliveries of potash salts in 1970, by State of destination

(Short tons K_2O equivalent)

Destination	Agricultural potash	Chemical potash	Destination	Agricultural potash	Chemical potash
Alabama	106,879	29,478	Nebraska	33,502	376
Arizona	1,089	17	Nevada	-------	692
Arkansas	66,044	471	New Hampshire	253	161
California	46,877	4,909	New Jersey	10,776	1,198
Colorado	9,066	84	New Mexico	1,439	341
Connecticut	4,057	200	New York	72,878	71,816
Delaware	15,231	10,654	North Carolina	141,359	70
District of Columbia	298	-------	North Dakota	9,794	-------
Florida	260,307	1,152	Ohio	247,468	7,231
Georgia	199,648	744	Oklahoma	28,900	359
Hawaii	22,816	-------	Oregon	10,995	1,036
Idaho	8,027	-------	Pennsylvania	42,782	3,853
Illinois	467,623	26,088	Rhode Island	1,831	696
Indiana	332,109	5,011	South Carolina	87,838	140
Iowa	371,684	1,414	South Dakota	9,147	32
Kansas	30,229	1,936	Tennessee	93,720	54
Kentucky	77,958	11,746	Texas	231,631	12,072
Louisiana	68 430	650	Utah	523	93
Maine	16,248	48	Vermont	4,848	16
Maryland	98,739	1,143	Virginia	131,033	398
Massachusetts	3,079	251	Washington	23,102	992
Michigan	113,848	1,589	West Virginia	3,689	1,581
Minnesota	325,001	517	Wisconsin	183,672	651
Mississippi	110,750	7	Wyoming	2,178	170
Missouri	163,594	1,536			
Montana	2,016	-------	Total	[1] 4,295,005	[2] 203,673

[1] Distribution of K_2O—1,435,002 tons as standard muriate, 1,504,932 tons as coarse muriate, 865,239 tons as granular muriate, 280,210 tons as soluble muriate, and 209,622 tons as sulfates.
[2] Distribution of K_2O—180,570 tons as muriate, 18,169 tons as soluble muriate, and 4,934 tons as sulfates.

Source: Potash Institute of North America, Atlanta, Ga.

STOCKS

Producers' yearend stocks of potassium salts, K_2O equivalent, were 15.8 percent larger than those in 1969. Yearend stocks of imported potash 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
1966	12	1,215	690
1967	12	1,501	863
1968	13	1,175	676
1969	12	723	392
1970	13	875	454

PRICES

The downward trend in prices of potassium muriate from 1966 to 1969 was reversed in 1970, as a result of the Saskatchewan government invoking its Potash Conservation Regulations of 1969, effective January 1, 1970. The unusually low prices of muriate in 1969 were mostly attributed to oversupply, particularly in North America. Competitors bidding for markets continually slashed prices. Saskatchewan not only put quantitative controls on its tremendous potash output potential, but also established a minimum price on Saskatchewan standard muriate at 33.75 cents (Canadian) per unit of K_2O equivalent, corresponding to $20.25 (US $18.75) per ton of muriate containing 60 percent K_2O.

Quoted prices of various potash materials for 1970 are shown in tables 6, 7, and 8.

The influence of the Saskatchewan regulations on domestic muriate prices may be illustrated as follows: The average sales value of domestic standard, coarse, and granular muriate, f.o.b. plants, was $12.76 per ton in 1969, compared with $18.26 per ton in 1970. Imports for consumption of muriate from Canada were valued at an average of $14.72 per ton at Canadian shipping points in 1969, compared with $20.77 per ton in 1970.

Table 6.—Prices for potassium products in 1970 [1]

Product	Jan. 1	July 3	July 24	Sept. 4	Dec. 31
Potassium chloride, chemical-grade (95 to 99 percent KCl), per short ton	$28.00–30.00	----------	----------	----------	$28.00–30.00
Potassium muriate, per unit-ton: [2]					
Standard, (60 percent K_2O minimum):					
New Mexico and Utah	.33–.335	----------	$0.33–0.34	----------	.33–.34
Trona, Calif. (freight equalized)	.42	----------	.43	----------	.43
Saskatchewan, Canada	.314	$0.314–0.3375	[3] .33–.3375	----------	.33–.3375
Coarse:					
New Mexico and Utah	.37–.375	----------	.37–.38	$0.39	.39
Trona, Calif. (freight equalized)	.46	----------	.47	----------	.47
Saskatchewan, Canada	.35–.351	.35–.3775	[3] .37–.3775	.39–.40	.39–.40
Granular:					
New Mexico and Utah	.39–.395	----------	.39–.40	.41	.41
Saskatchewan, Canada	.37	.37–.3975	[3] .39–.3975	.41–.42	.41–.42
Potassium sulfate, per unit-ton: [2] Agricultural, (50 percent K_2O minimum);					
Standard: Carlsbad, N. Mex	.80	----------	----------	----------	.80
Granular: Carlsbad, N. Mex	.90	----------	----------	----------	.90
Potassium manure salt, (20 percent K_2O minimum) [2]	.1765	----------	----------	----------	.1765

[1] Bulk, carlots, works.
[2] 20 pounds of equivalent K_2O.
[3] Starting July 24, the outside of the price range was quoted in Canadian funds.

Source: Oil, Paint and Drug Reporter.

Table 7.—Bulk prices for potash in 1970 [1]

(U.S. cents per unit K_2O)

Product	Jan. 1	Aug.	Sept.–Dec.
Muriate, 60 percent K_2O minimum:			
Carlsbad, N. Mex.:			
Standard	33	33	33.75
Coarse	37	37	39
Granular	39	39	41
Potasco, Saskatchewan:			
Standard	31.4	33	33.75
Coarse	35	37	39
Granular	37	39	41
Sulfate of potash, 50 percent K_2O minimum:			
Carlsbad, N. Mex.:			
Regular	80	80	--
Granular	90	90	--
Mine-run salts, 20 percent K_2O minimum, Carlsbad, N. Mex	17.65	17.65	--

[1] Carlots, f.o.b. cars.

Source: Potash Company of America, Division of Ideal Basic Industries, Inc.

Table 8.—Bulk prices for California potash [1]

(Cents per unit K_2O)

Product	1970		
	Jan.	July	Dec.
Muriate, 60 percent K_2O minimum:			
Standard	42	43	43
Coarse	46	47	47
Sulfate, 52 percent K_2O minimum:			
Standard	98	--	98
Granular	108	--	108

[1] Kerr-McGee Chemical Corp., formerly American Potash & Chemical Corp.—carlots f.o.b. Trona, Calif. Muriate quotations from price schedules dated Jan. 1, 1970, and July 1, 1970. Sulfate quotations from price schedule dated Dec. 1, 1969.

FOREIGN TRADE

Exports of 1.05 million tons of potash materials for fertilizer and chemical purposes in 1970 were 21.7 percent below the peak of 1968, and 16.9 percent below the level of 1969. The declines were largely attributed to smaller exports to various countries, particularly Japan, or more precisely, to loss of business to foreign potash-producing countries. Four countries received 52.8 percent of the total exports of potash materials for fertilizer purposes. They were Japan, 24.5 percent; Brazil, 10 percent; Taiwan, 9.4 percent; and Australia, 8.9 percent. Brazil received 58.1 percent of the total exports of potash materials for chemical purposes.

Imports for consumption of potash materials, totaling 4.42 million tons, were 11.1 percent above the record of 1969; the gain was mostly in muriate from Canada. Muriate continued to be the major imported potash material (96.3 percent), and Canada, which supplied 4.14 million tons of muriate, was the largest individual supplier for the eighth consecutive year. The average declared value per ton of Canadian muriate (unspecified grade) at Canadian shipping points was $20.77 per ton in 1970, compared with $14.72 per ton in 1969, $19.11 per ton in 1968, $23 per ton in 1967, and $25.36 per ton in 1966.

Table 9.—U.S. exports of potash materials

(Short tons and thousand dollars)

Materials	Approximate equivalent as potash (K_2O) (percent)	1969 Quantity	1969 Approximate equivalent as potash (K_2O) Quantity	1969 Approximate equivalent as potash (K_2O) Percent of total	1969 Value	1970 Quantity	1970 Approximate equivalent as potash (K_2O) Quantity	1970 Approximate equivalent as potash (K_2O) Percent of total	1970 Value
Used chiefly as fertilizers:									
Potassium chloride, all grades	60	1,034,141	620,485	87.5	$25,258	793,763	476,258	83.2	$21,965
Potassic chemical fertilizer, n.e.c	40	197,275	78,910	11.1	7,763	166,202	66,481	11.6	6,317
Natural potassic salt fertilizers, crude	20	1,220	244	----	40	6,445	1,289	.2	208
Total	--	1,232,636	699,639	98.6	33,061	966,410	544,028	95.0	28,490
Used chiefly in chemical industries:									
Potassium hydroxide	80	2,878	2,302	.1	455	6,853	5,482	1.0	969
Potassium peroxide	83	3	2	----	1	-------	-------	--------	-------
Potassium compounds, n.e.c	31	23,739	7,359	1.3	4,256	73,524	22,792	4.0	7,481
Total	--	26,620	9,663	1.4	4,712	80,377	28,274	5.0	8,450
Grand total	--	1,259,256	709,302	100.0	37,773	1,046,787	572,302	100.0	36,940

Table 10.—U.S. exports of potash materials, by countries

(Short tons and thousand dollars)

Destination	Fertilizer: Chloride quantity	Fertilizer: Chemical fertilizer, n.e.c. quantity	Fertilizer: Total Quantity	Fertilizer: Total Value	Chemical: Hydroxide caustic quantity	Chemical: Other n.e.c. quantity	Chemical: Total Quantity	Chemical: Total Value
1969:								
Australia	88,570	5,262	93,832	$2,630	217	455	672	$160
Belgium-Luxembourg	72	111	183	14	------	38	[1] 41	[1] 13
Brazil	134,966	11,889	146,855	3,218	386	925	1,311	253
Canada	800	59,660	[2] 61,169	[2] 2,556	1,437	7,093	8,530	1,480
Chile	19,683	3,750	23,433	615	5	105	110	36
Colombia	19,021	17,669	36,690	980	41	25	66	22
Costa Rica	12,114	10,276	22,390	564	1	8	9	4
India	------	------	------	------	44	27	71	21
Japan	335,747	33,123	368,870	9,635	------	5,406	5,406	237

Korea, Republic of	79,435	------	79,435	1,721	------	81	81	15
Mexico	39,704	21,146	[2] 60,880	[2] 1,614	48	1,812	1,860	428
Netherlands	12,322	------	12,322	275	48	104	152	65
New Zealand	63,517	646	64,163	2,173	7	103	110	34
Pakistan	------	------	------	------	46	463	509	91
Philippines	39,522	------	39,522	751	5	66	71	56
Sweden	10,255	281	10,536	341	------	102	102	27
Taiwan	102,906	18,575	121,481	2,946	------	1	1	3
Venezuela	16,087	1,819	17,906	481	70	251	321	82
Other countries	59,420	13,068	[2] 72,969	[2] 2,547	523	6,674	7,197	1,685
Total	1,034,141	197,275	1,232,636	33,061	2,878	23,739	26,620	4,712
1970:								
Australia	80,174	5,796	85,970	2,218	271	504	775	186
Belgium-Luxembourg	------	55	55	4	3	87	90	58
Brazil	85,562	11,228	96,790	2,480	1,218	45,447	46,665	1,832
Canada	16,978	48,729	[2] 65,829	[2] 2,543	2,374	7,768	10,142	1,820
Chile	24,618	2,983	27,601	753	16	41	57	19
Colombia	58,351	7,397	65,748	1,849	138	70	208	52
Costa Rica	17,000	7,920	[2] 25,692	[2] 635	4	359	363	19
India	------	------	------	------	------	250	250	58
Japan	200,585	33,338	[2] 236,163	[2] 6,896	------	221	221	93
Korea, Republic of	14,336	------	14,336	382	------	(3)	(3)	(3)
Mexico	36,381	27,291	[2] 64,430	[2] 2,103	659	1,998	2,657	539
Netherlands	------	------	------	------	------	662	662	246
New Zealand	66,858	164	67,022	2,208	14	99	113	34
Pakistan	------	------	------	------	56	5,777	5,833	426
Philippines	28,941	------	28,941	751	9	51	60	46
Sweden	8,660	55	8,715	208	------	106	106	27
Taiwan	91,160	------	91,160	2,653	4	30	34	13
Venezuela	5,588	------	5,588	108	351	345	696	147
Other countries	58,571	21,246	[2] 82,370	[2] 2,699	1,736	9,709	11,445	2,835
Total	793,763	166,202	[2] 966,410	28,490	6,853	73,524	80,377	8,450

[1] Includes potassium peroxide, 1969: Belgium-Luxembourg 5,280 pounds ($681). 1970: none.

[2] Includes crude natural potassic salt fertilizer—1969: Canada, 709 tons ($23,764); Mexico, 30 tons ($992); Bahamas, 44 tons ($2,245); Argentina, 437 tons ($13,195). 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).

[3] Less than ½ unit.

Table 11.—U.S. imports for consumption of potash materials

(Short tons and thousand dollars)

Materials	Approximate equivalent as potash (K_2O) (percent)	1969 Quantity	1969 Approximate equivalent as potash (K_2O) Quantity	1969 Approximate equivalent as potash (K_2O) Percent of total	1969 Value	1970 Quantity	1970 Approximate equivalent as potash (K_2O) Quantity	1970 Approximate equivalent as potash (K_2O) Percent of total	1970 Value
Used chiefly as fertilizers:									
Muriate (chloride)	60	3,829,215	2,297,529	98.2	$57,085	4,256,408	2,553,845	97.8	$88,991
Potassium nitrate, crude	40	11,314	4,526	.2	449	14,531	5,812	.2	812
Potassium sodium nitrate mixtures, crude	14	36,585	5,122	.2	1,370	56,159	7,862	.3	2,231
Potassium sulfate, crude	50	49,327	24,664	1.1	1,799	75,780	37,890	1.5	2,671
Other potash fertilizer material	6	38,834	2,330	.1	1,161	345	(1)	(1)	29
Total	--	3,965,275	2,334,171	99.8	61,864	4,403,223	2,605,409	99.8	94,734
Used chiefly in chemical industries:									
Bicarbonate	46	1,725	794		173	496	228		77
Bitartrate:									
Argols	20	---------	---------		-------	6	(1)		2
Cream of tartar	25	1,338	338		703	1,156	289		657
Carbonate	61	(1)	(1)		1	77	47		14
Caustic	80	1,824	1,459		408	2,812	2,250		509
Chlorate and perchlorate	36	669	241	0.2	150	657	237	0.2	144
Cyanide	70	1,035	725		439	926	648		410
Ferricyanide	42	1,051	441		667	752	316		464
Ferrocyanide	44	730	321		272	1,197	527		457
Nitrate	50	604	302		78	623	312		84
Rochelle salts	22	498	110		203	482	106		214
All other	31	r 3,673	r 1,139		r 2,136	5,657	1,754		3,571
Total	--	r 13,147	r 5,867		r 5,230	14,841	6,715		6,603
Grand total	--	r 3,978,422	r 2,340,038	100.0	r 67,094	4,418,064	2,612,124	100.0	101,337

r Revised.
[1] Less than 1/2 unit.

Table 12.—U.S. imports for consumption of potash materials, by countries

(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)
1969												
Belgium-Luxembourg	---	38	---	---	---	---	---	11	---	739	788	$365
Canada	---	---	---	---	3,708,648	10	163	---	236	38,499	3,747,556	56,256
Chile	---	---	---	---	---	11,036	33,233	---	1,500	---	45,769	1,702
France	13	192	22	80	1,200	40	3,187	---	14,451	1,402	20,587	940
Germany, West	---	631	---	477	69,496	228	2	384	20,732	2,030	93,980	3,290
Israel	---	---	---	---	46,847	---	---	---	---	76	46,923	931
Italy	871	---	---	---	---	---	---	209	12,408	r 80	r 13,568	r 1,069
Japan	---	160	---	265	---	---	---	---	---	r 648	r 1,073	r 991
Netherlands	---	16	---	---	---	---	---	---	---	1,341	1,357	391
Spain	454	---	85	---	3,000	---	---	---	---	201	3,740	403
Sweden	---	787	441	---	---	---	---	---	---	(1)	1,228	350
United Kingdom	---	---	---	161	2	---	---	---	---	219	382	163
Other	---	---	121	52	r 22	---	---	---	---	1,276	1,471	r 243
Total	1,338	1,824	669	1,035	3,829,215	11,314	36,585	604	49,327	r 46,511	r 3,978,422	r 67,094
1970												
Belgium-Luxembourg	---	68	---	---	---	20	---	---	5,968	1,375	7,431	590
Canada	---	---	---	6	4,137,401	30	174	---	---	765	4,138,376	86,641
Chile	---	---	---	---	---	9,402	54,877	---	---	---	64,279	2,518
Congo	---	---	---	---	25,529	---	---	---	---	---	25,529	641
France	12	400	---	45	---	---	---	---	18,724	301	19,482	772
Germany, West	1	650	19	448	14,700	208	---	425	39,920	2,461	58,832	3,389
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)	---	785	1,410	277
Total	1,156	2,812	657	926	4,256,408	14,531	56,159	623	75,780	9,012	4,418,064	101,337

r Revised.
1 Less than ½ unit.

WORLD REVIEW

World production of potash smashed all previous records, and Congo (Brazzaville) also became a major producer of potash.

Canada.—There were 10 potash mines in Saskatchewan in 1970. At yearend, eight were active, one (Cominco, Ltd.) was being dewatered as a result of a serious mine flood in August, and another one (Sylvite of Canada, Ltd.) was almost ready to go on stream. The companies and their potash capacities are as follows:

Company	Location	Annual capacity (million tons) KCl	K_2O equivalent
International Minerals & Chemical Corp., (Canada) Ltd. (IMC):			
K-1	Esterhazy	2.10	1.28
K-2	do	1.72	1.05
Kalium Chemicals, Ltd.	Belle Plaine	1.50	.94
Potash Co. of America (PCA)	Saskatoon	.76	.46
APM Operators, Ltd. (formerly Allan Potash Mines, Ltd.)	Allan	1.50	.91
Alwinsal Potash of Canada, Ltd	Lanigan	1.00	.60
Duval Corp. of Canada	Saskatoon	1.20	.73
Cominco, Ltd	Vanscoy	1.20	.72
Central Canada Potash Co., Ltd. (formerly Potash Division of Noranda Mines, Ltd.)	Vicount	1.50	.90
Sylvite of Canada, Ltd.	Rocanville	1.20	.73
Total		13.68	8.32

The Saskatchewan Government's Potash Conservation Regulations of 1969 which require producers to obtain licenses for potash production and disposal went into effect January 1, 1970. The Minister of Mineral Resources, with guidance from a three-member Potash Conservation Board, determines productive capacities, rates of production and disposal, prices, and other matters concerning potash. Specific regulations were issued for each mine. The minimum sale price for potassium muriate was set at 33.75 cents (Canadian) per unit of K_2O equivalent, corresponding to $20.25 (US $18.75) per ton of muriate containing 60 percent K_2O. The Board's quarterly market allotments of potash for the industry in 1970, based on K_2O equivalent, were 965,000 tons for the first quarter, 948,000 tons for the second quarter, 665,000 tons for the third quarter, and 805,000 tons for the fourth quarter, totaling 3.383 million tons. The regulations were slightly revised effective July 1, 1970. The section dealing with licenses for potash disposal was rescinded. Licenses to produce potash were issued on an annual basis, but subject to quarterly review.

Potash production quotas for the portion of the industry on stream in 1970 totaled 3.45 million tons of K_2O equivalent (including allowances of 91,895 tons for storage purposes) and represented 45.5 percent of the total rated capacity. By companies and in terms of K_2O equivalent, the production quotas were as follows: IMC, 1,130,952 tons (48.5 percent capacity); Kalium, 383,226 tons (40.9 percent capacity); PCA, 237,644 tons (51.7 percent capacity); APM Operators, 479,699 tons (52.6 percent capacity); Alwinsal, 235,926 tons (39.3 percent capacity); Duval, 303,664 tons (41.5 percent capacity); Cominco, 317,808 tons (44.1 percent capacity); and Central Canada Potash, 364,776 tons (40.5 percent capacity).[3]

Cominco, Ltd.'s potash mine at Vanscoy was accidentally flooded with water, the breakthrough reportedly occurring in the shaft during routine grouting operations to stop seepage well below the water-laden Blairmore Formation.[4]

Allan Potash Mines changed its name to APM Operators, Ltd., effective January 1. The new firm is owned by Swift Canadian Co., Ltd. (20 percent), Texas Gulf Potash Co., a subsidiary of Texas Gulf Sulphur Co. (40 percent), and U.S. Borax & Chemical Corp. (40 percent).

Noranda Potash Division of Noranda Mines, Ltd., also changed its name to Central Canada Potash Co., Ltd.; Noranda owns 51 percent of the new firm, and Central Farmers Fertilizer Co. owns the remainder.

Germany, East.—VEB Kombinat Kali's new potash facilities near Zielitz in the Wolmirstedt district are scheduled to start production early in 1972. The Calvörde-1 refinery will process potash ore from a nearby mine. Two shafts are being sunk to a depth of 800 meters to permit the extraction of sylvinite from the Rönnenberg

[3] Koepke, W. E. Potash. Canadian Min. J., v. 92, February 1971, pp. 145–147.

[4] Mining in Canada. Potash Production Quotas Assured. October 1970, p. 7.

Table 13.—Marketable potash: World production, by countries
(Thousand short tons K_2O equivalent)

Country [1]	1968	1969	1970 [p]
Canada	[r] 2,971	3,492	3,424
Congo (Brazzaville)	------	45	[e] 269
France	2,047	2,136	[e] 2,110
Germany:			
East	[r] 2,528	2,586	[e] 2,600
West	2,823	2,895	2,916
Israel	403	366	583
Italy	[r] 255	280	251
Spain	679	701	656
U.S.S.R.	3,439	3,505	4,905
United States	2,722	2,804	2,729
Total	17,867	18,810	20,443

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Chile also produces potash-bearing nitrate compounds, but data on K_2O equivalent are not available and quantity is relatively small.

horizon. Reserves of 16 to 17 percent K_2O ore in the district are estimated at 77 million short tons. The company is also sinking new shafts at Kaiseroda, Hämbach, and a site near Bad Salzungen to supplement production from its existing mines. Output of marketable potash salts is expected to exceed 3.3 million tons of K_2O equivalent by 1975.[5]

Germany, West.—Badische Anilin & Soda Fabrik A.G. (BASF) purchased a 95-percent interest in Wintershall A.G., Celle/Kassel, which produces half of the West German output of potash. BASF also acquired a 25-percent interest in Salzdetfurth A.G. of Hanover, which supplies 35 percent of the country's potash output. The remainder of the West German output of potash is produced by Kali-Chemie A.G. of Hanover.[6]

Israel.—Dead Sea Works, Ltd., has capacity to produce over 1.1 million short tons of potassium chloride (KCl) annually at Sodom. The company has three refineries: Plant A, built in 1953 and subsequently expanded, has a capacity of 220,000 tons of KCl; plant B, on stream since 1964 has a capacity of 441,000 tons of KCl; and plant C, finished in October 1969, has a capacity of 441,000 tons of KCl. An additional 220,000 tons of KCl capacity can be obtained with a moderate investment for expansion of facilities.[7]

Poland.—Poland recently became Eastern Europe's largest consumer of potash salts, using about 1 million short tons of K_2O equivalent annually. This large consumption of potash may expedite the development of domestic deep-lying potash deposits discovered in 1963 near Gdansk. The Zechstein Formation near there contains a zone of polyhalite up to 39 meters in thickness analyzing 7 to 12 percent K_2O. Drilling showed the existence of more than 350 million tons of potash ore; the potash minerals are believed to be kieserite, carnallite, and sylvite. The formation also extends under the Baltic Sea. A ground product suitable for direct application to soils will be produced initially. Output is expected to begin in 1973.[8]

TECHNOLOGY

Potash was suspected to exist in the thick salt beds of the Michigan Basin in the lower peninsula of Michigan for many years. A strong hunch, a few clues, and 30 years of persistence led Raymond J. Anderson, a Dow Chemical Co. engineer, and a team of other Dow specialists to the discovery of that potash. Although the deposits are lower grade and deeper than those mined in New Mexico, Utah, and Saskatchewan, they add substantially to the world resource of potash which may eventually become commercial.[9]

Considerable geologic and drill-hole data were studied in the search for potash. The deposits, consisting of bedded sylvinite, a mixture of sylvite (KCl) and halite (NaCl), were found to exist near the middle of the A–1 basal salt member of the Silurian age Salina Group and underlie approximately 13,000 square miles of the Michigan Basin.[10]

In one of the studies, 120 samples of core were taken between the depths of 8,287 and 8,392 feet from a well at Midland in Midland County, and were ana-

[5] Phosphorus and Potassium. New Plants and Projects. No. 50, November–December 1970, p. 60.
[6] Bureau of Mines. Mineral Trade Notes. V. 67, No. 7, July 1970, pp. 32–33.
[7] Phosphorus and Potassium. Dead Sea Works Now Among World's Largest Potash Producers. No. 46, March–April 1970, pp. 45–47.
[8] Industrial Minerals (London). Poland—Potash To Be Mined On Large Scale. No. 31, April 1970, pp. 43–44.
[9] Dow Diamond. A Geologic Detective Story—Dow Scientists Identify Potash Deposits. The Dow Chemical Co., v. 33, Fall 1970, pp. 28–30.
[10] Matthews, R. David (The Dow Chemical Co.). The Distribution of Silurian Potash in the Michigan Basin. 6th Forum on Geol. of Ind. Min., 1970, 14 pp.

lyzed for potassium and also bromine. High bromine content had been known to indicate the presence of potassium. The samples ranged from less than 50 parts per million to 1,600 parts per million in bromine and from less than 0.5 percent to more than 40 percent K_2O. The 92-foot interval of core between the depth of 8,295 and 8,387 feet was found to average approximately 4 percent K_2O. Three 5- to 15-foot sections within the interval contained appreciably higher grade material. The sylvite occurrence is unusual in that magnesium and potassium sulfate were not present in appreciable quantities.[11] A well drilled in Kent County was found to contain a 6.2-foot bed averaging 7.3 percent KCl at a depth of 5,045 feet. The thickness of this deposit was calculated from data on potassium analyses of the drill fluid and the rates of drilling and pumping. The results were later confirmed by gamma ray log, an inexpensive method for detecting potassium materials.[12]

Canada's newest potash producer, Sylvite of Canada, Ltd., a Division of Hudson Bay Mining & Smelting Co., Ltd., will use a Marietta four-rotor, crawler-mounted, self-propelled mining machine to mine potash when the mine, 10 miles from Rocanville, Saskatchewan, comes on stream in 1971. Room-and-pillar method of mining will be used with extraction at about 35 percent. The machine is 39 feet long, weighs 250 tons, and is the largest of its kind. It is capable of cutting and loading 11.5 tons of ore per minute, cutting to a height of 8 feet, advancing a full face of 180 square feet at the rate of 1 foot per minute, and towing an extensible conveyor composed of 200-foot sections. The broken ore will be transported from the rear of the boring machine to the extensible conveyor for delivery to the panel conveyor, and then in turn to the main conveyor for delivery to the storage silos at the shaft.[13]

The Bureau of Mines published a report that reviews the development of the world potash industry, analyzes trends leading to potash oversupply and low prices, and compares the economics of United States and Canadian potash production.[14]

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[11] Anderson, Raymond J., and G. C. Egleson. Discovery of Potash in the A-1 Salina Salt in Michigan. 6th Forum on Geol. of Ind. Min., 1970, 5 pp.

[12] Anderson, Raymond J., and E. C. Majeske. Detection of Potash Zones by Drilling Fluid Analysis. 6th Forum on Geol. of Ind. Min., 1970, 3 pp.

[13] Benson, Norman. Sylvite of Canada Newest Potash Producer. Western Miner., v. 43, No. 11, November 1970, pp. 30–38.

[14] Bureau of Mines Staff (Intermountain Field Operations Center, Denver, Colo.). The United States Position and Outlook in Potash. BuMines Inf. Cir. 8487, 1970, 47 pp. (For sale at U.S. Government Printing Office, Washington, D.C. 20402, at 50 cents per copy.)

Pumice

By Arthur C. Meisinger [1]

A slump in U.S. construction activity in 1970 was reflected in the sales and consumption of pumice. The quantity and value of pumice sold and used was 3.1 million short tons and $4.7 million, respectively. Production was the lowest in 6 years and represented a 13-percent decrease in quantity and a 7-percent decrease in value compared with that in 1969.

DOMESTIC PRODUCTION

Domestic production of pumice, pumicite, and volcanic cinder in 1970 was 475,000 short tons and $355,000 lower than in 1969. The decrease of 13 percent in quantity and 7 percent in value was primarily a result of the decline in U.S. construction activity, particularly in the area of road construction and maintenance. Volcanic cinder comprised 85 percent of U.S. output.

A more pronounced economic measure of the state of the pumice industry in 1970 was reflected in the decline in the number of operators and operations—46 fewer operators and 48 fewer operations than in 1969. Domestic output came from 96 firms, individuals, and governmental agencies producing from 123 operations in 15 States. Production in American Samoa was from one mine operated by the Samoan Government.

Oregon with a 21-percent increase in output over that of 1969 replaced Arizona as the leading producer. The combined output of both States accounted for 60 percent of the national total. California, Hawaii, and New Mexico had significant output; however, the quantity produced in each State was lower than that of 1969, particularly for California. California had the largest number of active operations (33), followed by Arizona with 24, and Hawaii with 19. Only volcanic cinder was produced in Arziona, Kansas, North Dakota, Texas, and American Samoa.

[1] Industry economist, Division of Nonmetallic Minerals.

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
1966	549	$2,629	2,669	$4,136	3,218	$6,765
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	478	1,222	2,656	3,473	3,134	4,695

[1] 1966 value f.o.b. mine or grinding plant; 1967–70 values f.o.b. mine.

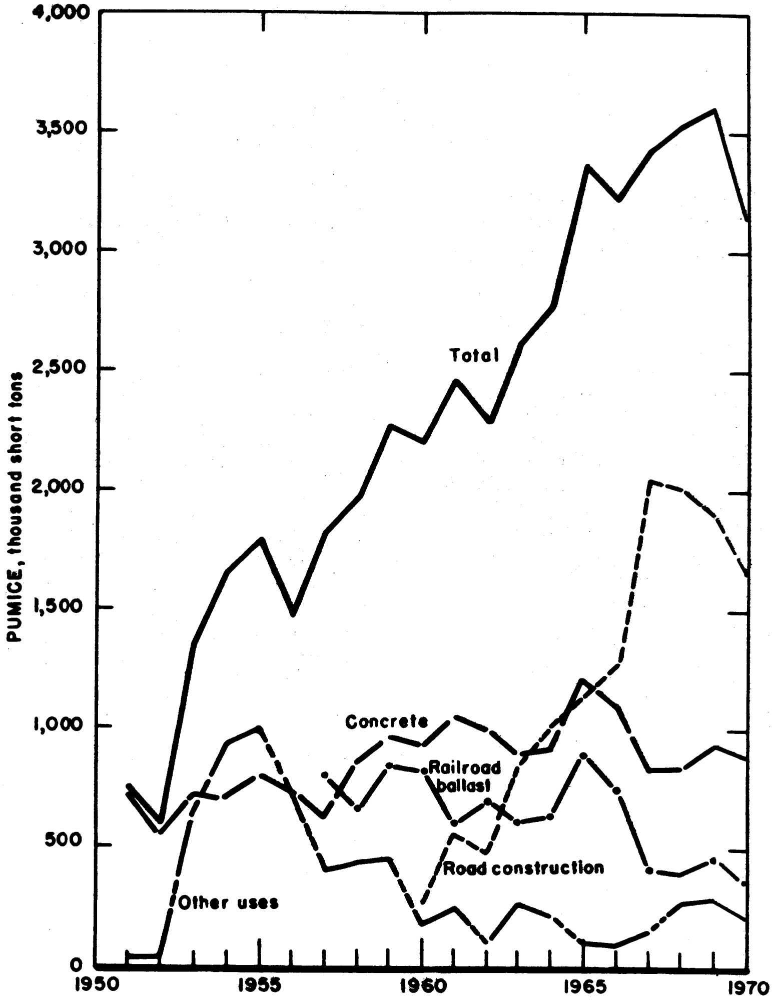

Figure 1.—Pumice sold or used by producers in the United States, by uses.

Table 2.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1969		1970	
	Quantity	Value	Quantity	Value
Arizona	910	$814	824	$627
California	866	1,229	491	841
Colorado	42	232	W	W
Hawaii	403	783	350	933
Idaho	21	62	41	83
Montana	134	102	-----	-----
Nevada	83	188	80	191
New Mexico	226	415	203	442
Oregon	875	1,139	1,061	1,252
Utah	10	21	W	W
Other States [1]	39	66	85	325
Total [2]	3,609	5,050	3,134	4,695
American Samoa	2	5	2	6

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Colorado (1970), Kansas, Nebraska, North Dakota (1970), Oklahoma, Texas, Utah (1970), Washington, and Wyoming (1969).
[2] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Road construction accounted for 53 percent of U.S. consumption of pumiceous materials, the same percentage as in 1969; concrete admixtures and aggregates, 29 percent; railroad ballast, 11 percent; and abrasive materials and miscellaneous uses, 7 percent. Compared with consumption the previous year, use in road construction decreased 13 percent; use in concrete, 4 percent; and use in railroad ballast, 22 percent.

Table 3.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1969		1970	
	Quantity	Value	Quantity	Value
Abrasive—Cleaning and scouring compounds	14	$19	17	$22
Concrete admixture and concrete aggregate	937	1,852	898	1,954
Railroad ballast	463	377	362	192
Road construction (includes ice control and maintenance)	1,912	1,910	1,666	1,683
Other uses [1]	283	892	192	844
Total [2]	3,609	5,050	3,134	4,695

[1] Includes miscellaneous abrasive uses, asphalt, 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 both crude and prepared pumice sold and used increased in 1970. Crude pumice was $1.14 per ton compared with $1.11 in 1969, and prepared pumice was $2.15 per ton compared with $1.85 in 1969. The weighted average value of pumice and volcanic cinder increased from $1.40 per ton in 1969 to $1.50. The average 1970 price per ton for pumice used in cleaning and scouring compounds was $1.33, a decrease of $0.08 from the 1969 price; for concrete admixtures and aggregates, $2.18, a $0.20 increase; for railroad ballast, $0.53, a $0.28 decrease; for road construction, $1.01, a $0.01 increase; and for other uses, including landscaping and roofing, $4.39, a $1.24 increase.

Prices were quoted nominally in trade publications. Quotations in Oil, Paint and Drug Reporter remained unchanged from 1969, and are as follows per pound, bags, in ton lots: Domestic, fine, $0.0460 to $0.0487; domestic, medium, $0.0510; domestic, coarse, $0.0460; imported (Italian), silk screened, coarse, $0.06 to $0.076; fine, imported, $0.05; and bagged, imported (Italian), sun-dried, fine and coarse, $91 per ton.

The American Paint Journal quoted the following prices at yearend 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. These prices are slightly higher than those in 1969.

FOREIGN TRADE

Pumice exports to 13 countries were substantially less (43 percent) than exports in 1969; however, total value of exports decreased only 9 percent.

Pumice imports of more than 365,000 short tons were 5 percent less than those in 1969, owing primarily to a decrease in pumice used in the manufacture of concrete masonry. Most of the imports continued to come from Greece and Italy. Imports classed as crude or unmanufactured increased 26 percent from 8,424 tons in 1969 to 10,639 tons, and pumice classed as wholly or partly manufactured increased 134 percent to 2,931 tons. Pumice imports used in the manufacture of concrete masonry products declined 6 percent from 374,606 tons in 1969 to 351,750 tons.

Pumice stone, TSUS No. 519.05, for use in concrete products, continued to be admitted into the United States duty-free. In accordance with the "Kennedy round" agreements, the duty on other pumice products was again reduced on January 1, 1971. Duties were as follows: TSUS No. 510.11, crude or crushed pumice, value not over $15 per ton, 0.025 cent per pound; TSUS No. 519.14, crude or crushed pumice, value over $15 per ton, 0.045 cent per pound; TSUS No. 519.31, grains or ground, pulverized or refined, 0.21 cent 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., 8 percent ad valorem.

Table 4.—U.S. exports of pumice

Year	Short tons	Value (thousands)
1967	343	$64
1968	624	54
1969	533	[1] 77
1970	304	70

[1] Adjusted by Bureau of Mines.

Table 5.—U.S. imports for consumption of pumice, by class and countries

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)
1969:							
Austria	-------	---	4	$15	-------	---	$19
Greece	-------	---	-------	---	203,977	$381	---
Italy	8,424	r $60	1,250	34	170,629	388	20
Other countries [1]	-------	---	1	1	-------	---	22
Total	8,424	60	1,255	50	374,606	769	61
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 [2]	-------	---	2	(3)	-------	---	5
Total	10,639	74	2,931	126	351,750	776	29

r Revised.
[1] Canada, Hong Kong, Japan, Malagasy Republic, Mexico, and West Germany.
[2] Canada, Hong Kong, United Kingdom, and West Germany.
[3] Less than ½ unit.

WORLD PRODUCTION

Table 6.—Pumice and related volcanic materials: World production, by countries
(Thousand short tons)

Country [1]	1968	1969	1970 [p]
Argentina [2]	14	33	[e] 33
Austria: Pozzolan	20	20	22
Cape Verde Islands: Pozzolan	9	20	26
Chile: Pozzolan	172	193	179
Dominica	[e] 60	61	[e] 60
France:			
Pumice	1	1	[e] 1
Pozzolan and lapilli	[r] 800	[e] 800	[e] 800
Germany, West (marketable)	3,926	4,410	4,644
Greece:			
Pumice	312	425	445
Pozzolan	524	617	599
Guadeloupe: Tuff (pozzolanic) [3]	35	39	[e] 40
Guatemala: Volcanic ash (for cement)	46	50	[e] 50
Italy:			
Pumice	702	[2] 837	[e] 840
Pumicite [e]	100	110	110
Pozzolan	4,727	4,756	[e] 4,760
Martinique: Pumice [3 4]	17	20	[e] 20
New Zealand	18	21	21
Spain [5]	187	255	[e] 250
United Arab Republic	[r] 9	(6)	(6)
United States (sold or used by producers):			
Pumice and pumicite	481	598	478
Volcanic cinder [7]	3,070	3,013	2,658
Total	[r] 15,230	16,279	16,036

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Pumice is also produced in Iceland, Iran, Japan, Mexico, Turkey, and the U.S.S.R. (sizable quantity), but data on production are not available. Japan's last available output figure was 110,000 tons in 1958.
[2] Unspecified volcanic materials produced mainly for use in construction products.
[3] Data converted from cubic meters on basis of estimated specific gravity of 1.0 for pumice and tuff.
[4] Output of material previously reported as tuff may actually represent calcareous tufa, and has been omitted pending clarification by source.
[5] Includes Canary Islands.
[6] Less than ½ unit.
[7] Includes American Samoa.

Rare-Earth Minerals and Metals

By Robert F. Griffith [1]

Rare-earth oxide (REO) contained in 1970 output of bastnaesite and monazite concentrates fell about 24 percent below that of 1969. Bastnaesite production decreased 26 percent while production of monazite concentrate increased 6 percent. Rest-of-the-world production of monazite concentrate, about 7,660 tons of contained REO, approached the record-high 1962 level. Domestic consumption of rare-earth minerals and concentrates was 11,500 tons of contained REO. Shipments of rare-earth products to domestic consumers, including reprocessed material from intracompany secondary plants, from the principal rare-earth processors was about 7,500 tons REO valued at $12.7 million, compared with 8,820 tons worth nearly $19 million in 1969. Use in petroleum cracking catalysts accounted for 45 percent of the volume. Sales of yttrium oxide and europium oxide for use in color television phosphors accounted for about 20 percent of the value.

Legislation and Government Programs.—Rare-earth elements were removed from the list of strategic and critical materials in March 1970. Plans were formulated to offer for sale, the resultant surplus Government stocks at an annual rate not to exceed 1,250 short tons of REO equivalent; 625 tons each in July and December. As of December 31, Government stocks consisted of 13,337 tons of REO equivalent in the following forms: Monazite, 5,088; bastnaesite, 3,243; sodium sulphate, 4,249; chlorides, 653. During the year, General Services Administration (GSA) sold 184 short dry tons of contained REO in rare-earth sodium sulphate.

DOMESTIC PRODUCTION

Concentrate.—The Mountain Pass, Calif., bastnaesite operation of Molybdenum Corporation of America (Molycorp), operating at about 45 percent of the yearly throughput capacity of 450,000 tons of ore, produced 10,037 tons of REO in flotation concentrate from 204,400 tons of ore. Output was at a lower rate than in 1969 to correspond with lower sales.[2] The company announced that a drilling program in 1970 increased proven ore reserves from 3.3 million tons averaging 8.2 percent REO to 6.5 million tons containing 8.6 percent REO. Probable reserves were stated to be much larger. The firm continued studies on the feasability of recovering yttrium and the heavy rare earths from tailings at the iron ore property of Republic Steel Corp. at Mineville, N.Y. Humphreys Mining Co. recovered monazite, containing about 55 percent REO, as a byproduct of titanium minerals and zircon from an ancient beach deposit controlled by E. I. du Pont de Nemours & Co., Inc., near Folkston, Ga. Under the firms land restoration program, more than 300 acres of mined land have been replanted or converted to recreation lakes and water storage areas. Production (shipments) was 6 percent greater than in 1969. On the other hand, minor production of low-grade monazite concentrate by Climax Molybdenum Co. from molybdenum mining at Climax, Colo., was discontinued.

Titanium Enterprises, a joint venture of American Cyanamid Co. and Union Camp Corp., continued construction of mining and milling facilities to exploit a large heavy mineral sand deposit near Green Cove Springs, Fla. Production of titanium minerals, zircon, and monazite is scheduled to begin in July 1972. Mining plans in-

[1] Physical scientist, Division of Nonferrous Metals.

[2] Molybdenum Corporation of America. 1970 Annual Report. Mar. 26, 1971, 12 pp.

clude a land reclamation program to improve the aesthetics of the area by creation of man-made lakes, by land grading and contouring, and by replacement of trees and topsoil.

Kerr-McGee Chemical Corp., a subsidiary of Kerr-McGee Corp., conducted pilot plant tests on a large heavy-mineral placer deposit in Western Tennessee. The minerals of economic interest are rutile, ilmenite, monazite, and zircon.

Compounds and Metals.—Production of rare-earth compounds at the solvent extraction plant of Molycorp at Mountain Pass increased 13 percent in terms of contained REO. Value of production declined because of the drop in output of europium oxide used in color television phosphors. The company's solvent extraction plant at Louviers, Colo., continued to produce high-purity yttrium, lanthanum, and gadolinium oxides, while plants at York and Washington, Pa., produced rare-earth compounds for petroleum cracking catalysts and rare-earth silicide for steel manufacture, respectively. Large-scale output of 99.9 percent cerium oxide began in 1970 from a new unit at the York, Pa., plant.

Other major rare-earth processors included Lindsay Rare Earths, Kerr-McGee Chemical Corp., West Chicago, Ill., and W. R. Grace & Co., Davison Chemical Division, Chattanooga, Tenn., and Pompton Plains, N.J. The former company received the President's Award for Safety in 1970, under the corporate safety program. Consumption of monazite at the Chattanooga plant of W. R. Grace & Co., currently the largest domestic processor of monazite, increased 50 percent in 1970. Smaller producers of rare-earth compounds and metals were: Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N.Y.; Michigan Chemical Corp., St. Louis, Mich; Research Chemicals, Division of Nuclear Corporation of America, Phoenix, Ariz.; Ronson Metals Corp., Newark, N.J.; and Transelco, Inc., Penn Yan, N.Y. Besides the Molcorp Louviers Colo. plant, other producers of yttrium oxide and metal were: W. R. Grace, Kerr-McGee, Michigan Chemical, Gallard-Schlesinger, and Nuclear Corp.

Ronson Metals and American Metallurgical Products were the only two domestic producers of mischmetal and other pyrophoric alloys.

CONSUMPTION AND USES

Consumption of REO contained in raw materials as reported by domestic chemical processors in 1970 was about 11,500 short tons. Bastnaesite consumption by chemical processors decreased 28 percent while consumption of monazite concentrate doubled for the second consecutive year.

Shipments of rare-earth products from primary processing plants to domestic consumers totaled about 6,270 tons REO valued at $11 million. This quantity includes intracompany shipments but does not include products derived from reprocessed shipments at secondary plants. The following estimated quantitative percent distribution of uses of rare-earth products in all forms (REO equivalent) is based on shipment information supplied by primary processors: Petroleum catalysts, 45; glass polishing, 25; ductile iron and steel, other alloys, and lighter flints, 15; arc light carbons, 7; glass additives, 6; research and development and other uses, 2. Shipments of yttrium and europium oxides, although accounting for about 20 percent of total value, decreased by more than 50 percent and represented considerably less than 1 percent of total weight of shipments.

The manufacture of petroleum cracking catalysts containing rare-earth zeolite (molecular sieve) as the active compound continued as the largest use, although declining in 1970 as most petroleum refineries completed the conversion to rare-earth catalysts.

The decline in use of rare-earth oxides for polishing plate glass was offset by an increase in demand for polishing eyeglasses, television tubes, camera lenses and mirrors. Glass additive applications increased, largely because of commercialization of an economical method of using cerium as a decolorizer of glass containers.

Metallurgical applications of rare-earth elements increased significantly in 1970. Mischmetal and rare-earth silicides were the forms most commonly used to add the rare earths to ductile iron and steel to promote ductility, to improve impact and yield strength and formability, and for the deoxidation and desulfurization of continuously cast and high-strength steels. Ferrocerium lighter flints containing as much as 25 percent iron accounted for the largest use of mischmetal. Because ferrous and nonferrous alloys ore increasingly important markets for rare-earth elements, discussions of applications, technology, and effects of rare earths in these alloys were published in 1970.[3] The results of a study on present and future uses of rare earths was also published in 1970.[4]

Binary alloys of cobalt with cerium, praseodymium, samarium, lanthanum, or yttrium were used in the manufacture of high-energy-product high-coercive-force permanent magnets for magnetic circuit applications replacing Alnico and platinum-cobalt magnets.

Cubic crystals of yttrium aluminum garnet (YAG) because of transparency, hardness, and high refractive index were used as gem stones subsituting for diamonds in jewelry. YAG, partially replaced (doped) with small quantities of neodymium or erbium to control wave lengths, was used as laser rod material in manufacturing, medical, military, and scientific applications.

STOCKS

Bastnaesite concentrate held at yearend by the sole producer and by the principal processors, although increasing by about 900 tons of REO, represented less than 2 months supply at the 1970 consumption rate. Monazite concentrate, held mostly by two chemical processors, decreased 17 percent in 1970. Yttrium oxide stocks held by eight firms increased 53 percent, while stocks of europium oxide reported by two companies remained at the 1969 level. Mischmetal stocks held by the two producers and stocks of high-purity metal held by five firms, in all, showed little change in 1970.

PRICES

The unit value of domestic monazite concentrate production remained firm at $180 per short ton while monazite sand was quoted in Metals Week at $180 to $200 per long ton, nominal. Prices for Australian monazite, minimum 60 percent REO plus ThO_2, quoted in Metal Bulletin (London) remained at £75 to £85 ($180 to $204) c.i.f. per long ton through mid-October, then rose to £80 to £90 ($192 to $216) for the remainder of the year. The average declared value of imported monazite concentrate ranged from $131 to $142 per long ton.

Bastnaesite Concentrate.—Unleached, leached, and calcined bastnaesite containing 55 to 60, 68 to 72, and 85 to 90 percent REO, was quoted at 30, 35, and 40 cents per pound of REO, respectively, f.o.b. Mountain Pass, Calif (truck), or Nipton, Calif. (rail), in 100-pound paper bags or 55-gallon steel drums in truckload or carload lots. Malaysian xenotime concentrate with a minimum of 25 percent Y_2O_3 was quoted throughout the year in Industrial Minerals (London) at $2 to $3 per pound of Y_2O_3.

Cerium oxide, 99.9 percent purity, became available in truckload lots at a reduced price of about $1.25 per pound f.o.b. plant. Quoted prices per pound f.o.b. plant on certain rare-earth compounds (commercial grade) were as follow: Mixed rare-earth oxides, 88 to 92 percent REO, $0.45; chlorides, $0.29; fluorides, $0.90; carbonates, $0.55; nitrates, $0.48; hydrates, $0.50.

Prices quoted by the principal producers for individual rare-earth oxides and metals are shown in table 1.

Compounds of didymium, a natural mixture of rare-earth elements less cerium, were quoted by one producer in 100-pound lots per pound as follow: Oxide, $1.30; chloride, $0.36; fluoride, $1.00; carbonate, $0.85; and hydrate, $1.25.

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[3] Hirschhorn, I. S. Recent Applications of the Rare Earth Metals in Nonferrous Metallurgy. J. Metals, v. 22, No. 10, October 1970, pp. 40–43.
Kippenhan, Nancy, and Karl A. Gschneidner, Jr. Rare-Earth Metals in Steels. Molybdenum Corp. of America, Institute for Atomic Research, Ames, Iowa, March 1970, 61 pp.

[4] National Materials Advisory Board. Trends in Usage of Rare Earths. NMAB-266, National Technical Information Service. Springfield, Va., October 1970, 67 pp.

Prices for yttrium products of 99.9 percent purity in commercial quantities were quoted per pound as follow: Oxalate, $13.00; nitrate, $10.00; chloride, $19.00; and garnet, $32.00. Yttrium phosphor of 99.99 percent purity was quoted at $36.00 per pound, refractory yttrium (95 percent) $30.00 and yttrium crystal (99.999 percent) $200.

Quoted prices on 1-pound ingots in 50- to 100-pound lots of 99.9 percent pure mischmetal and cerium-free mischmetal remained at $3 and $5, respectively, while a mixture of praseodymium and neodymium metal of 97 percent purity was quoted at $15 per pound. Rare-earth silicide containing 30 to 35 percent rare earths was quoted $0.44 per pound f.o.b. plant.

Prices for rare-earth-cobalt permanent magnet alloys in quantities of 10 to 100 pounds were quoted in 1970, per pound of single phase alloy, as follow: Cerium, $58.50; lanthanum, $60.25; praseodymium, $82.40; and samarium, $95.36. Substantially reduced forecast prices based on contract quantities for delivery within specified periods were quoted by a leading producer.

Cerium metal, 99 percent pure, delivered in the United Kingdom, remained at £7 ($16.80) per pound, nominal.

Table 1.—Prices of high-purity oxides and metals in 1970 [1]

Element	Oxide [2] (price, dollars per pound)	Metal [3] (price, dollars per pound)
Cerium	$1.50	$30.00
Lanthanum	3.75	35.00
Praseodymium	32.00	175.00
Neodymium	13.00	110.00
Samarium	30.00	145.00
Europium	415.00	32.00
Gadolinium	45.00	2,200.00
Terbium	280.00	700.00
Dysprosium	53.00	140.00
Holmium	140.00	285.00
Erbium	60.00	310.00
Thulium	1,200.00	2,750.00
Ytterbium	100.00	285.00
Lutetium	2,300.00	6,500.00
Yttrium	30.00	145.00

[1] Lower prices are available for contract quantities within specified periods.
[2] Minimum of 99.9 percent purity in 25- to 50-pound containers.
[3] Minimum 1 pound.

FOREIGN TRADE

Exports of ferrocerium and other pyrophoric alloys to 19 countries totaled 77,523 pounds valued at $274,682, a quantitative decrease of 25 percent. Shipments to the United Kingdom and Canada accounted for 70 percent of the total. The unit value for exports of these materials ranged from $1.85 to $11.60 per pound. The increase in unit value of 30 cents to $3.70 per pound for these exports, compared with 1969, was caused in part by the higher value assigned to many small shipments. Exports of bastnaesite concentrate are included in a basket category, nonmetallic minerals n.e.c. (TSUS No. 276.9800). According to the sole domestic producer, Molycorp, about 2,250 tons (REO content) was exported in 1970.

Imports of monazite sand, mostly from Australia and Malaysia, decreased 19 percent from the previous year, while a small quantity from Thailand equaled imports reported from Hong Kong in 1969.

Cerium oxide imports from France totaled 1,102 pounds valued at $2,351 and from Switzerland, 11 pounds of high-purity material worth $1,029, a significant drop from the total of more than 22,000 pounds imported in 1969. Imports of cerium chloride from West Germany and Austria totaled 800 pounds valued at $1,029, while imports of other cerium compounds, n.s.p.f., from West Germany decreased to 500 pounds worth $1,788.

Substantial quantities of mixed rare-earth chlorides resulting from the processing of monazite for thorium removal were imported from India and Brazil. This material is included in a basket category, mixture of two or more inorganic compounds, other (TSUS No. 423.9600); hence, accurate quantitative data are not available. It is estimated that 580 short tons of REO equivalent was imported in this form in 1970.

Imports of rare-earth metals are shown in table 3. These are high-value, specialty items with the exception of the imports from West Germany, which are believed to be shipments of didymium metal. The quantity and value of ferrocerium and other pyrophoric alloys decreased to 9,373 pounds worth $53,885 compared with 1969 receipts of 17,328 pounds valued at

$91,288. Japan supplied 81 percent of the quantity and value, followed by West Germany (1,022 pounds, $3,852), Austria (320 pounds, $1,700), Hong Kong (236 pounds, $1,527), Sweden 170 pounds, $418), France (36 pounds, $930), and the United Kingdom (18 pounds, $1,560).

Table 2.—U.S. imports for consumption of monazite, by countries

Country	1966		1967		1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	1,542	$176	1,540	$195	2,810	$369	2,478	$300	1,977	$251
Germany, West	-----	-----	24	4	24	4	-----	-----	-----	-----
Hong Kong	-----	-----	-----	-----	-----	-----	167	20	-----	-----
Indonesia	-----	-----	72	13	-----	-----	-----	-----	-----	-----
Korea, Republic of	-----	-----	49	7	-----	-----	-----	-----	-----	-----
Malaysia	785	92	273	38	1,514	188	1,561	174	1,307	157
Nigeria	-----	-----	133	13	19	2	-----	-----	-----	-----
South Africa, Republic of	115	9	-----	-----	-----	-----	-----	-----	-----	-----
Thailand	-----	-----	-----	-----	-----	-----	-----	-----	164	19
Total	2,442	277	2,091	270	4,367	563	4,206	494	3,448	427
REO content [e]	1,340	XX	1,150	XX	2,400	XX	2,310	XX	1,900	XX

[e] Estimate. XX Not applicable.

Table 3.—U.S. imports for consumption of rare-earth metals
(Including scandium and yttrium)

Country	1968		1969		1970	
	Pounds	Value	Pounds	Value	Pounds	Value
Australia	-----	------	---	-------	1	$704
Germany, West	3,355	$13,516	---	-------	343	5,150
Japan	5	1,070	254	$22,916	25	2,005
U.S.S.R	7	5,952	[r] 54	[r] 17,324	89	9,183
United Kingdom	7	5,131	[r] 7	[r] 6,724	16	3,731
Total	3,374	25,669	[r] 315	[r] 46,964	474	20,773

[r] Revised.

WORLD REVIEW

Australia.—Production of monazite concentrate with an average grade of 90 percent monazite continued at the record level set in 1969 of more than 4,000 short tons. Based on production data for coproduct heavy minerals through October, output of monazite concentrate for the year is estimated at 4,400 short tons. Consolidated[5] Goldfields (Australia) Pty., Ltd., through beneficial interests in Western Titanium N.L., and Associated Minerals Consolidated Ltd., was the principal producer.

Burundi.—Production of bastnaesite concentrate containing 68 to 70 percent rare-earth oxide was an estimated 330 short tons in 1970, about half the 1969 output. The concentrate was exported to France for processing.

Table 4.—Monazite concentrates: World production, by countries
(Short tons)

Country [1]	1968	1969	1970 [p]
Australia	[r] 3,590	4,397	[e] 4,400
Brazil	[r] 1,864	2,204	[e] 2,200
Ceylon	46	62	18
Congo (Kinshasa)	NA	196	158
India [2]	3,789	2,708	[e] 3,800
Malagasy Republic	2	2	------
Malaysia [3]	[r] 2,357	2,264	1,827
Nigeria [2]	7	14	[e] 10
Thailand	44	72	119
United States	W	W	W
Total	[r] 11,699	11,919	12,532

[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, Indonesia and North Korea produce monazite, but information is insufficient to make reliable estimates of output levels.
[2] Year beginning April 1.
[3] Exports.

[5] Statistical Bulletin (Canberra, Australia). Minerals and Mineral Products. No. 10.19, October 1970, 25 pp.

Canada.—Although production of yttrium oxide from uranium milling by Denison Mines Ltd. declined to 73,000 pounds in 1970 from 86,100 pounds in 1969, the value increased to $657,000 from $625,000. The yttrium product was shipped to chemical processors in the United States.

Finland.—Production of rare-earth concentrate from the Korsnas mine of Outokumpu Oy declined to 11,150 short tons in 1969 from 13,400 tons in 1968.[6] Based on the reported grade of 3.58 percent REO and 322 grams of europium oxide (Eu_2O_3) per ton, output in 1969 and 1968 was 400 short tons of REO plus 3.25 tons of Eu_2O_3 and 480 tons of REO plus 4.9 tons of Eu_2O_3, respectively. The concentrate was produced for sale to Typpi, Oy., Oulu, which reported an output of 208 short tons of rare-earth compounds in 1969 and 64 tons in 1968.

India.—The Alwaye plant, Kerala State, owned by Indian Rare Earths Ltd. (IRE), Bombay, processed 3,300 short tons of monazite and produced 3,850 tons of rare-earth chloride for the year ending March 31, 1970, according to the firms annual report. Small quantities of rare-earth fluoride and oxide were also produced. The heavy minerals and plant of IRE at Manavalakurichi produced slightly more than 2,700 short tons of monazite for processing at Alwaye.

Sales of rare-earth chloride increased substantially, particularly to Europe where the demand was nearly double that of the previous fiscal year. Sales totaled 4,690 short tons valued at $1,125,000.

M/s. Union Carbide India Ltd. was the distributor for IRE rare-earth compounds on a commission of 7.5 percent.

Japan.—Shin-Etsu Chemical Industry Co. Ltd., the largest producer of yttrium and heavy rare-earth oxides in Japan, named Ketjen N.V., Amsterdam, exclusive sales agent in Western Europe for its rare-earth products. The Japanese company, which operates a plant at Takefu in Fukui perfecture, received a substantial quantity of its rare-earth raw material from Molycorp.[7]

Mauritania.—Mining of a heavy rare-earth-yttrium deposit at Bou Naga was suspended because of surplus stocks held by the consuming company and majority owner, Produits Chimiques Péchiney-Saint-Gobain, Paris. The mine, started in October 1968, produced 1,400 metric tons of ore containing 4.4 percent yttrium oxide and 6 to 8 percent heavy rare-earth oxides, of which 600 tons of hand-cobbed concentrates was shipped to France. Operations are not expected to resume for at least a year.[8]

Norway.—A new company, A/S Megon, was established to investigate the feasibility of separation and production of rare-earth oxides and metals on a commercial scale from local carbonatite and apatite deposits.[9]

U.S.S.R.—The apatite deposits of the Kola Peninsula, U.S.S.R., mined for phosphate, contain about 1 percent rare-earth oxide. This large-scale mining complex—27 million metric tons in 1967—constitutes the most important potential supply of the rare-earth elements in Europe.[10]

Kolon Trading Co., Inc., New York, was named U.S. sales agent for rare-earth metals exported by Techsnabexport, Moscow, U.S.S.R.[11]

[6] Industrial Minerals (London). Outokumpu Oy's Higher Pyrite Production. No. 33, June 1970, p. 43.
[7] Industrial Minerals (London). Ketjen May Manufacture Rare Earths. No. 30, March 1970, p. 36.
[8] Industrial Minerals (London). Somirema Suspends Rare Earth Mining Operation. No. 30, March 1970, p. 36.
[9] Industrial Minerals (London). Rare Earths Industry Initiated. No. 30, March 1970, p. 37.
[10] Mining Magazine. Kola Apatite Mine. V. 122, No. 4, April 1970, p. 329.
[11] American Metal Market. Kolon Trading Will Market Russian Rare Metallics. V. 67, No. 201, Oct. 20, 1970, p. 12.

WORLD RESERVES

A review of world resources of rare-earth elements was compiled by John W. Adams of the U.S. Geological Survey and published in 1971 as chapter 3 of Bureau of Mines Information Circular 8476, titled, "The Rare-Earth Elements, Yttrium and Thorium, A Materials Survey." Table 5, taken from this publication, lists some of the more important rare-earth deposits of the world and their potential resources by countries.

Table 5.—Important rare-earth deposits of the world and their potential resources

Country and deposit	Type	Minerals	Remarks	Rare-earth oxide [1] resources (tons)
Australia:				
Various	Beach placers	Monazite	Byproduct of Ti-Zr	480,000
Mary Kathleen mine	Metamorphic	Allanite, stillwellite, others	Not evaluated	----------
Radium Hill	Vein	Brannerite	do	----------
Bolivia:				
Llallagua area	do	Monazite in tin deposits	do	----------
Brazil:				
Atlantic coast	Beach placers	Monazite	None	180,000
Others	Stream placers	do	do	----------
Morro do Ferro	Alkalic complex	Allanite, bastnaesite	do	300,000
Araxá	do	Unknown	do	90,000
Burundi:				
Karonge mine	Vein	Bastnaesite	do	----------
Canada:				
Blind River-Elliot Lake	Conglomerate	Brannerite, monazite	Byproduct potential may be much larger than shown.	50,000
Oka	Carbonatite	Pyrochlore up to 9 percent RE_2O_3.	Large byproduct potential	----------
Ceylon:				
West and northeast coasts	Beach placers	Monazite	1 northeast deposit	6,000
Congo (Kinshasa):				
Shinkolobwe	Vein	do	Mined out (?)	----------
India:				
Chiefly Kerala State	Beach placer	do	[2] 5,000,000 tons	[2] 3,000,000
Bihar and West Bengal	Alluvial placers	do	Large potential	----------
Indonesia:				
Various	Placers	do	Small production	----------
Kenya:				
Mrima (Jombo)	Alkalic complex and carbonatite	Monazite pyrochlore	Probably large deposit	----------
Korea:				
Various	Placers	Monazite	Partly evaluated	54,900
Malagasy Republic:				
Ft. Dauphin area	Placer	do	Indicated	60,000
Malaysia:				
Various	Placers	do	Tin mining byproduct	----------
Malawi:				
Kangankunde Hill	Carbonatite	do	Inferred for 100 feet of depth	10,800
Nigeria:				
Plateau Province	Tin placers	Monazite, thorite	Small annual production	----------
South Africa, Republic of:				
Glenover	Carbonatite	Monazite	Not evaluated	----------
Steenkampskraal	Vein	do	Mined out (?)	9,000
Taiwan:				
Coastal areas	Beach placers	do	None	6,000
Tanzania:				
Panda Hill (Mbeya)	Carbonatite	Pyrochlore, apatite	Large deposit	----------

See footnotes at end of table.

Table 5.—Important rare-earth deposits of the world and their potential resources—Continued

Country and deposit	Type	Minerals	Remarks	Rare-earth oxide [1] resources (tons)
U.S.S.R.:				
Kola area	Alkalic rocks and carbonatite	Apatite, loparite, others	Large, estimated 60,000,000 tons apatite (1933).	----------
Kyshtym area (Vishnevye Mt.)	Alkalic rocks and placers	Cerite, bastnaesite, allanite, apatite.	Apatite contains rare-earth oxides.	----------
United Arab Republic:				
Nile delta	Stream placers	Monazite	None	120,000
United States:				
Mountain Pass, Calif	Carbonatite	Bastnaesite	Large operation	5,000,000
Music Valley, Calif	Metamorphic rocks	Xenotime, monazite	Insufficient data	----------
Idaho-Montana placers, includes Bear Valley, Idaho.	Placer	Euxenite	None	36,000
		Uranothorite	do	----------
		Monazite	do	4,500
Lemhi Pass, Idaho-Mont	Vein	Thorite	Little data	----------
Mineral Hill district, Idaho-Mont	do	Thorite, monazite, others	do	----------
Bald Mountain, Wyo	Conglomerate	Monazite	None	15,000
Powderhorn and Wet Mountain areas, Colo.	Vein and carbonatite	Thorite, bastnaesite, xenotime	Little data	----------
Gallinas Mountains, N. M	Vein	Bastnaesite	do	----------
Piedmont area, N.C. and S.C	Stream placers	Monazite (minor xenotime)	Scattered deposits	600,000
Atlantic coast beaches	Beach placers	Monazite	Only Hilton Head Island, S.C. evaluated.	60,000
Mineville, N.Y	Magnetite deposit	Apatite, bastnaesite	Large rare-earth byproduct potential.	----------
Dover, N.J	do	Xenotime, doverite, bastnaesite.	Little data	----------
Uruguay:				
Atlantida	Beach placer	Monazite	1 area sampled	288
Total				10,082,488

[1] Monazite assumed to contain 60 percent rare-earth oxides; euxenite assumed to contain 15 percent rare-earth oxides.
[2] Estimated total for all deposits in India.

TECHNOLOGY

Concentration of monazite and associated heavy minerals by conventional wet-gravity methods becomes progressively less efficient as grain size decreased below 200 mesh. A patent was issued describing a large capacity, high-bulk-density, wet-gravity concentrator designed for the concentration of finely divided material.[12]

Mixtures of monazite and columbite-tantalite obtained as the residue from the concentration of African cassiterite are often discarded because of the difficulty in separating the two minerals. A flotation process was described capable of producing clean concentrates of monazite and of columbite-tantalite without producing a middling product.[13]

The demand for high-purity, individual rare earths or special mixtures of compounds is increasing at a faster rate than the demand for natural mixtures. The cost of separating the rare earths from each other accounts for a large part of the cost of the final product. Research by industry and Government was therefore directed toward lower cost individual rare earths through improvements in separation techniques in order to better the competitive position of the plentiful rare-earth elements compared with less abundant alternate materials.[14]

Research on the use of rare-earth metals in nodular iron, in high-strength, low-alloy (HSLA) structural steels, in continuous casting of certain other steels, and in refractory ferrous alloys received increasing attention in 1970. Improved analytical methods were developed for measuring and controlling the results of rare-earth metals introduced to ferrous melts as mischmetal or as rare-earth silicide.[15]

The fabrication, composition, and use of rare-earth chromites as high-temperature electrodes for magnetohydrodynamic (MHD) power generation was described.[16]

Two improved phosphors for taking X-ray pictures were developed; a europium doped phosphor, Ba $(PO_4)2$ and a phosphor made from oxysulfides of lanthanum and gadolinium containing small quantities of terbium.[17]

The discovery, development, properties and applications of rare-earth cobalt magnets were reviewed[18]

Rare-earth fluorides research studies indicated potential applications as solid lubricants at temperatures above 1,800° F.[19]

Three new isotopes of rare-earth elements, erbium-151, ytterbium-151 and 157, were discovered by scientists working with the Oak Ridge, Tenn. isochronous cyclotron.[20]

A research grant from the National Science Foundation was given to the Colorado School of Mines for a 2 year study of "Rare Earths in Rock Suites and Rock Forming Mineral Systems." The rare-earth elements are trace elements indicators of geologic processes.

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[12] Tomlinson, W. B. (assigned to Carpco Research & Engineering, Inc.). Improved Laminar Flow Sluice Concentrator and Method of Using it for Concentration of Values in Monazite Ore or Other Finely Divided Ores Containing Values and Gangue Minerals of Similar Specific Gravities. U.S. Pat. 3,509,997, May 5, 1970.

[13] Salatic, D., and P. Moiset Flotation of Monazite. Min. Mag., v. 122, No. 4, April 1971, p. 323.

[14] Millsap, W. A., and H. D. Peterson (assigned to Molybdenum Corp. of America). Solvent Extraction Separation of Europium Values From Bastnaesite Ore Leach Solutions or the Like. U.S. Pat. 3,524,723, Aug. 18, 1970.

Rosenbaum, Joe B., D. R. George, and Joan T. May. Metallurgical Application of Solvent Extraction (in Two Parts). 2. Practice and Trends. BuMines Inf. Circ. 8502, January 1971, 19 pp.

[15] Greene, A. M. What Rare Earths Add to Steel. Iron Age, v. 207, No. 8, Feb. 25, 1971, 3 pp.

[16] Nuclear Science Abstracts. Abstract No. 12673. V. 24, No. 7, April 1970, p. 1267.

[17] Rare-Earth Information (RIC) News. Speedy X-Ray. V. 5, No. 4, Dec. 1, 1970, p. 4.

———. Brighter X-Rays. V. 6, No. 1, March 1971, p. 2.

[18] Becker, J. J. Permanent Magnets. Scientific American, v. 223, No. 6, December 1970, pp. 92–100.

[19] Industry Week. Studies of Rare Earth Fluorides. V. 166, No. 25, June 22, 1970, p. 20.

[20] Chemical and Engineering News. Three New Isotopes of Rare-Earth Elements Have Been Discovered. V. 48, No. 11, Mar. 16, 1970, p. 31.

Salt

By Robert T. MacMillan [1]

Domestic salt production increased 3.5 percent in 1970, slightly below the average annual growth of 4.8 percent established by the industry in the past 10 years. The average value rose 5.5 percent in 1970. The largest percentage increases were in the production (5.8 percent) and value (10 percent) of rock salt. Most of the increased output was consumed by the chemical industry in the manufacture of chlorine and caustic soda and for deicing streets and highways. Imports increased 7 percent in quantity and 11 percent in value.

Legislation and Government Programs.—The U.S. Department of Commerce, National Bureau of Standards, released a Product Standard PS 14–69 on Salt in May 1970. The purpose of the Product Standard was "to establish, as a standard of practice in production, distribution, and use, the types of packages for various kinds of salt and the quantities in which such salt is packaged." The Product Standard was a revision of Simplified Practice R70–54 and reflects the current needs of the salt industry as well as the desires of the consumer. Although adoption of the standard is voluntary, widespread conformance to the standard will benefit both producers and consumers of salt. Copies may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is $0.10 per copy.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Production	NA	NA	NA	NA	46,672
Sold or used by producers	36,463	38,946	41,274	44,245	45,804
Value	$229,985	$251,210	$272,275	$287,680	$303,523
Exports	662	678	728	716	423
Value	$4,472	$4,583	$4,650	$4,486	$3,657
Imports for consumption	2,479	2,843	3,456	3,302	3,536
Value	$6,464	$8,541	$11,487	$11,990	$13,329
Consumption, apparent	38,280	41,111	44,002	46,831	48,917
World: Production	122,274	131,092	138,426	148,789	156,365

NA Not available.

DOMESTIC PRODUCTION

Seventeen States recorded salt production in 1970. The two leading States, Louisiana and Texas, produced 52 percent of the total output. New York, Ohio, and Michigan contributed 35 percent. Salt was produced by 54 companies at 99 plants in the United States and Puerto Rico in 1970. Twelve companies, each producing more than 1 million tons in 1970, operated 44 plants and accounted for 88 percent of the total U.S. salt output. Fifteen companies with a production of less than 1 million tons but greater than 100,000 tons operated 27 plants and accounted for 10 percent of the total production. Twenty-seven other companies whose individual production was less than 100,000 tons operated 28 plants and supplied the remaining 2 percent of the total salt output. Twelve plants, each with a production of over 1 million tons, accounted for 58 percent of the total domestic salt production. Thirteen plants, producing between 500,000 and 1 million tons, accounted for 20 percent of the total output. The remaining 22 percent was supplied by 74 plants. Two new salt companies reported production in 1970. Milford Hall produced solar-evaporated salt near Springerville, N. Mex., and the Great Salt Lake Minerals and Chemical Corp. produced solar-evaporated salt and other chemicals from the brines of the Great Salt Lake.

Table 2.—Salt sold or used by producers in the United States, by methods of recovery
(Thousand short tons and thousand dollars)

Recovery method	1969		1970	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	332	$8,827	348	$10,253
Vacuum pans	3,055	73,100	3,114	78,052
Solar	1,907	13,004	1,589	13,698
Pressed blocks	369	9,622	365	10,021
Total [1]	5,663	104,553	5,415	112,024
Rock:				
Bulk	13,314	84,100	14,090	93,023
Pressed blocks	83	2,352	79	2,269
Total [1]	13,397	86,452	14,170	95,291
Salt in brine (sold or used as such)	25,185	96,675	26,220	96,208
Grand total [1]	44,245	287,680	45,804	303,523

[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	1969		1970	
	Quantity	Value	Quantity	Value
California	1,895	W	1,656	$14,407
Kansas [1]	1,270	$17,090	1,230	18,206
Louisiana	12,435	61,102	13,584	64,854
Michigan	4,819	45,961	4,899	49,963
New York	5,582	45,561	5,990	47,254
Ohio	5,844	43,519	5,329	47,498
Oklahoma	9	51	W	W
Texas	9,261	43,012	10,184	45,000
Utah	481	4,439	366	3,638
West Virginia	1,309	4,978	1,190	5,171
Other States [2]	1,340	21,967	1,376	7,532
Total	44,245	287,680	45,804	303,523
Puerto Rico	32	395	32	395

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Quantity and value of brine included with "Other States."
[2] Includes Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, New Mexico, North Dakota, Virginia, and States indicated by symbol W.

Table 4.—Evaporated salt sold or used by producers in the United States
(Thousand short tons and thousand dollars)

State	1969		1970	
	Quantity	Value	Quantity	Value
Kansas	623	$13,810	670	$15,178
Louisiana	277	7,598	270	7,888
Michigan	1,137	27,552	1,186	28,948
New York	W	17,143	628	18,087
Ohio	774	W	771	W
Oklahoma	5	42	W	W
Utah	W	W	350	3,543
Other States [1]	2,847	38,408	1,540	38,379
Total	5,663	104,553	5,415	[2] 112,024
Puerto Rico	32	395	32	395

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes California, Hawaii, Nevada, New Mexico, North Dakota, Texas, 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
1966	10,080	$61,118
1967	11,661	71,953
1968	12,461	79,867
1969	13,397	86,452
1970	14,170	95,291

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	
	Quantity	Value	Quantity	Value	Quantity	Value
1966	328	$8,529	60	$1,682	388	$10,211
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	365	10,021	79	2,269	444	12,290

CONSUMPTION AND USES

The chemical manufacturing industry continued to consume nearly two-thirds of the domestic salt production. The chlor-alkali industry consumed 47 percent and soda ash production required 14 percent. Other chemicals required 3 percent.

The second largest consuming use (17 percent of the total output in 1970) was for snow and ice removal and road base stabilization. About 2 percent of the total salt output was sold to grocery stores and may be assumed to have been for table use; however, the total quantity of salt used for food and food-related uses also includes uses by meat packers, tanners, and casing manufacturers, and in the fishing, dairy, canning, baking, flour, and other food industries. These uses totaled 2.6 million tons in 1970 and represented 5.6 percent of the total salt output. Of the total salt production in 1970, 57 percent was produced and consumed as brine, 31 percent as rock salt, and 12 percent as evaporated salt.

Table 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1969				1970			
	Evaporated	Rock	Brine	Total [1]	Evaporated	Rock	Brine	Total [1]
Chlorine	302	1,546	17,089	18,937	262	2,629	18,354	21,245
Soda ash	W	W	6,658	6,659	(2)	(2)	6,445	6,445
Soap (including detergents)	29	W	W	36	(3)	(3)	(3)	(3)
All other chemicals	W	1,815	W	2,641	335	579	495	1,409
Textile and dyeing	130	80	------	210	115	82	------	197
Meatpackers, tanners, and casing manufacturers	262	356	------	618	266	370	------	636
Fishing	14	4	------	18	25	5	------	30
Dairy	45	5	------	50	51	8	------	60
Canning	155	W	W	213	159	63	(2)	222
Baking	101	5	------	106	107	8	(2)	116
Flour processors (including cereal)	60	W	W	68	68	11	(2)	79
Other food processing	145	W	W	177	440	43	(2)	483
Ice manufacturers and cold storage companies	W	6	W	11	(4)	(4)	(4)	(4)
Feed dealers	765	415	------	1,180	822	543	------	1,365
Feed mixers	342	192	------	534	330	216	------	546
Metals	W	137	W	210	63	W	W	252
Ceramics (including glass)	5	11	------	16	(4)	(4)	------	(4)
Rubber	44	38	73	155	71	W	W	206
Oil	48	49	83	180	51	78	85	214
Paper and pulp	157	W	W	341	61	135	183	380
Water softener manufacturers and service companies	390	401	8	799	447	W	W	691
Grocery stores	634	447	------	1,081	642	294	------	936
Railroads	5	25	------	30	(4)	(4)	------	(4)
Bus and transit companies	1	12	------	13	(4)	(4)	------	(4)
States, counties, and other political subdivisions (except Federal)	344	6,561	4	6,909	160	7,586	4	7,750
U.S. Government	W	32	W	55	30	77	(2)	107
Miscellaneous [5]	1,232	1,020	746	2,998	690	972	608	2,270
Total [1]	5,663	13,397	25,185	44,245	[6] 5,319	[6] 14,180	[6] 26,140	[7] 45,639

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 difference at the point in which the data were recorded.
[7] Differs from totals in tables 1, 2, and 3 because of difference at the point in which the data were recorded.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1969 Evaporated	1969 Rock	1970 Evaporated	1970 Rock
Alabama	54	444	51	417
Alaska	13	-------	5	W
Arizona	W	7	13	W
Arkansas	19	83	23	109
California	955	W	852	89
Colorado	123	32	100	46
Connecticut	26	W	27	W
Delaware	7	W	7	W
District of Columbia	3	1	4	W
Florida	31	103	41	130
Georgia	53	W	65	260
Hawaii	W	-------	W	-------
Idaho	52	W	37	W
Illinois	296	875	325	729
Indiana	142	387	159	480
Iowa	178	311	191	288
Kansas	79	234	80	166
Kentucky	39	481	47	534
Louisiana	31	308	41	288
Maine	W	155	9	W
Maryland	W	W	47	W
Massachusetts	82	472	44	544
Michigan	172	685	192	W
Minnesota	130	499	144	352
Mississippi	26	73	25	97
Missouri	93	265	99	356
Montana	43	1	30	1
Nebraska	87	91	98	75
Nevada	W	W	28	W
New Hampshire	W	W	7	W
New Jersey	185	W	161	614
New Mexico	16	84	21	89
New York	353	2,003	331	W
North Carolina	111	143	120	171
North Dakota	35	6	58	6
Ohio	307	952	335	1,388
Oklahoma	43	51	48	68
Oregon	23	W	7	W
Pennsylvania	200	867	184	1,105
Rhode Island	10	W	10	W
South Carolina	34	22	44	25
South Dakota	62	27	49	26
Tennessee	116	W	124	W
Texas	115	441	118	319
Utah	122	W	119	W
Vermont	6	W	7	W
Virginia	100	95	96	W
Washington	W	W	W	W
West Virginia	21	113	24	178
Wisconsin	151	576	170	488
Wyoming	23	3	20	2
Other [1]	896	2,507	480	4,740
Total	5,663	13,397	[2 3] 5,319	[3] 14,180

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes shipments to Puerto Rico and States indicated by symbol W and exports.
[2] Data may not add to totals shown because of independent rounding.
[3] Differs from totals in tables 2, 4, and 5 because of difference at the point in which the data were recorded.

PRICES

Prices per 100 pounds quoted in Oil, Paint and Drug Reporter for various grades of salt in 1970 were as follows:

	January	March	April	December
Salt, evaporated, common, in bags, carlots, or truck lots, works	$1.14	$1.24	$1.29	$1.29
Salt, chemical grade, same basis	1.25	1.35	1.40	1.40
Salt, rock, medium, coarse, same basis	.82	.82	.87	.87
Salt, rock, extra coarse, same basis	.87	.87	.92	.92

The average value of evaporated salt reported by producers to the Bureau of Mines in 1970 was $20.69 per ton. On the same basis, the average value of rock salt was $6.72, and that of brine was $3.67.

FOREIGN TRADE

Slightly less than 1 percent of the U.S. total salt output was exported to 65 countries in 1970. Salt exports were considerably less than in 1969, when 1.6 percent of the total salt sold or used was exported. Most of the salt exports went to Canada and Japan.

Imports of salt in 1970 were 7 percent greater than in 1969 and were nearly 8 percent of the 1970 domestic production. Canada, Mexico, and the Bahamas were the source of 83 percent of the salt imports. Newly developed solar-salt-producing areas in the Bahamas contributed to the increase in salt imports.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

Area	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
American Samoa	232	$10	329	$13
Guam	112	14	(1)	(1)
Puerto Rico	13,857	1,154	15,504	943
Virgin Islands	168	22	230	13

[1] Effective Jan. 1, 1970 data no longer available.

Table 10.—U.S. exports of salt, by countries

(Thousand short tons and thousand dollars)

Destination	1969		1970	
	Quantity	Value	Quantity	Value
Australia	1	$71	1	$97
Canada	298	2,004	221	1,803
Costa Rica	(1)	31	1	48
Japan	396	1,795	187	909
Mexico	2	49	3	98
Saudi Arabia	(1)	31	2	180
South Africa, Republic of	3	16	(1)	14
Other	16	489	8	508
Total	716	4,486	423	3,657

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of salt, by countries [1]

(Thousand short tons and thousand dollars)

Country	1969		1970	
	Quantity	Value	Quantity	Value
Bahamas	595	$2,372	706	$2,817
Canada	1,008	4,587	1,383	6,560
Chile	557	2,112	293	1,145
Mexico	754	1,425	858	1,816
Romania	------	------	19	177
Spain	37	264	17	47
Tunisia	187	469	134	357
United Arab Republic	39	130	------	------
United Kingdom	16	66	49	135
Venezuela	91	449	77	266
Other	18	116	(2)	9
Total	3,302	11,990	3,536	13,329

[1] Includes salt brine from West Germany through the New York City customs district for 1969, 601 short tons ($5,912).
[2] Less than ½ unit.

Table 12.—U.S. imports for consumption of salt, by classes

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable) [1]	
	Quantity	Value	Quantity	Value
1968	27	$467	3,429	$11,020
1969	11	316	3,291	11,674
1970	45	625	3,491	12,704

[1] Includes salt brine from Canada through Detroit customs district for 1968, 300,596 short tons ($89,187); 1969, West Germany through the New York City customs district, 601 short tons ($5,912).

Table 13.—U.S. imports for consumption of salt, by customs district [1]

(Thousand short tons and thousand dollars)

Customs district	1969		1970	
	Quantity	Value	Quantity	Value
Baltimore, Md	224	$717	304	$1,048
Boston, Mass	128	401	207	755
Bridgeport, Conn	172	671	154	525
Buffalo, N.Y	17	72	13	62
Chicago, Ill	76	334	295	1,327
Cleveland, Ohio	143	617	191	853
Detroit, Mich	551	2,526	642	3,199
Duluth, Minn	35	155	33	159
Juneau, Alaska	2	70	-----	-----
Los Angeles, Calif	198	448	227	471
Milwaukee, Wis	158	691	138	604
New York City	174	761	141	552
Norfolk, Va	35	171	9	36
Ogdensburg, N.Y	9	43	(2)	(2)
Philadelphia, Pa	51	140	-----	-----
Portland, Maine	371	1,765	296	1,405
Portland, Oreg	133	166	149	207
Providence, R.I	138	400	87	318
St. Albans, Vt	16	66	(2)	3
San Juan, Puerto Rico	6	32	12	72
Savannah, Ga	224	830	222	822
Seattle, Wash	429	884	388	844
Wilmington, N.C	12	30	28	67
Other	(2)	(2)	(2)	(2)
Total	3,302	11,990	3,536	13,329

[1] Includes salt brine from West Germany through the New York City customs district for 1969, 601 short tons ($5,912).
[2] Less than ½ unit.

Table 14.—U.S. imports for consumption of salt, by uses

Use	Thousand short tons
Government (highway use)	2,285
Chemical industry	228
Water conditioning service companies	204
Other	196
Total	[1] 2,913

[1] Does not agree with totals in tables 11 and 13 because of incomplete data on the uses of imported salt.

WORLD REVIEW

Australia.—Salt production in Australia increased as production from several new solar salt fields became available. Conditions for producing solar salt in Australia are claimed to be among the best in the world. These include low rainfall, high evaporation rate, high salinity of oceans and natural brines, and suitable topographical features and harbors. Most of the increased salt-producing capacity is for the export market, mainly for Japan.

Italy.—A new 1-million-ton-per-year evaported salt plant is nearing completion at Ciro Marina, Italy. Salt will be produced by solution mining methods at a new mine in Tempa del Salto in the Province of Catanzaro and transferred 26 miles by pipeline to the evaporating plant. The salt will be used mainly in the chlor-alkali industry.[2]

[2] Industrial Minerals. Montedison Rock Salt Mine. No. 37, October 1970, p. 33.

Table 15.—Salt: World production, by countries

(Thousand short tons)

Country [1]	1968	1969	1970 p
North America:			
Canada	4,864	4,657	5,052
Bahamas	e 880	750	685
Martinique	-------	358	e 330
Honduras	25	31	e 30
Costa Rica	13	10	8
El Salvador	r 27	30	35
Mexico	3,966	4,287	4,578
United States (including Puerto Rico):			
Rock salt	12,461	13,397	14,170
Other salt:			
United States	28,813	30,848	31,634
Puerto Rico	32	32	32
South America:			
Argentina	r 814	520	e 550
Brazil	r 1,376	1,796	2,010
Chile	940	1,467	569
Colombia:			
Rock salt	r 350	379	587
Other salt	207	368	254
Dominican Republic	18	e 20	e 20
Peru	r 128	102	e 105
Venezuela	139	188	293
Europe:			
Austria	r 443	461	543
Bulgaria	130	e 130	132
Czechoslovakia	r 177	183	e 200
Denmark [2]	165	271	376
France:			
Rock salt and brine salt	r 3,795	4,318	4,502
Marine salt	1,102	1,064	e 1,100
Germany:			
East	2,172	2,174	e 2,300
West (marketable):			
Rock salt	r 7,610	8,430	10,126
Marine salt and other	r 721	784	822
Greece	109	83	e 90
Italy:			
Rock salt and brine salt	2,895	3,086	3,165
Marine salt	r 1,424	1,264	1,650
Netherlands	2,660	2,942	3,163
Poland:			
Rock salt	1,068	1,285	1,349
Other salt	r 1,834	1,820	1,851
Portugal:			
Rock salt	167	183	214
Marine salt	290	157	e 220
Romania	2,610	e 2,600	3,155
Spain:			
Rock salt	r 1,005	1,186	e 1,200
Marine salt [3]	1,002	850	e 880
Switzerland	281	294	368
U.S.S.R.	12,125	13,228	e 14,300
United Kingdom:			
Rock salt	r 1,119	1,558	1,778
Other salt	r 6,732	7,276	7,523
Yugoslavia	197	234	231
Africa:			
Algeria	e 132	165	110
Angola	80	88	97
Ethiopia (including Eritrea) [4]	r 257	258	287
Ghana	e 30	40	18
Kenya	r 32	47	39
Malagasy Republic	19	24	24
Mali	3	3	e 3
Mauritania	r 1	1	e 1
Mauritius	r 5	4	e 4
Morocco	[5] 45	74	63
Mozambique	r 34	[6] 11	[6] 32
Niger e	4	4	4
Senegal	92	88	e 130
Somali Republic	e 1	2	e 2
South Africa, Republic of	377	417	463
South-West Africa, marine salt e	121	121	121
Sudan	55	56	58
Tanzania	33	37	46
Tunisia	397	312	331
Uganda	4	5	3
United Arab Republic	r 685	424	e 550

See footnotes at end of table.

Table 15.—Salt: World production, by countries—Continued
(Thousand short tons)

Country [1]	1968	1969	1970 p
Asia:			
Afghanistan	r 41	41	e 40
Burma	r 143	194	173
Ceylon	108	125	71
China, mainland e	16,500	16,500	17,600
Cyprus	r 5	6	8
India (including Goa)	5,560	7,033	6,160
Indonesia e	r 90	200	200
Iran [4]	r 236	260	278
Iraq	r 47	55	e 50
Israel	72	74	e 70
Japan	r 1,065	1,082	1,060
Jordan	r 19	21	28
Korea:			
North e	r 600	600	600
Republic of	618	319	446
Kuwait	r 5	4	e 4
Laos e	r 4	3	1
Lebanon e	33	31	30
Mongolia e	9	9	9
Pakistan:			
Rock salt	r 361	393	349
Other salt	629	612	491
Philippines	239	255	232
Ryukyu Islands e	7	7	7
Southern Yemen	87	e r 66	e 55
Syrian Arab Republic e	22	24	24
Taiwan	343	422	590
Thailand e	165	220	e 220
Turkey	626	e 630	640
Vietnam:			
North e	165	165	165
South	r 174	130	e 130
Yemen e	r 90	120	110
Oceania:			
Australia	r 1,008	1,852	e 1,900
New Zealand	62	54	58
Total	r 138,426	148,789	156,365

e Estimate. p Preliminary. r Revised.
[1] Salt is produced in many other countries, including Libya and Cape Verde Islands, 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] Rock salt only.
[6] Marine salt only.

Morocco.—A large rock salt deposit about 15 miles north of Casablanca has been delineated by close drilling. The part of the deposit that was drilled contained 800 million tons of 97.5 to 98 percent NaCl. The deposit, which ranges from 1,200 to 1,500 feet in depth, is 260 feet thick and may contain 2 billion tons of salt.[3]

Nicaragua.—A new salt plant, Salines Nicaraguenses S.A. (SANISA), was inaugurated by the President of Nicaragua. The plant, which is on the Pacific coast, will extract salt from sea water by solar evaporation. Annual production is expected to be about 22,000 short tons and will be used in producing caustic soda and chlorine for the chemicals market.[4]

United Arab Republic.—Solar salt produced from salinas along the coast of the Mediterranean Sea is the chief source of Egyptian salt. The procedure and equipment used for producing a purified salt product was published.[5]

[3] Mining Magazine. Moroccan Rock Salt. V. 123, No. 5, November 1970, p. 431.
[4] Bureau of Mines. Mineral Trade Notes. V. 67, No. 9, September 1970, p. 20.
[5] Saada, M.Y. and others. Washing Egyptian Common Salt. Mining and Minerals Engineering, v. 6, No. 6, June 1970, pp. 34–36.

TECHNOLOGY

A compilation of the most recent technological trends in salt production and consumption and the latest geological theories on the formation of salt and other evaporite deposits was published in a two-volume compendium of papers presented at the Third Salt Symposium held in Cleveland, Ohio, in 1969.[6] A total of 97 papers was presented at the symposium, which covered a wide range of subject matter including the geochemistry and tectonics of salt formations; solution mining, underground storage and waste disposal; and geophysics, subsidence, and hydraulic fracturing studies related to salt mining.

A detailed description of modern rock salt mining procedures was published in an article concerning four mines of the International Salt Co.[7]

The mining operations at Retsof, N.Y., Cleveland, Ohio, Detroit, Mich., and Avery Island, La., have many similarities. The room-and-pillar method is used in all four mines, and salt extraction averages between 50 and 75 percent. The unextracted salt remains as supporting pillars ranging in size from 60 by 80 to 90 by 100 feet. After cutting a 10-foot-deep slot at its base, the wall of rock salt is drilled and blasted with dynamite and prilled ammonium nitrate mixed with fuel oil. Millisecond-delay blasting caps attached to the explosives in each set of holes control the blasting pattern and provide optimum blasting effect and minimum production of fines. The broken salt is loaded mechanically into trucks or conveyor belts and hauled to the crushers, which may be either underground or on the surface. After crushing and screening to size, the salt is hauled to storage.

A solution mining process for recovering mineral values from rock salt, sylvanite, trona, or other soluble mineral salts was patented.[8] The process is applicable to a plurality of flat, relatively thin beds. Injection and output wells are sunk to the lowermost exploitable bed which is hydraulically fractured and contacted with a solvent (water) to dissolve and remove the mineral values, eventually forming a cavity from the injection well to the output well. When the lower bed is depleted, the solvent is diverted to the next overlying bed.

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[6] Rau, J. S., and L. F. Delwig (eds.). Third Symposium on Salt. Northern Ohio Geological Society, Cleveland, Ohio, 1970, v. 1–2.

[7] Skillings' Mining Review. International Salt Co.'s Four Mining Operations. V. 59, No. 32, Aug. 8, 1970, pp. 1, 8–11.

[8] Carmody, D. W. (assigned to Hardy Salt Co.). Methods of Solution Mining. U.S. Pat. 3,510,167, May 5, 1970, 6 pp.

Sand and Gravel

By Harold J. Drake [1]

Demand for sand and gravel is principally in the construction industry. The restraint in that industry in 1970, owing to a tight money supply, resulted in only a small increase in consumption of sand and gravel. The level of consumption in 1970, nevertheless, was the highest on record.

Average prices of sand and gravel rose about 10 percent and 5 percent, respectively, and the average unit value, f.o.b. plant, of sand and gravel combined increased about 4 percent.

DOMESTIC PRODUCTION

Domestic production of sand and gravel, which had reached an alltime high of 937 million tons valued at $1.1 billion in 1969, increased to 944 million tons valued at $1.1 billion in 1970 (table 1). Output from commercial operations accounted for about four-fifths of total output and rose only slightly, but that of Government-and-contractor operators rose about 2.5 percent. U.S. producers supplied all domestic requirements for these products.

Production of sand and gravel for the construction industry amounted to 906 million tons valued at $1 billion. These production and value figures represent increases of about 1 percent and 5 percent, respectively, from the levels of 1969. Industrial sand production amounted to 29 million tons valued at $101 million, unchanged from that of 1969.

In 1970 California accounted for approximately 15 percent of domestic production; the midwestern States of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin accounted for about 29 percent. Other States that produced substantial quantities of sand and gravel were Alaska, New York, Texas, and Washington.

The number of commercial sand and gravel plants decreased from 6,309 in 1969, to 5,918 in 1970. Approximately 51 percent of the output in 1970 came from plants in which annual production ranged from 50,000 tons to 400,000 tons. Plants producing 1 million or more tons per year accounted for about 15 percent of domestic production.

One of the most advanced sand and gravel plants went into operation at Steilacoom, Wash.[2] The new plant, owned by Pioneer Sand and Gravel Co., a division of Lone Star Cement Corp., features a fully automatic remote control system that regulates all phases of plant operation including excavation, processing, stockpiling, blending, and loading for transport to markets. The system permits great flexibility and more efficient and economical production with a minimum manpower requirement.

A new sand and gravel plant owned by Whittaker and Gooding Co. was placed into operation near Ann Arbor, Mich.[3] The plant, built to replace a smaller plant owned by the company, will supply concrete sands, beneficated gravel aggregates, pea gravel, and other gravels to a market area encompassing Ann Arbor, Ypsilanti, and southern Detroit.

Faced with depleted reserves and low-quality deposits, C. M. Page Co. Inc., Orono, Me., combined operations of two gravel plants and began development of a limestone quarry for coarse aggregate to eventually replace its gravel operations.[4]

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[1] Physical scientist, Division of Nonmetallic Minerals.
[2] Trauffer, Walter E. Pioneer's 1,800-TPH Plant Serves Puget Sound Area. Pit and Quarry, v. 62, No. 9, March 1970, pp. 112–142.
[3] Herod, Buren C. Michigan Producer Builds for Future. Pit and Quarry, v. 63, No. 5, November 1970, pp. 80–89.
[4] Truffer, Walter E. How a Marine Gravel Producer Stays Ahead of Deposit Depletion. Pit and Quarry, v. 62, No. 11, May 1970, pp. 153, 162.

Mining and processing of dune sands just west of Santa Maria, Calif., by California Sand Co., Inc., is underway.[5] Sands produced include blasting, traction, and foundry sands, and sands for fertilizer, pipe linings, and recreational uses.

Dredge mining in the United States was discussed in a brief article[6] as was Knoxville Sand and Gravel Co.'s dredging operations on the Tennessee River.[7] The Knoxville company replaced its dipper dredge with a new, automated suction unit that discharges into a companion floating sand plant. The company also uses another dredge for extracting gravel.

The usefulness of portable processing plants in aiding companies to supply specialty products that cannot be produced from stationary facilities was demonstrated by Connersville Gravel Co., Inc., Connersville, Ind.[8] In addition, the company was able to place the portable plant close to construction projects thereby eliminating the longer hauls from its stationary plants.

[5] Utley, Harry F. Specialty Sands Produced for New California Plant. Pit and Quarry, v. 62, No. 10, April 1970, pp. 155–156.
[6] Stearn, Enid W. Dredging in the Aggregates Industry. Rock Products, v. 73, No. 9, September 1970, pp. 74–76.
[7] Herod, Buren C. Knoxville Sand and Gravel Modernizes its River Operations. Pit and Quarry, v. 63, No. 5, November 1970, pp. 100–102.
[8] Herod, Buren C. Complementary Portable Plant Boosts Service Capability. Pit and Quarry, v. 68, No. 5, November 1970, pp. 108–109.

Table 1.—Sand and gravel sold or used by producers in the United States,[1] by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operation and use	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Construction:				
Building:				
Sand	r 170,520	r $192,789	166,211	$197,553
Gravel	r 135,705	r 191,495	129,964	191,342
Paving:				
Sand	131,456	135,780	138,959	147,988
Gravel	r 350,232	r 354,897	363,577	384,515
Fill:				
Sand	41,630	27,862	33,467	21,209
Gravel	55,318	38,736	43,210	26,582
Railroad ballast:				
Sand	663	556	1,235	727
Gravel	2,189	1,971	2,768	2,416
Other:				
Sand	7,599	6,827	14,360	16,040
Gravel	6,672	7,288	12,392	14,620
Total construction [2]	r 901,974	r 958,201	906,139	1,002,986
Industrial sand:				
Underground:				
Glass	10,547	36,398	10,813	39,492
Molding	r 10,605	r 30,371	8,078	24,544
Grinding and polishing	354	995	313	744
Blast sand	1,219	6,743	1,103	5,489
Fire or furnace	473	1,005	368	842
Engine	920	2,062	844	2,062
Filtration	194	745	257	618
Oil hydrafrac	274	2,046	296	2,360
Other	r 2,534	r 7,192	4,858	9,819
Total [2]	27,123	87,567	26,931	85,968
Ground sand [3]	1,900	14,460	2,211	15,226
Total industrial [2]	29,021	102,026	29,145	101,191
Miscellaneous gravel	6,173	9,441	8,658	11,521
Grand total [2]	937,169	1,069,667	943,941	1,115,705
Commercial:				
Sand	r 339,453	r 431,441	332,545	438,670
Gravel	r 391,524	r 464,157	399,942	483,894
Government-and-contractor: [4]				
Sand	41,422	34,401	50,833	46,052
Gravel	164,762	139,670	160,619	147,089

r Revised.
[1] Excludes American Samoa, Panama Canal Zone, 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.

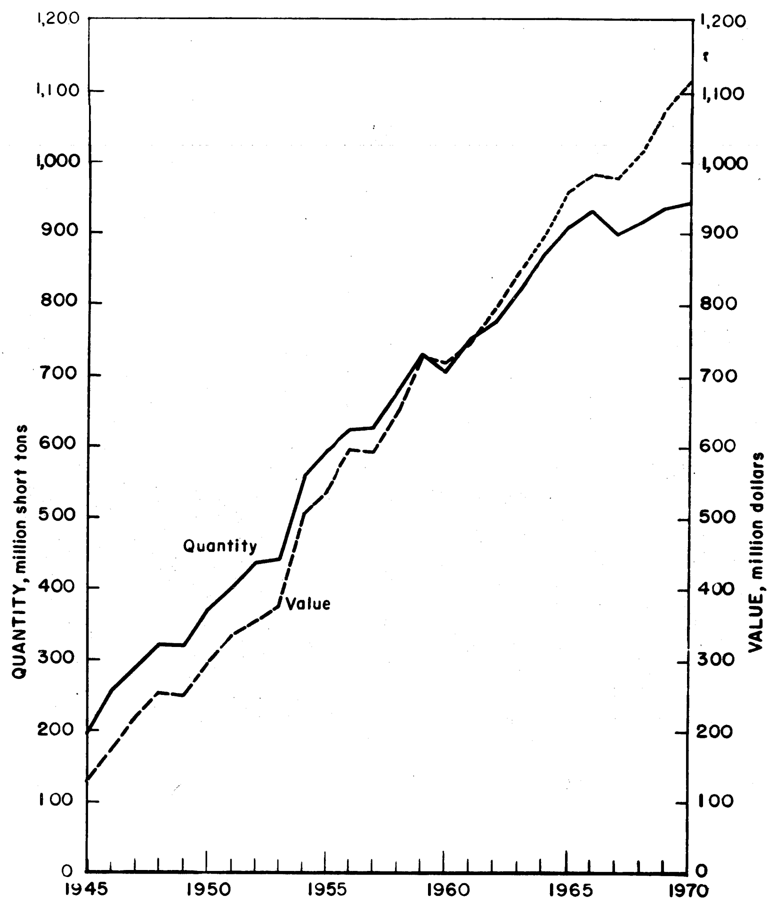

Figure 1.—Production and value of sand and gravel in the United States.

CONSUMPTION AND USES

U.S. consumption of sand and gravel amounted to 944 million tons valued at $1.1 billion in 1970, about 1 percent and 4 percent, respectively, above consumption in 1969. Consumption of sand and gravel for building and paving increased about 1 percent, and sand and gravel for fill, ballast, and other uses declined about 6 percent. In the aggregate, these uses accounted for about 96 percent of the quantity and 90 percent of the value of consumption.

Consumption of industrial sand—29 million tons valued at $101 million—was unchanged from that of 1969. Consumption of glass and molding sands, which account for about four-fifths of industrial sand consumption, fell about 11 percent. Consumption of ground sand in 1970 was 16 percent above that of 1969.

Manufactured sand, as a substitute for natural sand, was discussed in an article that detailed types of resources, methods of crushing, and types of classifying systems.[9]

[9] Szaj, Arnold P. Crushing to Produce Manufactured Sand. Rock Products, v. 73, No. 3, March 1970, pp. 68–70, 102.

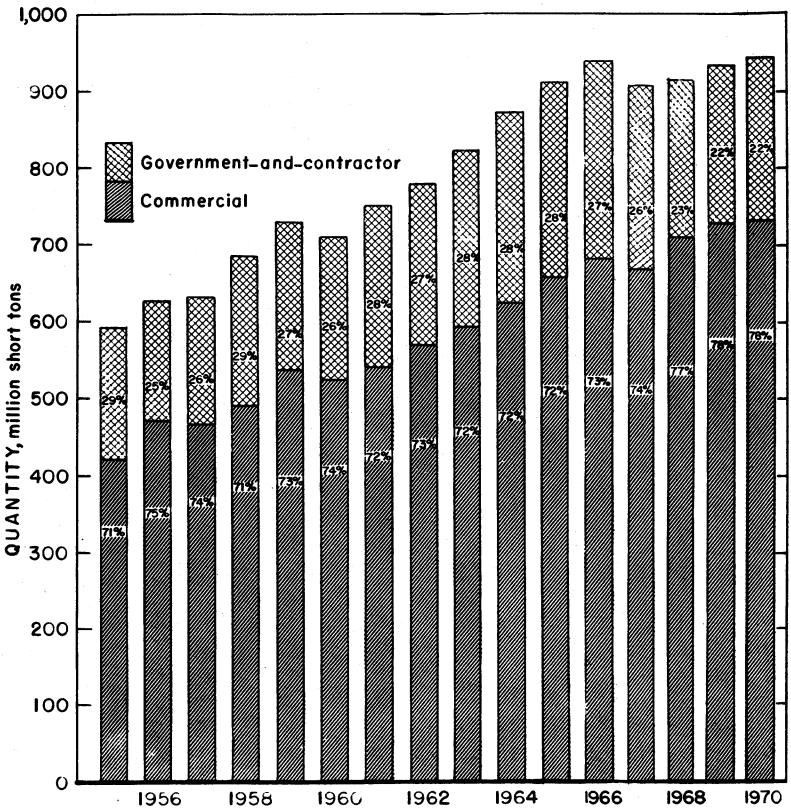

Figure 2.—Sand and gravel sold or used in the United States.

PRICES

Representative carload-lot prices of sand in 21 cities at the end of 1970 ranged from $1.55 per ton in Cincinnati to $5.75 per ton in Atlanta, according to the Engineering News-Record. The average of the sand prices reported was $3.03 per ton, compared with $2.76 per ton in 1969. Prices for either ¾-inch or 1½-inch gravel ranged from $1.70 per ton in Cincinnati to $4.65 per ton in Pittsburgh. The average of the ¾-inch-gravel prices reported for 20 cities was $3.18 per ton, compared with $3.04 per ton in 1969. For 1½-inch gravel, the average for 17 cities was $3.06 per ton, compared with $2.94 per ton in 1969. The average value of sand and gravel sold or used by producers, f.o.b. plant, was $1.18 per ton; the comparable value in 1969 was $1.14 per ton.

FOREIGN TRADE

Exports declined from 2.1 million tons valued at $7.7 million in 1969 to 1.2 million tons valued at $5.9 million in 1970. The greater bulk of sand and gravel exports and imports consisted of construction materials going to or from Canada.

U.S. imports of sand and gravel in 1970 amounted to 879,000 tons valued at $1.6 million, compared with 898,000 tons valued at $1.4 million in 1969.

WORLD REVIEW

Canada.—The Department of Mines, Ontario, Canada, published a study of sand and gravel pits and stone quarries that indicated ways to alter mining operations in order to improve the appearance of the mine site, eliminate objectionable forms of pollution, and better utilize mined-out properties. Construction Aggregates, Ltd., opened a new road gravel plant at Furry Creek, British Columbia, to help supply the Greater Vancouver area.[10]

Norway.—Deposits of olivine at Norddal [11] and Aaheim [12] were being utilized to produce olivine sand for use as a molding material by foundries. Olivine sand has certain technical advantages over silica sand and additionally, eliminates the health risks associated with the latter.

Sweden.—Exploitation of an olivine deposit at Handol continued, as demand for olivine sand for use in foundries expanded in recent years.[13] The bulk of the production consists of two principal grades: minus 4 millimeters to dust, and minus 1 millimeter to dust.

United Kingdom.—The sand and gravel industry of Scotland was reviewed in an article that discussed the rapid development of the industry, the increasing demands being made upon it, and the difficulties of establishing new production points.[14]

The first in a series of surveys to determine the extent of sand and gravel reserves in southeast England was completed by the Mineral Assessment Unit of the Institute of Geological Sciences.[15]

A new sand and gravel plant went into production near Harlington, a suburb of London, to supply concrete aggregates to local construction firms.[16] The owners screened the plant with shrubbery, instituted noise and dirt abatement practices, and agreed to restore worked-out areas into arable land.

A new sand plant, incorporating a number of novel features, was installed by Sandsfield Gravel Co. at its Brandesburton Quarry in Yorkshire.[17] At this plant classification and dewatering occur in one operation and the two grades produced are then treated separately in density separators to remove impurities.

Mixconcrete Aggregates Ltd. of Northampton brought its Charlecote Quarry into full production.[18] In order to insure that the operation would not change the surrounding environment, the plant was placed below the existing ground level, elaborate soundproofing measures were undertaken to reduce plant noise to a minimum, and vehicular traffic to and from the quarry was prohibited in local villages.

Hoveringham Gravel Ltd. opened a third sand and gravel plant near Reading to serve local markets,[19] and Blue Circle Aggregates Ltd. constructed three new plants to serve the Midland market.[20]

A reduction in equipment and manpower requirements and an overall increase in plant efficiency were accomplished by development of a dewatering feeder conveyor unit by Messrs. Folley Brothers of Henley, and Harleyford Hydro Sand Equipment Co. Ltd. of Herleyford, Marlow.[21]

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[10] Trauffer, Walter E. New British Columbia Road Gravel Plant. Pit and Quarry, v. 63, No. 3, September 1970, pp. 80–84, 90.

[11] Industrial Minerals. Norddal:k/s Norddal Olivin A/S and Co., Division of H. Bjorum. No. 29, February 1970, pp. 17–19.

[12] Industrial Minerals. Aaheim: Operations of A/S Olivia. No. 29, February 1970, pp. 15–16.

[13] Industrial Minerals. Handol: Taljstens A. B. Division of the Hoganas Group. No. 29, February 1970, pp. 20–21.

[14] Mclellan, A. G. Sand and Gravel in Scotland. Cement Lime and Gravel, v. 45, No. 6, June 1970, pp. 154–156.

[15] Cement Lime and Gravel. First Sand and Gravel Resources Survey is Completed. V. 45, No. 3, March 1970, p. 73.

[16] Cement Lime and Gravel. New Aggregate Plant for London Firm. V. 45, No. 4, April 1970, pp. 89–94.

[17] Cement Lime and Gravel. A New Goal/Sand Separation Plant. V. 45, No. 2, February 1970, pp. 37–40.

[18] Cement Lime and Gravel. Winning Sand and Gravel in Shakespeare Country. V. 45, No. 3, March 1970, pp. 61–64.

[19] Cement Lime and Gravel. Winning Sand and Gravel in the Kennet Valley. V. 46, No. 5, May 1971, pp. 119–123.

[20] Cement Lime and Gravel. Modern Control Methods at a Sand and Gravel Plant. V. 45, No. 11, November 1970, pp. 279–284.

[21] Mining and Minerals Engineering. Productivity Increased at Thames Valley Gravel Operation. V. 6, No. 10, October 1970, pp. 6–7.

TECHNOLOGY

The relationship that exists between chemistry and the sand and gravel industry was discussed in a paper presented to the Road and Building Materials Group of the Society of Chemical Industry, London, England.[22]

The use of olivine sand as a substitute for silica sand as a foundry molding material was discussed in articles that dealt with properties and uses of olivine[23] and resources and increasing use of the mineral.[24]

The production of manufactured sand by crushing rock was undertaken in the United Kingdom to augment diminishing supplies of high-quality deposits suitable for the manufacture of glass.[25] Crushing was used to produce manufactured sand by Genessee Sand and Gravel Co. Inc., Waukesha, Wis., from a vast accumulation of unmarketable stone and gravel.[26]

The first use of a computer to control plant operations was at Kaiser Sand and Gravel Co.'s new Radum, Calif., plant.[27] The plant, which went into full production early in 1970, has a capacity of 4 million tons per year, and was designed to meet increasing market demand for sand and gravel.

Sand and gravel operations in the United States were improved by changing methods of mining and processing, and by the addition of novel operating techniques. Nugent Sand Co., Inc., Muskegon, Mich., a major supplier of industrial sand, built a new classifying plant and commenced hydraulic mining in order to improve the quantity of its products, and to increase its capacity.[28] Windsor Sand and Gravel Co., Windsor, Calif., replaced seven truck haulers and a 5-cubic-yard, front-end loader with a 32-cubic-yard, elevating, tractor scraper.[29] An immediate increase in production by the substitution of rubber-tired loaders for a stationary crane was realized by Wilson Brothers, Rives Junction, Mich.[30] A unit train transportation system will be used by Penn Industries at its new facility at Plainsboro, N.J.[31]

Santa Clara Sand & Gravel Co. was conducting at Sunol, Calif., a unique (for the United States) mining operation using a fully automated floating clamshell dredge that discharges into floating conveyors.[32] The terms of the mining lease stipulate the creation of a large recreational lake upon termination of the mining operation. The company, as it mines, develops a desired lake-bottom configuration and seals it by returning fine sand rejected by the dewatering screens.

[22] Jordan, J. P. R. Chemistry and the Sand and Gravel Industry. Chem. and Ind. (London), No. 27, July 4, 1970, pp. 889–892.
[23] Beckius, Kurt. Olivine: Its Properties and Uses. Ind. Miner. No. 29, February 1970, pp. 22–26.
[24] Industrial Minerals. Opportunities for Increasing Olivine Output. No. 29, February 1970, pp. 11–13.
[25] Industrial Minerals. New Source of Sand for Glass Making. No. 30, March 1970, p. 39.
[26] Shannon, James J. Crusher Transforms Surplus Stone and Gravel to Marketable Product. Rock Products, v. 73, No. 9, September 1970, pp. 106–107.
[27] Pit and Quarry. Kaiser's New 2,000-TPH, $10 million Sand and Gravel Plant. V. 62, No. 12, June 1970, pp. 68–86, 105.
[28] Pit and Quarry. New Mining, Process Systems Boost Nugent Sand's Service. V. 22, No. 12, June 1970, pp. 100–105.
[29] Rock Products. Elevating Scraper Loads and Hauls at Windsor Sand and Gravel. V. 73, No. 4, April 1970, pp. 46–47.
[30] Pit and Quarry. Loader Replaces Crane in Michigan Gravel Pit. V. 63, No. 2, August 1970, p. 32.
[31] Pit and Quarry. McCormack Sand Division Will Use Unit Train to Connect New Plant With Barge Facility. V. 62, No. 8, February 1970, pp. 27–30.
[32] Pit and Quarry. California Plant Using German System of Dredging Sand and Gravel. V. 62, No. 12, June 1970, pp. 134–139.

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
1966	368,321	$408,757	566,160	$576,225	934,481	$984,982
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	r 380,878	r 465,843	r 556,291	r 603,826	r 937,169	r 1,069,667
1970	383,378	484,722	560,563	630,985	943,941	1,115,705

r Revised.
[1] Excludes American Samoa, Panama Canal Zone, 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 States and classes of operations [1]

(Thousand short tons and thousand dollars)

State	1969						1970					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	8,323	$9,427	---------	---------	8,323	$9,427	6,705	$8,076	20	$68	6,725	$8,144
Alaska	943	1,123	15,261	$17,492	16,205	18,615	2,441	3,755	23,384	37,337	25,825	41,092
Arizona	r 10,614	r 12,909	6,129	5,315	r 16,744	r 18,224	11,272	14,140	6,549	5,664	17,822	19,804
Arkansas	10,067	12,919	2,608	2,030	12,674	14,949	10,639	13,553	2,662	2,484	13,301	16,036
California	102,013	134,532	22,705	21,351	124,718	155,883	103,726	143,459	36,533	30,762	140,259	174,221
Colorado	10,682	14,098	9,195	13,168	19,877	27,266	15,360	17,827	6,902	6,363	22,261	24,190
Connecticut	7,793	9,940	1,064	419	8,857	10,359	6,615	9,073	150	129	6,765	9,202
Delaware	2,257	2,074	---------	---------	2,257	2,074	1,565	1,603	---------	---------	1,565	1,603
Florida	13,737	13,457	672	531	14,409	13,988	12,182	12,086	300	168	12,482	12,254
Georgia	3,824	4,709	---------	---------	3,824	4,709	3,667	4,437	---------	---------	3,667	4,437
Hawaii	552	1,816	---------	---------	552	1,816	514	1,679	---------	---------	514	1,679
Idaho	2,119	2,698	6,435	4,885	8,555	7,583	4,895	3,911	8,058	6,111	12,953	10,022
Illinois	43,278	56,144	860	544	44,138	56,688	43,508	59,884	418	271	43,926	60,155
Indiana	25,352	26,950	866	488	26,218	27,438	22,566	25,280	911	516	23,476	25,796
Iowa	16,730	16,753	1,662	1,114	18,391	17,867	16,333	17,333	4,726	3,309	21,058	20,642
Kansas	9,734	8,576	2,295	1,485	12,029	10,061	10,457	10,619	2,511	1,733	12,968	12,351
Kentucky	8,124	9,509	240	119	8,364	9,628	8,522	10,373	239	101	8,760	10,474
Louisiana	17,715	21,278	416	616	18,131	21,895	17,746	21,527	410	836	18,155	22,363
Maine	3,047	2,603	8,228	3,423	11,275	6,026	3,612	3,299	9,358	3,589	12,971	6,888
Maryland	13,986	21,141	244	86	14,230	21,226	12,821	20,415	129	19	12,951	20,434
Massachusetts	16,489	20,178	2,967	2,772	19,456	22,950	15,305	19,773	2,620	2,472	17,925	22,244
Michigan	50,661	54,636	7,431	4,332	58,092	58,968	45,235	49,768	7,857	4,878	53,092	54,646
Minnesota	41,803	36,125	6,318	4,066	48,121	40,191	37,733	33,172	9,119	5,630	46,851	38,802
Mississippi	11,140	11,811	344	451	11,484	12,263	10,599	11,738	260	211	10,859	11,950
Missouri	10,886	14,524	53	50	10,940	14,574	12,395	15,327	51	52	12,446	15,379
Montana	2,140	2,855	14,455	11,529	16,595	14,383	2,189	2,761	17,086	17,488	19,275	20,249
Nebraska	11,962	12,940	796	652	12,758	13,592	11,301	12,065	931	910	12,232	12,974
Nevada	4,918	7,521	3,529	3,313	8,447	10,834	6,405	8,143	2,169	1,677	8,574	9,819
New Hampshire	4,330	4,285	1,980	865	6,310	5,149	5,160	4,458	1,369	295	6,529	4,753
New Jersey	20,325	33,977	---------	---------	20,325	33,977	16,723	31,564	10	8	16,732	31,571
New Mexico	3,246	4,402	5,328	6,020	8,574	10,422	5,710	4,993	4,956	5,523	10,666	10,516
New York	26,620	33,610	13,186	8,908	39,806	42,518	26,128	32,759	9,408	6,079	35,537	38,839
North Carolina	7,553	9,589	3,009	1,848	10,562	11,437	9,089	11,133	3,683	2,143	12,772	13,277
North Dakota	4,100	4,488	2,939	2,786	7,039	7,274	6,950	5,909	1,140	427	8,090	6,336
Ohio	r 50,002	r 64,531	27	21	r 50,029	r 64,552	41,844	57,283	225	223	42,069	57,506
Oklahoma	4,060	5,874	1,202	1,282	5,262	7,156	3,878	5,891	1,798	1,367	5,675	7,258
Oregon	11,946	14,765	3,795	5,726	15,740	20,491	12,158	15,307	5,375	10,671	17,532	25,978
Pennsylvania	18,105	31,451	---------	---------	18,105	31,451	18,504	33,915	---------	---------	18,504	33,915
Rhode Island	2,409	2,900	71	116	2,480	3,015	2,297	2,801	90	113	2,387	2,913
South Carolina	5,692	8,229	---------	---------	5,692	8,229	5,864	7,766	---------	---------	5,864	7,766
South Dakota	3,252	3,338	7,906	7,469	11,158	10,807	7,015	6,238	9,541	10,419	16,556	16,656
Tennessee	5,555	9,194	619	515	6,175	9,709	5,931	9,945	785	694	6,715	10,639

See footnotes at end of table.

Table 3.—Sand and gravel sold or used by producers in the United States, by States and classes of operations [1]—Continued

(Thousand short tons and thousand dollars)

State	1969						1970					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Texas	24,226	$33,123	5,746	$ 6,633	29,972	$39,756	27,464	$42,252	3,973	$4,110	31,438	$46,362
Utah	5,649	r 5,911	13,503	10,131	19,151	r 16,042	8,993	8,466	3,017	1,973	12,010	10,439
Vermont	2,643	2,781	694	247	3,336	3,028	2,986	3,575	1,061	547	4,046	4,122
Virginia	12,062	15,922	78	32	12,140	15,954	11,062	15,207	64	22	11,126	15,229
Washington	18,032	20,744	16,213	10,302	34,245	31,046	18,166	23,125	6,923	4,777	25,089	27,902
West Virginia	r 5,021	r 11,475	---------	---------	r 5,021	r 11,475	4,396	11,473	---------	---------	4,396	11,473
Wisconsin	31,771	28,521	11,044	6,893	42,815	35,414	30,529	28,227	10,574	6,880	41,103	35,107
Wyoming	3,492	3,243	4,076	4,045	7,568	7,288	5,338	5,201	4,109	4,096	9,447	9,298
Total [2]	r 730,980	r 895,599	206,189	174,070	r 937,169	r 1,069,667	732,493	922,564	211,454	193,145	943,941	1,115,705
American Samoa	---------	---------	7	7	7	7	---------	---------	e 26	e 25	e 26	e 25
Panama Canal Zone	60	97	---------	---------	60	97	e 60	e 97	---------	---------	e 60	e 97
Puerto Rico	9,265	22,774	167	522	9,432	23,296	e 9,265	e 22,774	e 167	e 522	e 9,432	e 23,296

e Estimate. r Revised.
1 Excludes American Samoa, Panama Canal Zone, 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 1970, by States, uses, and classes of operations [1]

(Thousand short tons and thousand dollars)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commerical		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,675	$1,998	-------	-------	875	$896	9	$31
Alaska	119	222	15	$87	47	139	6,781	12,102
Arizona	3,873	4,840	-------	-------	598	434	1,218	1,098
Arkansas	1,398	1,766	30	21	1,785	1,823	1,094	1,051
California	24,193	32,669	96	157	14,978	18,195	8,458	7,345
Colorado	2,438	2,951	78	16	661	453	722	897
Connecticut	1,579	2,185	-------	-------	1,653	2,450	27	22
Delaware	286	395	-------	-------	160	198	-------	-------
Florida	8,288	7,700	-------	-------	W	W	-------	-------
Georgia	2,737	2,637	-------	-------	387	313	-------	-------
Hawaii	445	1,516	-------	-------	9	6	-------	-------
Idaho	188	327	-------	-------	22	44	4,651	3,893
Illinois	6,281	6,993	-------	-------	8,969	9,345	2	2
Indiana	4,208	4,071	-------	-------	4,680	4,568	22	11
Iowa	3,069	3,405	6	8	3,186	3,553	399	466
Kansas	4,089	4,076	-------	-------	3,141	3,184	1,009	683
Kentucky	3,516	4,409	-------	-------	2,332	2,691	-------	-------
Louisiana	5,015	5,258	173	346	2,049	2,084	26	52
Maine	489	388	-------	-------	452	438	425	155
Maryland	5,202	7,634	-------	-------	1,549	2,461	-------	-------
Massachusetts	2,907	3,871	-------	-------	2,502	2,799	615	357
Michigan	6,971	6,181	-------	-------	4,884	4,720	2,055	1,163
Minnesota	4,627	4,332	-------	-------	2,091	1,547	2,037	1,210
Mississippi	2,255	1,912	-------	-------	1,765	1,703	25	37
Missouri	4,352	3,866	-------	-------	1,514	1,456	16	17
Montana	272	440	-------	-------	77	122	2,193	3,042
Nebraska	2,591	2,709	-------	-------	1,477	1,658	96	181
Nevada	893	1,473	1	5	25	39	189	285
New Hampshire	794	701	-------	-------	656	548	396	119
New Jersey	4,358	5,573	-------	-------	1,833	2,159	-------	-------
New Mexico	511	597	-------	-------	276	305	254	324
New York	9,582	12,608	43	65	3,740	4,414	905	501
North Carolina	3,267	3,494	-------	-------	1,946	1,721	1,969	1,335
North Dakota	485	567	27	13	221	185	13	5
Ohio	6,608	8,506	-------	-------	8,427	9,999	89	93
Oklahoma	1,737	1,899	323	304	717	826	1,020	386
Oregon	1,213	1,780	-------	-------	819	997	217	347
Pennsylvania	4,700	7,749	-------	-------	3,158	5,088	-------	-------
Rhode Island	653	822	-------	-------	206	251	45	56
South Carolina	3,310	2,012	-------	-------	W	W	-------	-------
South Dakota	496	567	-------	-------	254	287	248	205
Tennessee	1,822	2,660	-------	-------	935	1,678	2	2
Texas	8,886	10,894	20	2	2,080	2,426	605	704
Utah	1,117	1,252	8	12	569	479	420	262
Vermont	468	589	-------	-------	358	303	521	260
Virginia	4,116	5,226	-------	-------	2,497	2,212	6	1
Washington	2,281	3,334	13	22	1,062	1,238	266	266
West Virginia	1,233	1,775	-------	-------	343	568	-------	-------
Wisconsin	3,640	3,439	-------	-------	2,451	1,947	2,359	1,274
Wyoming	145	227	-------	-------	561	600	1,726	1,725
Undistributed	-------	-------	-------	-------	852	473	-------	-------
Total	165,378	196,495	833	1,058	95,829	106,023	43,130	41,965
American Samoa	-------	-------	4,347	5,009	-------	-------	-------	-------
Panama Canal Zone [e]	60	97	-------	-------	-------	-------	-------	-------
Puerto Rico [e]	2,726	6,730	137	425	1,945	4,445	30	98

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Excludes American Samoa, Panama Canal Zone, and Puerto Rico.

Table 4.—Sand and gravel sold or used by producers in the United States in 1970, by States, uses, and classes of operations [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	104	$47	------	------	W	W	------	------
Alaska	------	------	2	5	26	$29	310	$775	10	$71
Arizona	W	W	570	208	31	31	W	W	------	------
Arkansas	------	------	135	78	------	------	43	43	------	------
California	W	W	3,061	2,799	363	121	852	989	------	------
Colorado	------	------	129	105	2	3	322	448	------	------
Connecticut	------	------	329	205	------	------	241	276	32	23
Delaware	------	------	W	W	------	------	W	W	------	------
Florida	------	------	W	W	298	153	W	W	------	------
Georgia	------	------	22	23	------	------	57	62	------	------
Hawaii	------	------	W	W	------	------	------	------	------	------
Idaho	------	------	W	W	20	1	1,019	628	10	2
Illinois	------	------	W	W	------	------	W	W	------	------
Indiana	W	W	828	583	------	------	W	W	1	1
Iowa	W	W	971	724	------	------	W	W	2	1
Kansas	W	W	935	528	2	1	172	162	------	------
Kentucky	------	------	942	813	------	------	------	------	------	------
Louisiana	------	------	W	W	------	------	------	------	------	------
Maine	------	------	280	127	200	48	W	W	32	9
Maryland	------	------	W	W	36	5	W	W	------	------
Massachusetts	------	------	540	234	168	36	608	779	68	109
Michigan	W	W	3,655	1,783	677	291	546	500	132	77
Minnesota	W	W	813	707	123	53	W	W	90	40
Mississippi	W	W	W	W	------	------	W	W	------	------
Missouri	------	------	330	232	------	------	90	89	------	------
Montana	------	------	5	6	26	18	W	W	------	------
Nebraska	W	W	699	608	11	5	W	W	------	------
Nevada	------	------	114	167	70	34	31	70	8	4
New Hampshire	------	------	434	259	18	6	635	378	------	------
New Jersey	W	W	1,002	575	------	------	2,640	3,750	5	5
New Mexico	------	------	76	76	26	21	W	W	2	2
New York	------	------	704	327	1,692	561	303	283	67	37
North Carolina	W	W	431	278	432	324	W	W	830	251
North Dakota	------	------	151	138	------	------	------	------	------	------
Ohio	W	W	1,284	1,079	------	------	277	300	------	------
Oklahoma	W	W	254	141	------	------	295	290	9	7
Oregon	W	W	368	311	6	3	50	56	6	4
Pennsylvania	------	------	85	113	------	------	739	1,449	------	------
Rhode Island	------	------	W	W	------	------	W	W	------	------
South Carolina	W	W	W	W	------	------	W	W	------	------
South Dakota	------	------	110	60	1	1	W	W	25	13
Tennessee	------	------	W	W	------	------	49	91	------	------
Texas	------	------	314	234	3	(3)	960	1,251	------	------
Utah	------	------	245	70	80	2	W	W	11	8
Vermont	------	------	206	76	36	20	W	W	------	------
Virginia	W	W	357	173	51	18	W	W	------	------
Washington	------	------	604	342	694	348	92	116	114	67
West Virginia	------	------	W	W	------	------	------	------	------	------
Wisconsin	------	------	1,945	1,090	142	62	W	W	177	102
Wyoming	------	------	36	21	------	------	W	W	1	1
Undistributed	1,235	$727	5,163	3,669	------	------	2,397	2,421	------	------
Total	1,235	727	28,233	19,014	5,234	2,195	12,728	15,206	1,632	834
American Samoa	------	------	------	------	22,035	20,309	------	------	------	------
Panama Canal Zone [e]	------	------	------	------	------	------	------	------	------	------
Puerto Rico [e]	------	------	1,012	1,205	------	------	------	------	------	------

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Excludes American Samoa, Panama Canal Zone, 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 1970, by States, uses, and classes of operations [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	------	------	------	------	W	W
Alaska	------	------	------	------	------	------	------	------	------	------
Arizona	------	------	------	------	------	------	(2)	W	------	------
Arkansas	W	W	W	W	------	------	W	W	------	------
California	1,513	$7,446	W	W	------	------	179	$1,168	W	W
Colorado	------	------	------	------	------	------	W	W	------	------
Connecticut	------	------	(2)	W	------	------	------	------	------	------
Delaware	------	------	------	------	------	------	------	------	------	------
Florida	W	W	W	W	------	------	W	W	(2)	W
Georgia	W	W	W	W	------	------	W	W	------	------
Hawaii	------	------	------	------	------	------	------	------	------	------
Idaho	------	------	------	------	------	------	------	------	------	------
Illinois	2,140	5,429	1,109	$4,303	W	W	168	898	W	W
Indiana	W	W	W	W	------	------	------	------	W	W
Iowa	------	------	W	W	------	------	W	W	------	------
Kansas	------	------	W	W	------	------	W	W	------	------
Kentucky	------	------	------	------	------	------	W	W	W	W
Louisiana	------	------	------	------	------	------	W	W	------	------
Maine	------	------	------	------	------	------	------	------	------	------
Maryland	------	------	------	------	------	------	W	W	------	------
Massachusetts	------	------	W	W	------	------	W	W	------	------
Michigan	W	W	3,188	5,994	W	W	W	W	------	------
Minnesota	W	W	W	W	------	------	W	W	------	------
Mississippi	------	------	W	W	------	------	------	------	------	------
Missouri	565	1,722	W	W	W	W	W	W	------	------
Montana	------	------	------	------	------	------	W	W	------	------
Nebraska	------	------	------	------	------	------	(2)	W	------	------
Nevada	W	W	W	W	------	------	------	------	W	W
New Hampshire	------	------	------	------	------	------	------	------	------	------
New Jersey	1,545	6,869	613	2,949	------	------	114	455	W	W
New Mexico	------	------	------	------	------	------	------	------	------	------
New York	------	------	139	687	------	------	------	------	------	------
North Carolina	------	------	------	------	------	------	------	------	------	------
North Dakota	------	------	------	------	------	------	------	------	------	------
Ohio	W	W	464	2,146	------	------	W	W	W	W
Oklahoma	W	W	W	W	------	------	W	W	------	------
Oregon	------	------	------	------	------	------	W	W	------	------
Pennsylvania	W	W	102	401	W	W	W	W	36	$123
Rhode Island	------	------	W	W	------	------	------	------	------	------
South Carolina	W	W	W	W	------	------	20	103	W	W
South Dakota	------	------	------	------	------	------	------	------	------	------
Tennessee	W	W	W	W	------	------	W	W	14	27
Texas	W	W	139	434	------	------	W	W	------	------
Utah	------	------	------	------	------	------	W	W	------	------
Vermont	------	------	------	------	------	------	------	------	------	------
Virginia	W	W	------	------	------	------	------	------	W	W
Washington	------	------	------	------	------	------	W	W	------	------
West Virginia	W	W	W	W	W	W	W	W	W	W
Wisconsin	W	W	782	2,190	------	------	73	253	------	------
Wyoming	------	------	------	------	------	------	------	------	------	------
Undistributed	5,050	18,026	1,542	5,440	313	$744	549	2,612	318	692
Total	10,813	39,492	8,078	24,544	313	744	1,103	5,489	368	842
American Samoa	------	------	------	------	------	------	------	------	------	------
Panama Canal Zone [e]	------	------	------	------	------	------	------	------	------	------
Puerto Rico [e]	------	------	------	------	------	------	------	------	------	------

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Excludes American Samoa, Panama Canal Zone, and Puerto Rico.

[2] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States, in 1970, by States, uses, and classes of operations [1]—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)—Continued									
	Engine		Filtration		Oil (hydrafrac)		Other		Ground sand	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	W	W	------	------	W	W	------	------
Alaska	------	------	------	------	------	------	17	$54	------	------
Arizona	------	------	(2)	W	W	W	------	------	------	------
Arkansas	------	------	------	------	------	------	W	W	W	W
California	54	$189	W	W	W	W	52	258	137	$1,482
Colorado	W	W	W	W	W	W	W	W	------	------
Connecticut	------	------	------	------	------	------	W	W	------	------
Delaware	------	------	------	------	------	------	------	------	------	------
Florida	W	W	W	W	------	------	W	W	W	W
Georgia	W	W	W	W	------	------	W	W	W	W
Hawaii	------	------	------	------	------	------	W	W	------	------
Idaho	------	------	------	------	------	------	------	------	------	------
Illinois	W	W	W	W	W	W	W	W	W	W
Indiana	W	W	------	------	------	------	W	W	W	W
Iowa	(2)	W	W	W	------	------	W	W	------	------
Kansas	16	24	W	(2)	------	------	W	W	24	51
Kentucky	W	W	------	------	------	------	------	------	W	W
Louisiana	W	W	------	------	------	------	------	------	W	W
Maine	W	W	------	------	------	------	W	W	------	------
Maryland	------	------	------	------	------	------	------	------	W	W
Massachusetts	------	------	W	W	------	------	W	W	------	------
Michigan	W	W	------	------	------	------	W	W	W	W
Minnesota	W	W	------	------	W	W	W	W	W	W
Mississippi	W	W	------	------	------	------	------	------	------	------
Missouri	W	W	W	W	------	------	W	W	W	W
Montana	------	------	------	------	------	------	W	W	------	------
Nebraska	------	------	------	------	------	------	------	------	------	------
Nevada	------	------	------	------	------	------	W	W	W	W
New Hampshire	------	------	------	------	------	------	W	W	------	------
New Jersey	W	W	W	W	------	------	271	699	89	850
New Mexico	------	------	------	------	------	------	W	W	------	------
New York	W	W	W	W	------	------	W	W	W	W
North Carolina	------	------	W	W	------	------	------	------	------	------
North Dakota	------	------	------	------	------	------	------	------	------	------
Ohio	W	W	W	W	------	------	W	W	W	W
Oklahoma	W	W	------	------	W	W	W	W	W	W
Oregon	W	W	------	------	------	------	W	W	------	------
Pennsylvania	W	W	(2)	W	(2)	W	W	W	62	685
Rhode Island	------	------	------	------	------	------	W	W	------	------
South Carolina	W	W	W	W	------	------	W	W	72	701
South Dakota	------	------	------	------	------	------	W	W	------	------
Tennessee	W	W	------	------	------	------	W	W	W	W
Texas	W	W	W	W	W	W	107	305	605	1,434
Utah	W	W	------	------	------	------	W	W	W	W
Vermont	------	------	------	------	------	------	------	------	------	------
Virginia	W	W	(2)	W	------	------	W	W	W	W
Washington	------	------	------	------	------	------	------	------	55	595
West Virginia	W	W	(2)	W	------	------	W	W	W	W
Wisconsin	W	W	W	W	W	W	------	------	W	W
Wyoming	------	------	------	------	------	------	W	W	------	------
Undistributed	774	1,849	257	$618	296	$2,360	4,411	8,503	1,167	9,428
Total	844	2,062	257	618	296	2,360	4,858	9,819	2,211	15,226
American Samoa	------	------	------	------	------	------	------	------	------	------
Panama Canal Zone [e]	------	------	------	------	------	------	------	------	------	------
Puerto Rico [e]	------	------	------	------	------	------	------	------	------	------

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Excludes American Samoa, Panama Canal Zone, and Puerto Rico.

[2] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States, in 1970, by States, uses, and classes of operations [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	1,854	$2,852	-------	-------	1,154	$1,375	11	$37
Alaska	317	168	5	$2	224	532	15,838	24,610
Arizona	2,913	4,112	48	40	2,414	3,617	4,997	4,222
Arkansas	1,530	2,734	-------	-------	4,618	5,299	1,538	1,413
California	24,532	34,542	124	179	30,979	39,992	20,956	20,370
Colorado	3,275	5,252	384	14	7,438	7,176	4,224	4,910
Connecticut	917	1,552	-------	-------	832	1,122	41	48
Delaware	75	135	-------	-------	W	W	-------	-------
Florida	W	W	-------	-------	W	W	2	15
Georgia	W	W	-------	-------	W	W	-------	-------
Hawaii	41	112	-------	-------	9	30	-------	-------
Idaho	274	491	66	80	748	829	2,020	1,750
Illinois	7,580	8,370	7	5	12,307	15,127	408	264
Indiana	3,390	4,577	95	42	7,381	8,740	792	462
Iowa	1,208	2,184	7	8	3,897	4,018	4,283	2,804
Kansas	207	241	-------	-------	1,183	1,267	1,499	1,049
Kentucky	578	806	-------	-------	1,032	1,454	238	101
Louisiana	6,805	8,926	169	338	3,667	4,796	42	100
Maine	420	191	12	3	978	1,263	8,481	3,325
Maryland	3,694	7,153	-------	-------	1,337	2,120	94	13
Massachusetts	2,840	5,121	71	176	3,287	3,910	1,626	1,650
Michigan	6,201	10,006	38	24	17,116	16,245	4,474	3,103
Minnesota	3,518	5,929	-------	-------	23,223	17,441	6,351	4,095
Mississippi	2,264	2,682	-------	-------	3,761	4,751	235	174
Missouri	1,916	2,590	-------	-------	3,111	3,104	29	31
Montana	502	665	-------	-------	1,002	1,166	14,336	14,122
Nebraska	825	864	29	44	5,055	5,758	748	630
Nevada	1,119	1,894	389	234	2,090	2,066	1,368	994
New Hampshire	385	554	-------	-------	1,095	1,104	955	171
New Jersey	1,532	3,356	-------	-------	1,016	1,450	3	2
New Mexico	676	867	4	9	3,906	2,776	4,539	5,092
New York	4,763	7,591	-------	-------	4,093	4,675	4,346	3,559
North Carolina	1,084	1,792	-------	-------	1,620	1,917	452	233
North Dakota	804	1,095	107	47	5,047	3,746	981	357
Ohio	7,192	9,905	3	5	13,970	19,248	134	125
Oklahoma	42	54	25	37	37	50	420	634
Oregon	2,951	3,918	155	89	4,775	6,360	4,954	10,208
Pennsylvania	3,501	5,897	-------	-------	3,531	6,523	-------	-------
Rhode Island	619	950	-------	-------	303	359	45	56
South Carolina	W	W	-------	-------	W	W	-------	-------
South Dakota	152	245	2	2	4,762	4,062	9,144	10,079
Tennessee	872	1,137	-------	-------	1,198	1,470	744	653
Texas	8,840	15,391	52	42	3,196	4,507	3,294	3,361
Utah	1,400	1,573	7	16	4,973	4,475	1,625	1,311
Vermont	515	816	-------	-------	1,163	1,589	504	267
Virginia	2,670	5,009	-------	-------	564	758	3	1
Washington	3,990	5,524	17	37	7,680	9,733	4,776	3,665
West Virginia	978	1,520	-------	-------	425	641	-------	-------
Wisconsin	4,292	4,402	-------	-------	15,488	13,401	7,437	5,213
Wyoming	217	384	23	43	3,673	3,608	2,329	2,300
Undistributed	1,855	3,697	-------	-------	903	1,286	-------	-------
Total	128,125	189,826	1,839	1,516	222,261	246,936	141,316	137,579
American Samoa	-------	-------	-------	-------	-------	-------	-------	-------
Panama Canal Zone [e]	-------	-------	-------	-------	-------	-------	-------	-------
Puerto Rico [e]	1,760	5,839	-------	-------	1,147	3,779	-------	-------

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Excludes American Samoa, Panama Canal Zone, and Puerto Rico.

Table 4.—Sand and gravel sold or used by producers in the United States, in 1970, by States, uses, and classes of operations [1]—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction—Continued											
	Railroad ballast (commercial)		Fill				Other				Gravel miscellaneous (commercial)	
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	----	----	W	W	-----	-----	124	$152	----	----	W	W
Alaska	----	----	1,063	$973	705	$417	334	858	4	$20	9	$29
Arizona	W	W	749	541	101	97	36	62	153	176	8	17
Arkansas	----	----	44	30	-----	-----	W	W	----	----	649	607
California	286	$422	1,616	1,302	6,536	2,588	874	1,151	(2)	1	345	533
Colorado	W	W	523	516	1,429	499	W	W	62	24	114	146
Connecticut	W	W	389	277	-----	-----	95	155	51	37	W	W
Delaware	----	----	W	W	-----	-----	W	W	----	----	W	W
Florida	----	----	W	W	-----	-----	-----	-----	----	----	----	-----
Georgia	----	----	W	W	-----	-----	-----	-----	----	----	----	-----
Hawaii	----	----	W	W	-----	-----	2	2	----	----	----	-----
Idaho	----	----	2,494	1,414	706	86	117	152	585	299	W	W
Illinois	W	W	1,403	1,050	-----	-----	W	W	----	----	22	103
Indiana	W	W	1,481	1,038	-----	-----	W	W	----	----	----	-----
Iowa	W	W	W	W	14	3	2,435	1,572	13	19	W	W
Kansas	W	W	38	40	-----	-----	50	42	----	----	206	715
Kentucky	30	51	39	39	1	(2)	W	W	----	----	----	-----
Louisiana	----	----	W	W	-----	-----	1	1	----	----	W	W
Maine	W	W	204	125	198	46	W	W	10	2	W	W
Maryland	----	----	W	W	-----	-----	-----	-----	----	----	W	W
Massachusetts	21	40	1,349	854	2	3	318	522	71	141	629	690
Michigan	138	186	383	229	446	201	354	522	34	19	213	136
Minnesota	166	191	1,818	499	517	233	510	629	----	----	131	166
Mississippi	W	W	W	W	-----	-----	W	W	----	----	W	W
Missouri	----	----	9	10	-----	-----	20	23	5	4	100	83
Montana	75	92	169	118	475	276	56	104	57	31	W	W
Nebraska	----	----	298	160	38	25	127	113	9	25	209	175
Nevada	525	236	1,365	1,110	141	116	-----	-----	4	4	34	169
New Hampshire	----	----	239	129	-----	-----	W	W	----	----	423	401
New Jersey	----	----	1,235	1,856	2	1	211	429	----	----	169	409
New Mexico	----	----	123	112	98	45	3	5	33	29	96	205
New York	----	----	1,789	910	2,329	1,354	W	W	26	2	721	809
North Carolina	W	W	W	W	-----	-----	-----	-----	1	1	W	W
North Dakota	144	76	86	87	12	4	11	14	----	----	(2)	1
Ohio	W	W	1,520	1,224	-----	-----	W	W	----	----	904	1,257
Oklahoma	----	----	-----	-----	-----	-----	-----	-----	----	----	5	20
Oregon	W	W	875	594	37	19	801	930	----	----	90	106
Pennsylvania	W	W	W	W	-----	-----	563	895	----	----	127	195
Rhode Island	----	----	W	W	-----	-----	-----	-----	----	----	W	W
South Carolina	----	----	W	W	-----	-----	W	W	----	----	----	-----
South Dakota	W	W	117	91	2	2	W	W	118	118	889	691
Tennessee	W	W	W	W	40	40	W	W	----	----	W	W
Texas	----	----	252	180	-----	-----	1,402	2,303	----	----	87	47
Utah	114	14	184	88	858	346	83	96	7	16	10	7
Vermont	----	----	170	77	-----	-----	W	W	----	----	W	W
Virginia	----	----	W	W	5	2	W	W	----	----	11	20
Washington	W	W	1,520	1,225	964	332	174	276	79	40	376	465
West Virginia	W	W	W	W	-----	-----	-----	-----	----	----	----	-----
Wisconsin	158	99	1,443	799	459	229	17	21	----	----	W	W
Wyoming	295	110	60	46	29	26	168	127	1	1	137	37
Undistributed	816	899	2,019	1,849	-----	-----	2,183	2,455	----	----	1,944	3,282
Total	2,768	2,416	27,066	19,592	16,144	6,990	11,069	13,611	1,323	1,009	8,658	11,521
American Samoa	----	----	-----	-----	-----	-----	-----	-----	----	----	----	-----
Panama Canal Zone [e]	----	----	-----	-----	-----	-----	-----	-----	----	----	----	-----
Puerto Rico [e]	----	----	675	776	-----	-----	-----	-----	----	----	----	-----

[e] Estimate. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Excludes American Samoa, Panama Canal Zone, 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 uses [1]

(Thousand short tons and thousand dollars)

Year	Sand							
	Building		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1966	808	$943	37,087	$29,702	12,920	$8,430	1,663	$927
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	833	1,058	43,130	41,965	5,234	2,195	1,632	834

Year	Gravel								Total Government-and-contractor sand and gravel [2]	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1966	2,869	$3,131	158,709	$134,180	39,298	$29,268	1,530	$1,441	254,884	$208,022
1967	863	1,074	153,274	182,734	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

[1] Excludes American Samoa, 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 types of producers [1]

(Thousand short tons and thousand dollars)

Type of producer	1966		1967		1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	67,163	$43,821	68,655	$44,903	62,939	$42,146	65,786	$45,691	67,238	$39,446
Contractor	187,721	164,201	169,643	157,330	143,866	129,176	140,403	128,377	144,214	153,699
Total [2]	254,884	208,022	238,298	202,233	206,805	171,327	206,189	174,070	211,454	193,145
State	150,304	131,921	148,697	134,243	125,627	108,980	122,484	108,414	136,800	134,482
Counties	60,966	41,973	60,004	41,390	53,087	38,408	52,547	39,429	58,180	37,159
Municipalities	2,916	2,576	3,001	2,202	4,200	3,208	3,784	4,466	3,285	3,125
Federal agencies	40,698	31,552	26,596	24,398	23,891	20,731	27,374	21,761	13,189	18,379
Total	254,884	208,022	238,298	202,233	206,805	171,327	206,189	174,070	211,454	193,145

[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 classes of operation and degree of preparation [1]

(Thousand short tons and thousand dollars)

	1969		1970	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	r 668,413	r $853,835	680,319	$887,792
Unprepared	62,569	41,766	52,167	34,794
Total [2]	r 730,980	r 895,599	732,493	922,564
Government-and-contractor operations:				
Prepared	156,394	142,967	184,120	177,976
Unprepared	49,793	31,103	27,333	15,164
Total [2]	206,189	174,070	211,454	193,145
Grand total [2]	r 937,169	r 1,069,667	943,941	1,115,705

r Revised.
[1] Excludes American Samoa, Panama Canal Zone, 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)	1969				1970			
	Plants [2]		Production		Plants [2]		Production	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	2,375	37.7	26,219	3.6	2,042	34.5	22,133	3.0
25,000 to 50,000	1,047	16.6	38,513	5.3	1,016	17.2	36,929	5.1
50,000 to 100,000	1,023	16.2	74,626	10.2	1,020	17.2	75,971	10.4
100,000 to 200,000	855	13.6	122,222	16.7	856	14.5	124,013	16.9
200,000 to 300,000	r 415	6.6	r 100,679	r 13.8	371	6.3	92,858	12.7
300,000 to 400,000	208	3.2	72,899	10.0	216	3.6	75.000	10.2
400,000 to 500,000	113	1.8	50,139	r 6.8	130	2.2	58,271	8.0
500,000 to 600,000	81	1.3	44,377	6.1	62	1.0	34,707	4.7
600,000 to 700,000	40	.6	25,810	3.5	51	.9	32,984	4.5
700,000 to 800,000	41	.6	30,794	4.2	31	.5	23,240	3.2
800,000 to 900,000	20	.3	17,072	2.3	30	.5	25,773	3.5
900,000 to 1,000,000	18	.3	17,278	2.4	24	.4	23,741	3.2
1,000,000 and over	73	1.2	110,352	15.1	69	1.2	106,873	14.6
Total	r 6,309	100.0	r 730,980	100.0	[3] 5,918	100.0	732,493	100.0

r Revised.
[1] Excludes American Samoa, Panama Canal Zone, and Puerto Rico.
[2] Includes a few companies operating more than 1 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 classes of operation and methods of transportation [1]

	1969		1970	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	r 642,025	69	643,853	68
Rail	56,565	6	52,034	6
Waterway	31,912	3	30,638	3
Unspecified	477	(2)	5,957	1
Total commercial [3]	730,980	78	732,493	78
Government-and-contractor: Truck [4]	206,189	22	211,454	22
Grand total [3]	r 937,169	100	943,941	100

r Revised.
[1] Excludes American Samoa, Panama Canal Zone, and Puerto Rico.
[2] Less than 0.5 percent.
[3] Data may not add to totals shown because of independent rounding.
[4] 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 uses

(Thousand short tons and thousand dollars)

Use	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Abrasives	253	$2,191	260	$2,196
Chemicals	291	799	77	651
Enamel	52	493	45	450
Filler	123	1,253	152	1,281
Foundry uses	274	1,725	206	1,485
Glass	330	1,951	349	2,080
Pottery, porcelain, tile	269	2,913	261	3,168
Unspecified	309	3,132	861	3,912
Total [3]	1,900	14,460	2,211	15,226

[1] Arkansas, California, Florida, Georgia, Illinois, Indiana, Kansas (1970), Kentucky, Louisiana, Maryland, Michigan, Minnesota, Missouri, Nevada (1970), New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin (1970).
[2] Excludes American Samoa, Panama Canal Zone, 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
1968	25	$144	729	$984	754	$1,128
1969	43	194	r 855	1,253	r 898	1,447
1970	64	262	815	1,338	879	1,600

r Revised.
[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 Frank L. Fisher [1]

Production of silicon metal and ferrosilicon increased during the year to meet the growing consumer demand for a wide variety of products. A scarcity of ferrosilicon in Europe and Japan continued to buoy up the worldwide price. High-purity and ultra-high-purity metal, while small in volume, continued to be an important cog in the electronic industry. One company announced the production of its 50 millionth silicon electronic device since the metal was introduced in electronic applications in 1957.

DOMESTIC PRODUCTION

Production of silicon metal showed an approximately 8-percent increase over that of 1969. Producer stocks were higher, increasing to 6,089 tons during the year. The rise in production paralleled the worldwide increase in demand for ferroalloys. The larger electric furnaces with closer operational control introduced in 1970 resulted in a more uniform, higher-quality product. Production of miscellaneous silicon alloys dropped sharply compared with the previous year. Foote Mineral Company began production of silicon metal at its facility in Wenatchee, Wash., and the Jackson Iron & Steel Company, Jackson, Ohio, ceased silicon metal production in 1970.

[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1970 [1]

(Short tons, gross weight)

Alloy	Silicon content (percent)	Producers' stocks as of Dec. 31, 1969 [r]	Production	Shipments	Producers' stocks as of Dec. 31, 1970
Silvery pig iron	5–24	W	W	W	W
Ferrosilicon (includes briquets)	25–55	32,273	423,774	331,338	63,197
Do	56–70	W	W	W	W
Do	71–80	14,389	139,315	138,172	22,875
Do	81–95	2,324	10,004	11,050	1,602
Silicon metal (excludes semiconductor grades)	96–99	3,923	109,011	97,725	6,089
Miscellaneous silicon alloys (exclusive of silicomanganese)	-----	4,640	48,659	39,344	8,694
Other silicon alloys and products	-----	1,936	7,306	6,380	2,890

[r] Revised. W Withheld to avoid disclosing individual 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 1970

Producers	Plant location	Product
Air Reduction Co. Inc., Airco Alloys and Carbide Division.	Calvert City, Ky	FeSi.
Do	Niagara Falls, N.Y	FeSi, silvery iron.
Universal Oil Products Co., Alabama Metallurgical Corp. Division.	Selma, Ala	FeSi.
Chromium Mining and Smelting Corp	Woodstock, Tenn	Do.
Foote Mineral Co	Graham, W. Va	Do.
Do	Keokuk, Iowa	FeSi, silvery iron.
Do	Vancoram, Ohio	FeSi.
Do	Wenatchee, Wash	FeSi, Si.
The Hanna Furnace Corp	Buffalo, N.Y	Silvery iron.
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Interlake Steel Corp	Beverly, Ohio	FeSi, Si.
National Metallurgical Corp	Springfield, Oreg	Si.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeSi, Si.
Do	Philo, Ohio	Do.
Do	Powhatan Point, Ohio	Do.
Do	Tacoma, Wash	Do.
Reynolds 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

The use of silicon and its compounds decreased from that of 1969. One exception was 56–70 percent ferrosilicon, which showed a 45 percent increase in consumption. The consumption of silicones and high-purity electronic-grade silicon metal continued to show gains as expanded markets developed for these products. Continued demand for silicone products seems assured because of the inherent properties they exhibit on chemical inertness, heat stability, water repellency, and dielectric strength. Since General Electric Co. introduced the silicon controlled rectifier (SRC) in 1957, this one company has produced more than 50 million such devices.

Table 3.—Consumption by major end uses and stocks of silicon alloys and metal in the United States in 1970

(Short tons)

	Silvery pig iron	Ferrosilicon[1] Silicon content (percent)				Silicon metal	Miscellaneous silicon alloys[2]
	5–24	25–55	56–70	71–80	81–95	96–99	
Steel:							
Carbon	5,315	104,561	13,124	19,922	177	W	14,710
Stainless and heat-resisting	W	16,626	174	5,746	132	119	421
Alloy (excludes stainless and heat-resisting)	4,987	42,160	3,172	35,973	1,035	1,423	3,295
Tool	------	2,061	W	661	W	W	W
Cast irons	131,634	134,710	1,450	18,654	4,729	W	47,123
Superalloys	W	391	W	23	W	W	9
Alloys (excludes alloy steels and superalloys)	W	3,517	W	W	W	42,757	W
Miscellaneous and unspecified	6,046	14,363	242	618	6,075	16,394	4,426
Total	147,982	318,389	18,162	81,597	12,148	60,693	69,984
Consumers stocks Dec. 31, 1970	12,723	29,045	1,766	5,118	2,098	6,849	8,456

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.

PRICES

Silicon metal and ferrosilicon prices increased during the year. An additional price increase announced in December will be effective by mid-January 1971. Silica, amorphous in 50-pound bags was quoted at $27 per short ton at the end of 1970 for the 96–99 percent through 200-mesh screen size. The prices were higher for finer mesh material. Quartz rock crystals were quoted at $330–$1,100 per short ton and optical quality at $2.50–$50 per pound. The higher prices are attributed to rising raw material, labor, power, and environmental control costs.

FOREIGN TRADE

Exports of ferrosilicon increased sharply during the year with 44,694 short tons exported valued at nearly $11.9 million. West Germany was the major importing country followed by Romania, Canada, and Japan. Twenty-two other countries reported shipments of ferrosilicon from the United States. Imports were down approximately 30 percent although the value totaling $4.1 million was about the same as that imported in 1969. Canada, France and Japan were the major sources of imported ferrosilicon among the 10 countries exporting the metal to the United States.

Table 4.—U.S. exports of ferrosilicon

Year	Short tons	Value (thousands)
1968	18,372	$4,481
1969	6,487	1,666
1970	44,694	11,887

Table 5.—U.S. imports for consumption of ferrosilicon, by grades and countries

Grade and country	1968			1969			1970		
	Short tons		Value (thousands)	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
8 percent but less than 60 percent silicon:									
Canada	12,419	2,608	$729	15,344	4,515	$1,074	9,450	1,738	$652
France	354	171	97	r 612	r 294	r 181	1,395	670	473
Germany, West	281	130	74	77	39	22	402	200	119
Italy	------	------	------	31	15	11	80	38	21
Japan	3,459	1,705	884	3,534	1,683	850	2,035	958	595
Norway	1	(1)	(1)	3	1	(1)	59	26	18
South Africa, Republic of	------	------	------	64	32	3	------	------	------
Total	16,514	4,614	1,784	r 19,665	r 6,579	r 2,141	13,421	3,630	1,878
60 percent but not over 80 percent silicon:									
Canada	------	------	------	1,379	1,067	261	4,722	3,648	908
France	1,849	1,127	550	r 2,465	r 1,624	r 676	2,676	1,634	1,010
Germany:									
East	------	------	------	------	------	------	28	21	10
West	462	277	137	404	248	120	405	248	128
India	------	------	------	1,925	1,444	269	------	------	------
Japan	------	------	------	661	529	130	------	------	------
Norway	1,037	794	141	3,471	2,645	453	620	464	92
Rhodesia, Southern	1,459	1,117	186	------	------	------	------	------	------
South Africa, n.e.c.	21	16	3	------	------	------	------	------	------
South Africa, Republic of	1,292	1,006	183	1,410	1,095	203	433	330	69
Yugoslavia	1,920	1,373	150	2,101	1,599	295	------	------	------
Total	8,040	5,710	1,350	r 13,816	r 10,251	r 2,407	8,884	6,345	2,217
Over 80 percent but not over 90 percent silicon:									
Italy	178	153	38	20	17	4	------	------	------
South Africa, Republic of	158	135	35	113	97	25	99	85	22
Total	336	288	73	133	114	29	99	85	22
Grand total	24,890	10,612	3,207	33,614	16,944	4,577	22,404	10,060	4,117

r Revised.
1 Less than ½ unit.

Silver

By J. M. West [1]

Mine production of silver was up 7 percent to 45.0 million ounces, imports exceeded exports by 34.7 million ounces, and consumption, including that for coinage, declined nearly 20 percent to 129.1 million ounces in 1970. The outstanding event in silver was the price reaction after General Services Administration (GSA) stopped its weekly sales of silver on November 10; instead of rising as this source of supply was withdrawn, prices fell, the sharpest drop beginning on November 25, and bottomed out for the year on December 10 at 157.200 cents per ounce (New York, Handy & Harman). Trading of silver futures on the New York Commodity Exchange (COMEX) and Chicago Board of Trade increased during the year, and a new market for trading silver futures was opened on the West Coast Commodity Exchange at Los Angeles, Calif., on October 15, 1970.

Declining consumption of silver was attributed to the general economic recession, which particularly reduced consumption by the automotive, electronics, aerospace, and appliance industries, and to a slack in defense procurement. Uses in electrical contacts and conductors, photographic materials, brazing alloys and solders, and catalysts were the principal losers. Silver used in commemorative coins and medals rose sharply to an estimated 7 million ounces, despite other declines in demand for sterling and electroplated silver products. Silver use in U.S. coins dropped to 0.7 million ounces, but legislation was passed at yearend to coin 40-percent-silver Eisenhower dollars that will consume about 47.5 million ounces of Treasury silver within the next 5 years. Part of this

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.–Salient silver statistics

	1966	1967	1968	1969	1970
United States:					
Mine production .... thousand troy ounces	43,669	32,345	32,729	41,906	45,005
Value .... thousands	$56,464	$50,135	$70,191	$75,040	$79,696
Ore (dry and siliceous) produced:					
Gold ore .... thousand short tons	2,580	2,315	2,003	2,002	2,092
Gold-silver ore .... do	248	157	199	216	104
Silver ore .... do	1,069	904	701	755	674
Percentage derived from—					
Dry and siliceous ores	33	39	39	36	33
Base-metal ores	67	61	61	64	67
Refinery production [1] .... thousand troy ounces	[2] 48,358	30,268	[r] 34,052	[r] 51,676	54,688
Exports [3] .... do	85,538	70,769	125,761	88,909	27,614
Imports, general [3] .... do	63,032	55,520	70,709	71,876	62,300
Stocks Dec. 31:					
Treasury [4] .... million troy ounces	594	351	256	104	25
Industry [5] .... thousand troy ounces	57,244	83,358	166,356	[r] 198,790	210,150
Consumption: Industry and the arts .... do	183,696	171,031	145,293	141,544	128,404
Coinage .... do	53,852	43,851	36,833	[r] 19,407	709
Price [6] .... per troy ounce	$1.293+	$1.550+	$2.144+	$1.790+	$1.771–
World:					
Production .... thousand troy ounces	266,731	258,203	275,264	290,469	301,745
Consumption: [7] Industry and the arts .... do	355,100	[r] 346,800	[r] 349,600	[r] 364,400	357,600
Coinage [7] .... do	[r] 129,500	[r] 105,300	[r] 89,300	[r] 55,700	40,300

[r] Revised.
[1] From domestic ores.
[2] U.S. Bureau of the Mint.
[3] Excludes coinage.
[4] Excludes silver in silver dollars.
[5] Includes silver in COMEX warehouses and silver registered to Chicago Board of Trade.
[6] Average New York price.
[7] Free world only. Source: Handy & Harman.

silver will come from a reduction in the National Stockpile requirement and the balance from existing Treasury stocks. Producer-consumer stocks declined 3.4 million ounces to 82.2 million ounces during the year, but COMEX and Chicago Board of Trade stocks rose a total of 14.8 million ounces.

Legislation and Government Programs.—GSA weekly sales of Treasury silver, which began August 4, 1967, were terminated after the last sale on November 10, 1970. During this period, foreign and domestic bidders purchased 304,886,975 fine troy ounces of contained silver for a total payment of $561,864,722. Sales of Treasury silver during 1970 totaled 67.2 million ounces at offerings of about 1.5 million ounces each week. On June 2, 1970, the GSA set a 5-percent deposit to accompany all bids, which was to be sacrificed in event of default.

The Treasury program for melting silver coins, which began in 1968, was completed on June 30, 1970, and yielded a total of 212,269,681 ounces of fine silver. This program contributed to the supplies sold weekly by GSA. Most of the coins, 90-percent silver, had accumulated after mid-1967 at the Federal Reserve banks as the result of substitution and nonrecirculation.

The Federal Reserve Board proposed a regulatory amendment that would prevent member banks from counting silver coins held for either bullion or numismatic value as part of their required reserves, but no action was taken in 1970.

Directives were issued to Department of the Interior bureaus and offices to establish and pursue programs for recovering silver from photographic fixing solution and scrap film.[2] Installation of local silver recovery units for hyposolutions was advocated wherever feasible.

Legislation enacted 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 composite cupronickel Eisenhower dollars and Kennedy half-dollars for general circulation. The new coins were expected to become available by or before mid-1971. The GSA Administrator was directed to transfer to the Secretary of the Treasury 25.5 million fine troy ounces of silver from the 165 million ounces in the National Stockpile, thereby reducing the stockpile to the revised requirement level of 139.5 million ounces. Also, GSA was authorized to sell on a bid basis about 2.9 million uncirculated, 90-percent silver dollars, most of them minted in Carson City, Nev., between 1878 and 1891 and stored in Treasury vaults.

Exploration assistance was provided by the Office of Minerals Exploration, U.S. Geological Survey, on three silver and gold-silver deposits, two of which were in California and one in Nevada. The total value of contracts negotiated for silver prospects was $40,135, of which the Government share was $37,600.

DOMESTIC PRODUCTION

Mine production of recoverable silver rose 7 percent in 1970, mainly as a result of increased byproduct output from copper mines in Montana, Arizona, New Mexico, and Utah. Base metal ores supplied 66 percent and silver ores 32 percent of the total output; the small remainder came from gold and gold-silver production. Idaho, where ores are mined largely for their silver content, recorded a 1-percent increase in production. Idaho contributed 42.5 percent of the total U.S. output of silver, down almost 3 percent compared with 1969. Arizona, Utah, and Montana were the next highest in output, accounting for 16, 13, and 10 percent, respectively, of the total.

Twenty-five leading silver producers contributed 81 percent of the total output, four of these (first, second, seventh, and eighth) mining silver ores alone and the others mining base metals, in general. Ten mines produced over 1 million ounces of silver each, and their combined outputs equaled 62 percent of the total domestic production. Domestic mines provided 35 percent of the total silver consumed in industry and arts.

The Sunshine mine, of the Sunshine Mining Co. in Idaho's Coeur d'Alene region remained the country's leading silver mine. Production reported by the company

[2] Federal Register. Reclamation of Precious Metals and Critical Materials. V. 35, No. 124, June 26, 1970, p. 10433.

was 8,441,961 ounces, about 1 percent higher than in 1969. Ore grade averaged 33.4 ounces per ton, compared with 30.8 ounces in 1969, reflecting the use of improved mining techniques. Silver ore reserves were increased to over 1 million tons by Sunshine Mining Co.; the company planned a 50-percent participation in diamond drilling on the new 4,800-foot level of the Silver Syndicate mine.

Hecla Mining Co. reported 6,245,087 ounces of silver produced in 1970, down 5 percent from 1969 output. The firm's Lucky Friday mine in Idaho supplied 200,448 tons of ore averaging 14.35 ounces of silver per ton, 9.81 percent lead, and 1.09 percent zinc. During the year, reserves at Lucky Friday were increased from 598,000 to 624,000 tons. Development to the 3,650-foot level of the mine was essentially completed, and a mine shaft station was cut at the 4,050-foot level.

Hecla Mining participated with the American Smelting and Refining Co. (ASARCO) in development of the Silver Summit mine of Consolidated Silver Corp. in the Coeur d'Alene; the main shaft was being extended from the 3,000-to the 4,000-foot level, and deeper development was planned. At the Galena mine, under lease from Callahan Mining Corp., ASARCO produced 3,619,630 ounces of silver and 1,261 tons of copper from 154,258 tons of ore and scheduled new development on the 4,600-foot level. At the Coeur project of Coeur d'Alene Mines Corp., ASARCO, and Day Mines, Inc., ore reserves were developed totaling 235,000 tons and averaging 25.1 ounces of silver per ton and 0.9 percent copper.

Bunker Hill Co. produced 3.4 million ounces of silver in 1970, of which 1.4 million was from the Crescent mine, where output was to be doubled in 1971. Substantial tonnages of silver-lead ore were developed on the new 1,500-and 1,750-foot levels of the Dayrock mine of Day Mines, Inc.

Kennecott Copper Corp. reported silver production of 4,338,730 ounces in 1970, the bulk coming from its Bingham Canyon, Utah, copper operations. The Anaconda Co. undertook a joint venture with ASARCO in 1970 to explore and develop new lead-zinc-silver reserves for United Park City Mines Co. in Utah. Anaconda's entire silver production (domestic and foreign) of 12,576,000 ounces in 1970 included 1,206,310 ounces from its new Twin Buttes copper mine in Arizona and 966,428 ounces from its Butte, Mont. operations. ASARCO completed a 1,650-foot production shaft at its Leadville, Colo., lead-zinc-silver project and began construction of a 700-ton-per-day mill. Ore reserves of 2.4 million tons were established containing significant values in silver. The Mayflower mine of New Park Mining Co., in the Park City district, Utah, which was operated under lease by Hecla Mining, produced 115,762 tons of ore averaging 5.2 ounces of silver and 0.5 ounce of gold per ton, 4.5 percent lead, 2.9 percent zinc, and 1 percent copper; ore reserves were 240,000 tons at yearend. Duval Corp. was expected to recover about 0.5 million ounces per year from its Sierrita copper-silver-molybdenum mine in Arizona, which went into initial production in 1970. Homestake Mining Co. operated the Bulldog mine at Creede, Colo., where reserves in early 1970 were 409,000 tons averaging 21.8 ounces of silver per ton and 2.7 percent lead.

Estimates of large quantities of low-grade silver ores associated with lead, zinc, and manganese in Colorado were reported and recommendations made for future development.[3]

Sunshine Mining Co. considered construction of a silver refinery near Kellogg, Idaho, based on a process of roasting concentrates followed by hydrometallurgy and electrolysis, but had made no decision on the project at yearend. Ag-Met, Inc., began production of secondary silver, mainly from discarded film and photographic chemicals, at Lofty, Pa., and expected output to reach 6 million ounces in 1971. Sabin Metal Corp. recovered silver from photographic materials in its new plant at Rochester, N.Y.

Smelter and refinery reports in 1970 showed that 56.0 million ounces of silver was produced from old scrap and 24.0 million ounces from new scrap compared with revised 1969 data of 79.8 million and 35.9 million ounces, respectively, for old and new scrap. Smelter production, including silver from domestic and imported sources totaled 161.4 million ounces in 1970 compared with 199.2 million ounces in 1969.

[3] Meeves, Henry C., and Richard P. Darnell. Silver Potential and Economic Aspects of the Leadville District, Lake County, Colo. BuMines Inf. Circ. 8464, 1970, 105 pp.

CONSUMPTION AND USES

Silver consumption in industry and the arts, as reported to the Bureau of Mines by manufacturers and consumers, declined 9 percent from the quantity consumed in 1969. The greatest drop was in use for electrical/electronic contacts and conductors which was down 18 percent. Declines were recorded for uses in photography, sterling and electroplated wares, mirrors, brazing alloys and solders, catalysts, and bearings. The slump in consumption was attributed mostly to the general economic recession in 1970 rather than to any technological changes affecting use patterns; another factor was reduced military demand. A significant increase was noted in use of silver for batteries, largely related to their utilization in submarines. Most, if not all, of this silver will be reclaimed and recycled after serving its purpose. Consumption in jewelry posted a significant increase; other expanding uses were in dental and medical supplies.

Silver consumed in commemorative medals and other collector's items rose sharply during 1970, largely the result of expanded activities by the Franklin Mint, which dedicated a modern silver casting and minting facility at Franklin Center, Pa., in the early part of the year. This contributed to the increase in the miscellaneous category shown in table 9. Several other private mints also sold commemorative silver in various forms.

Use of silver in coinage by the U.S. Bureau of the Mint declined to 0.7 million ounces, compared with 19.4 million ounces in 1969. Only limited numbers of clad half-dollar, 40-percent silver coins were produced.

CBS Electronic Video Recording Co., Division of Columbia Broadcasting System, Inc., prepared to market a cassette television system utilizing silver halide photographic film for reproduction. The potential for expanded consumption of silver for this purpose was believed sizable.[4] Other significant new markets were foreseen in commemorative coins and medals, meteorological applications, and germicidal and fungicidal uses. Eastman Kodak Co., the leading consumer of silver in photographic products, planned major capital expenditures for plant expanisons in 1971.[5] Several new palladium and silver conductor inks for electronic circuits were marketed,[6] and favorable customer acceptance was reported for silverplated stainless steel.[7]

PhotoHorizons Division of Horizons Research Inc. supplied the U.S. Air Force with silverless photographic film for experimental use in duplicating systems;[8] a silverless process described as a breakthrough in high-temperature, soft-soldering was developed.[9] The technique employing a sacrificial metal coating for use on copper, copper alloys, and low-carbon steel was said to be applicable to automobile radiators and home appliances.

STOCKS

During 1970 the outflow of Treasury bullion totaled 67.9 million ounces, including 67.2 million ounces sold through GSA weekly auctions and 0.7 million ounces used in coinage. Yearend Treasury stocks were estimated at 25.1 million ounces in bullion, coin bars, and coinage metal fund silver. New York Commodity Exchange (COMEX) stocks at yearend were 116.4 million ounces, compared with 112.9 million ounces on December 31, 1969. Chicago Board of Trade stocks were 11.6 million ounces at yearend, compared with only 0.3 million ounces on December 31, 1969. No stocks were reported held by the West Coast Commodity Exchange. With addition of reported industrial stocks of about 81.9 million ounces, visible stocks totaled 235

[4] Wilcox, R. L. Silver-Free At Last and Gold—The Growth Commodity. American Metal Market. Precious Metals Report, Sec. 2, Feb. 25, 1971, pp. 4A, 5A, and 13A.

[5] American Metal Market. Eastman Kodak Plans $364 Million in Worldwide Capital Expenditures. V. 78, No. 17, Jan. 26, 1971, p. 12.

[6] American Metal Market. Palladium-Silver Used for Conductive Inks. V. 77, No. 174, Sept. 11, 1970, p. 15.

[7] American Metal Market. Silver-Plated Stainless Durability Outstanding. V. 77, No. 102, May 21, 1970, p. 8.

[8] American Metal Market. Makes First Delivery of Nonsilver Film. V. 77, No. 161, Aug. 21, 1970, p. 17.

[9] Schwaneke, A. E., Wilbert L. Falke, and Orrin K. Crosser. A New High-Temperature, Soft-Solder System. BuMines Tech. Prog. Rept. 29, December 1970, 17 pp.

million ounces at yearend. Sizable but unmeasured stocks in the form of bars and coins remained in private hands and bank vaults.

PRICES

New York prices for silver in 1970, as quoted daily by Handy & Harman in cents per ounce, reached a high for the year of 193.00 on January 29, declined to 157.50 in late May, and rose to peaks of 186.00 in August and early September. Prices then declined but rose again to about 180.00 at the end of October, followed by a drop to the year's low of 157.20 on December 10. At yearend the price had recovered to 163.50. The average price for 1970 was 177.082 cents per ounce.

Prices for spot delivery of silver on the London market (in U.S. equivalent) ranged from a high of 192.80 cents in March to a low of 156.80 cents in May and averaged 176.575 cents for the year.

Prices were influenced during the year by sales of Treasury silver through GSA and by speculative activities which caused an unexpected market reaction when sales were terminated on November 10: Instead of rising when this supply was cut off, New York spot prices quoted at 181.00 on November 10 continued to drop. Final sales on that date went to one bidder at an average of 183.4 cents per ounce. During the total period of weekly Treasury silver auction sales, which began August 4, 1967, 140 purchasers were awarded a total of 304,886,975 troy ounces of contained silver on bids totaling $561,864,722 for an average payment of 184.3 cents per ounce of silver.

Futures trading of silver continued on COMEX, with a volume for the year of 6.9 billion ounces, compared with 6.6 billion ounces in 1969. Record trading of nearly 810 million ounces took place in the month of November; November 24 was the peak day, 168.4 million ounces changing hands. December's closing prices for future delivery, in cents per ounce, were 163.60 (January 1971), 177.50 (December 1971), and 184.00 (May 1972. Silver futures trading was also active both on the Chicago Board of Trade, where 1.8 billion ounces was traded in 1970, and on the newly established market on the West Coast Commodity Exchange, where 66 million ounces was traded between October 15 and the end of 1970.

FOREIGN TRADE

Silver exports declined sharply in 1970 to 27.6 million ounces, less than one-third of the total exported in 1969. Exports of bullion went mainly to Switzerland and Japan, and those of waste, scrap, and sweepings went mainly to Belgium-Luxembourg and Canada.

Silver imports declined 13 percent to 62.3 million ounces, of which 29.6 million ounces or 47 percent was in the form of refined bullion. The main sources of imports were Canada (59 percent) and Peru (18 percent); the balance was provided by 22 other countries.

The result of foreign trade in silver was a net import of 34.7 million ounces, compared with the net export of 17.0 million ounces in 1969.

WORLD REVIEW

World production of silver rose about 11.3 million ounces or 4 percent to a total of 301,745 million ounces. Peru recorded the largest increase and, Canada, despite an increase, dropped to second place behind the United States as the world's largest producer. Declines were noted in outputs for only a few countries. About 44 percent of world production of silver came from the North American Continent and 62 percent from the Western Hemisphere.

World consumption in arts and industry was estimated to be about 358 million ounces, down 7 million ounces from that of 1969. Free world use of silver in coinage was estimated at 40.3 million ounces, down from 55.7 million ounces in 1969. The decline was accountable to the sharp drop in U.S. coinage to less than 1 million ounces in 1970. Much of the gap between world production and consumption continued to be supplied by the weekly auctions of the U.S. Government through GSA sales of Treasury silver. The last of these auctions was held November 10, 1970; thereafter, only industry sources, commodity trading stocks, and privately held stocks were available to consumers. About two-thirds of the world supply of new silver production continued to come from copper and lead-zinc ores.

Free world holdings of silver bullion in the hands of investors and speculators increased during the year to an estimated 450 million ounces.[10] It was also estimated that with higher prices 500 million ounces more could come into the market from holdings of U.S. silver coins. Estimates of smuggled shipments from India during 1970 were placed at 25 million ounces. It remained a subject of speculation whether India, with its large privately held stocks and articles of silver, might become an important source of silver supply, if prices rise higher.

Australia.—Mount Isa Mines Ltd. continued diamond drilling at the Hilton mine, which is under development in its North Lease area about 12 miles north of Mount Isa, Queensland. Contracts were let to sink and equip hoist and service shafts. A production goal of 16,000 tons of ore per day was set for 1976, with silver-lead concentrates to be smelted at Mount Isa. Silver content of the ore was estimated at 5.8 ounces per ton. Production by Mount Isa Mines Ltd. rose to 11.72 million ounces in 1970, compared with 10.05 million ounces in 1969.[11] The bulk of the silver-lead-zinc ore was mined from the No. 5 ore body in the Black Star area and Racecourse ore bodies between the No. 9 and No. 11 levels. In 1970, extraction began from the Racecourse orebodies between the No. 11 and No. 13 levels. Use of cemented hydraulic fill allowed recovery of over a quarter million tons of high-grade ore from pillars. Silver recovery was improved at the mill by substituting soda ash for lime in the flotation circuit. The average silver content of silver-lead-zinc ores mined was 5.9 ounces per ton.

About 80 miles north of Mount Isa, Placer Exploration Ltd. drilled several exploration holes on claims optioned from Triako (Australia) Pty. Ltd., cutting rich lead-zinc-silver mineralization at depths of about 1,500 feet. Drilling continued in early 1971.

Massive sulfides were found in limited drilling by Jododex (Australia) Pty. Ltd. near Tavago in New South Wales. Early estimates indicated over 7 million tons of ore averaging 2.9 percent copper, 3.3 percent lead, 9.4 percent zinc, and 1.9 ounces of silver per ton. Mining feasibility studies were in progress. North Broken Hill Ltd. treated a larger tonnage of ore than in 1969; the grade averaged about 7.3 ounces of silver per ton, 13.2 percent lead, and 10.6 percent zinc through the first half of 1970.

Burma.—Silver-lead production of the once famous Bawdwin mines at Namtu was estimated at slightly less than 750,000 ounces. New silver-lead-zinc mines under development in the Kalagwe area of the Northern Shan States were expected to begin producing as early as 1971 at a rate of about 40,000 tons of ore per year.

Canada.—Silver output rose about 2.5 percent in 1970. According to projections, Canadian silver production was expected to reach 45 to 50 million ounces per year by 1975.[12]

The world's largest single producer of silver ore, Ecstall Mining Ltd., owned by Texas Gulf Sulphur Co., produced concentrates containing 13,023,200 ounces of silver, somewhat less than the 13,822,000 ounces reported in 1969. The company's Kidd Creek mine, Timmins district, Ontario, was being developed for underground mining, to be coordinated with existing open pit operations. Reserves were reported sufficient to continue mining at the 1970 rate of 3.6 million tons of ore per year for more than 25 years. Canadian Copper Refiners, Ltd., controlled by Noranda Mines Ltd., was a major source of refined silver, producing 12.4 million ounces at its Montreal East plant in 1970. Cominco Ltd. produced 6.04 million ounces of silver at its Trail, British Columbia, smelter, 60 percent of the ore coming from the company's own mines, chiefly the Sullivan and Bluebell. A deep-drilling program at the Bluebell was continued into 1971.

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[10] Handy & Harman. The Silver Market in 1970, 55th Annual Review, p. 19.

[11] Mount Isa Mines Ltd. Annual Report, 1970, 33 pp.

[12] George, J. G. Silver. Canadian Minerals Yearbook 1969, Mineral Resources Branch, Department of Energy, Mines and Resources, (Ottawa), 1970, 16 pp.

United Keno Hill Mines Ltd. produced 2.6 million ounces of silver in 1970, the bulk of this from the Calumet mine, with minor tonnages from the Elsa mine and development ore from the Husky mine, all near Elsa, Yukon Territory. Cominco Ltd. expanded its exploration program at a gold-silver-lead-zinc-copper property in the Hackett River area, Northwest Territories, on an option from Bathhurst Inlet Mining Corp., and planned 10,000 feet of diamond drilling.

Production by Echo Bay Mines Ltd. at Port Radium on Great Bear Lake, Northwest Territories, was about the same as in 1969 when 2.4 million ounces of silver and 341 tons of copper was produced. Shaft sinking was underway to develop five more levels at 150-foot intervals below the existing third level. Development continued at the Granduc Copper mine in northwestern British Columbia, which is under lease by American Smelting & Refining Co. and Granduc Operating Co., a subsidiary of Newmont Mining Corp. Milling at a rate of 7,500 tons per day was expected to yield about 750,000 ounces of byproduct silver per year. Initial development ore returned 0.3 ounce of silver per ton. Columbia Metals Corp. Ltd. was to start milling silver-lead-zinc ores in 1971 at about 125 tons per day from its new mine south of Revelstoke, British Columbia. Beginning in 1971, Placid Oil Ltd. scheduled production at 750 tons per day at its new copper-gold-silver mine at Cranbrook, British Columbia.

In northwest Ontario, Mattagami Lake Mines Ltd. began developing a 3,000-ton-per-day copper-zinc-silver mine based on recent discoveries in the Sturgeon Lake area. Ore was expected to average about 1 ounce of silver per ton, and reserves in the main zone were estimated between 10 and 15 million tons to a depth of 600 feet. Also at Sturgeon Lake, Falconbridge Nickel Mines Ltd. struck rich copper-zinc ore that assayed between 5 and 10 ounces of silver per ton on property optioned from New Brunswick Uranium Metals & Mining Ltd. Agnico Mines Ltd., south of Cobalt, Ontario, produced 640,255 ounces of silver from 35,860 tons of high-grade ore in the first half of 1970. Carndesson Mines Ltd. explored a property on the border of Lanarck and Frontenac Counties and found average grades for a 5-foot vein of 1.3 ounces of silver, 7.5 pounds of antimony, 13.4 pounds of copper, and 0.68 pound of mercury per ton. Average silver content of copper-zinc ores from six principal mines of Hudson Bay Mining and Smelting Co., Ltd., in western Manitoba was 0.6 ounce per ton, with tonnage milled totalling about 4,700 tons per day.

Lake Dufault Mines Ltd., with operations in the Noranda district, western Quebec, reported ore reserves at its new south section of about 2.1 million tons averaging 1.1 ounces of silver, 3.5 percent copper, and 3.6 percent zinc. A 3,982-foot production shaft was completed on the property in late 1970. Open pit mining was considered at the silver-lead-zinc property of North America Rare Metals, Ltd., and Mistango River Mines Ltd., west of Bathhurst, New Brunswick.

Greenland.—Vestgron Mines Ltd. planned further exploration of a property optioned from Greenex A/S at Marmorilik, on the west coast of Greenland, where high-grade zinc-lead ore was found on a cliff high above a fiord. Inferred reserves were 2.5 million tons of ore averaging 0.8 ounce of silver per ton, 17 percent zinc, and 4 percent lead.

Honduras.—Silver production at the El Mochito mine of New York and Honduras Rosario Mining Co. was 3.63 million ounces in 1970; the grade of ore milled averaged 14.5 ounces per ton. Ore reserves were increased to 2.13 million tons averaging per ton, 12.3 ounces of silver and 0.008 ounces of gold, 9.23 percent lead, and 9.73 percent zinc. Mine production was scheduled to expand to 300,000 tons of ore per year in 1971. At yearend 1970, the company held 1.6 million ounces of silver bullion in anticipation of higher prices. When the new Honduras mining code was enacted in August 1970, a 4 percent production tax was added on silver and gold.

Mexico.—American Smelting and Refining Co.'s subsidiary, Asarco Mexicana S.A., operated eight mines and four reduction plants, producing 15,687,000 ounces of silver from 2.3 million tons of ore mined during the company's fiscal year ending in June 1970. Construction of facilities was nearly complete at Asarco Mexicana's Inguarán mine in the State of Michoacan. Production of concentates was scheduled to begin in early 1971 at a 2,200-ton-per-day mill. The concentrates contain an estimated 78,000 ounces of silver and 13,000 tons of copper per year. Lead smelter and mine expansions were expected to result in rising silver-lead output. Pure Silver Mines Ltd. (Canada) continued development of a major silver mine in conjunction with Cia Mineral Fresnillo S.A. and Industrias Peñoles S.A. at the Mother Lode property, several miles from Guanajuato, Mexico. Indicated ore in late 1970 totalled 3 million tons that averaged about 14 ounces of silver and 0.08 ounce of gold per ton. Sinking of a 2,000-foot production shaft was begun and a 1,500-ton-per-day mill was planned. Rich silver ores were also under development at the nearby Peregrina and Cebada properties. The Fresnillo Co., affiliated with International Mining Corp., produced over 5 million ounces of silver from Mexican mines in its fiscal year ending June 30, 1970. Indicated reserves of 25.4 million tons of ore, with a grade of 3 ounces of silver per ton and 0.71 percent copper, were disclosed by drilling at the property of Mineral Mexicano de Avino S.A., northeast of Durango, Mexico.

Peru.—At its Cerro de Pasco Corp. smelting facilities at La Oroya, northeast of Lima, Cerro Corp. produced 20,823,000 ounces of silver in 1970 (including silver in exported blister copper), of which 49 percent was from purchased ores.[13] Cerro, through its Peruvian subsidiary, operated the following six mines: Cerro de Pasco, Morococha, Casapalca, San Cristóbal, Yauricocha, and Cobriza, all in central Peru; these mines produced silver and other metals. Of these, Cerro de Pasco was the principal source of silver, with both underground and open pit operations. Extensive new development of copper deposits in Peru was expected to spur output of byproduct silver. Predictions were made by the Peruvian National Mining Corp. that copper output might triple to 600,000 tons per year in 1980 and related silver output might increase 45 percent. Charter Consolidated Ltd. explored the Berenguela manganese-silver mine at Juliaco, Puno Province, and was considering using the Torco smelting process of its parent firm, Anglo-American Corp. of South Africa Ltd., to treat the highly refractory ores and to recover the two metals. A 500-ton-per-day mill was completed at the Ticapampa lead-zinc-silver mine, in which W.R. Grace & Co. held an interest.

Philippines.—Assays of copper ore from the property of Lobo Mines, Inc., which in 1970 was exploring a cluster of three mineralized breccia pipes on the island of Luzon, indicated the presence of silver in amounts of possible significance, that is, 1 to 2 ounces per ton. Construction of a mill was planned for the site in 1971, and a large open pit mine was proposed.

United Kingdom.—Net imports of silver in the first 11 months of 1970 were 25.8 million ounces, compared with 78.0 million ounces during the similar period of 1969. Imports from the U.S.S.R. were 11.4 million ounces, compared with 11.25 million ounces in the first 11 months of 1969 and from Dubai, Trucial States, 9.16 million ounces compared with 14.55 million ounces during the same period of 1969. The Dubai silver is almost entirely comprised of metal smuggled out of India and Pakistan in exchange for gold. Belgium and Australia were also important sources of United Kingdom silver; West Germany and Italy were the main destinations for exports.

TECHNOLOGY

At Bureau of Mines laboratories, work was conducted on silver extraction using sodium chloride solutions, treatment with sulfur dioxide, and electrooxidation. New information was obtained on association of silver values with jarosite in ores from one mine using an electron probe on specimens. The Bureau published a report describing a unique treatment for a wide variety of electroplating wastes containing silver and other metals. By the method, metals were quantitatively precipitated as cyanides; at the same time toxic components were adequately neutralized to meet most water quality standards.[14] It was found in Bureau experiments that zinc-base die cast scrap could be successfully substituted for the more expensive pure

[13] Metal Bulletin (London). Cerro's La Oroya. No. 5527, Aug. 25, 1970, pp. 21–25.
———. Cerro's La Oroya. No. 5528, Aug. 28, 1970, p. 17.

[14] George, L. C., and A. A. Cochran. Recovery of Metals From Electroplating Wastes by the Waste-Plus-Waste Method. BuMines Tech. Prog. Rept. 27, August 1970, 9 pp.

zinc in the desilvering of lead in refining operations. This work was performed at the Rolla Metallurgy Research Center, Rolla, Mo., where additional information can be obtained. A series of investigations continued on ground-control problems particularly important to deep silver mining in the Coeur d'Alene district of Idaho.

In a new postulation as to the source of silver in the bonanza deposits mined in the late 1860's in White Pine County, Nevada, it was suggested that the unleached black calcite underlying remnants of the Pilot Shale could be the source and may constitute a significant ore zone in itself.[15] Mining history and problems in the Leadville district of Colorado were reviewed, and silver resources, particularly in the manganese-bearing halos around major deposits, were estimated.[16]

A newly designed incinerator unit for old photographic film was in operation at Kodak Park, N.Y. It has the capacity to treat 4,500 pounds of film per hour and has a silver recovery efficiency of over 99 percent.[17] Work also continued on a completely wet chemical process for recovering silver from old film that would avoid possible release of air pollutants.

Further study into the influence of light on oxidation-reduction processes of silver-silver oxide electrodes revealed a possible mechanism for the defects.[18] Thermodynamic properties of molten copper-silver alloys such as those used in brazing were found at variance with established values for alloys that were silver-rich.[19] Silver reactions with fluorine were studied, and experimental results were published.[20]

Interest continued to grow in employing silver for batteries because of its unique operational qualities. One study revealed the operating characteristics for lithium and silver chloride button cells.[21] Among favorable features were high cell voltage, wide operating-temperature range, and good performance at low temperatures. Measurements were made of electromotive forces in molten silver chloride-alkali chloride solutions,[22] and of such forces at different hydrostatic pressures in molten silver nitrate-silver chloride mixtures.[23] Vapors over molten silver chloride were analyzed by a mass spectrometer, and the vapor pressure at about the melting point was found to be only 10^{-6} atmospheres.[24]

Various silver alloys were investigated for their physical properties or hydrogen absorption rates.[25] Rare-earths and their properties in combination with silver were subjects of several investigations.[26]

Two articles of significance to the study of silver mineralogy were published in 1970. One deals with phase relations, and the other with transition points for combinations of silver, arsenic, and sulfur.[27]

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[15] Smith, Roscoe M. Treasure Hill Reinterpreted. Econ. Geol., v. 65, No. 5, August 1970, pp. 538–540.

[16] Meeves, Henry C., and Richard P. Darnell. Silver Potential and Economic Aspects of the Leadville District, Lake County, Colo. BuMines Inf. Circ. 8464, 1970, 105 pp.

[17] Ewell, T. W., and J. Piper. Design of New Silver Recovery Incinerator. Paper presented at May 1970 Incinerator Division Conference, American Soc. Mech. Engs., Cincinnati, Ohio.

[18] Memming, R., F. Möllers, and G. Neumann. Photoelectro-chemical Processes on Silver-Silver Oxide Electrodes. J. Electrochem. Soc., v. 117, No. 4, April 1970, pp. 451–457.

[19] Choudary, U. V., and A. Ghosh. Thermodynamics of Liquid Copper-Silver Alloys by a Solid Electrolyte Cell. J. Electrochem. Soc., v. 117, No. 8, August 1970, pp. 1024–1028.

[20] O'Donnell, Patricia M. A Kinetic Study of the Fluorination of Silver. J. Electrochem. Soc., v. 117, No. 10, October 1970, pp. 1273–1275.

[21] Cook, Glenn M. Lithium/Silver Chloride Button Cells. J. Electrochem. Soc., v. 117, No. 4, April 1970, pp. 559–562.

[22] Pelton, A. D. and S. N. Flengas. Thermodynamics of Molten Silver Chloride-Alkali Chloride Solutions by Electromotive Force Measurements. J. Electrochem. Soc., v. 117, No. 9, September 1970, pp. 1130–1140.

[23] Townsend, H. S., and Paul Duby. Cation Transport Numbers in Molten $AgNo_3$-AgCl Mixtures by Pressure-EMF Measurements. J. Electrochem. Soc., v. 117, No. 9, September 1970, pp. 1126–1129.

[24] Visnapuu, A., and J. W. Jensen. Composition and Properties of Vapors Over Molten Silver Chloride. J. Less-Common Metals, v. 20, No. 2, February 1970, pp. 141–148.

[25] Newton, C. J., and A. W. Ruff, Jr. X-ray Study of Annealing in Plastically Deformed Ag. Sn Alloys. Met. Trans., v. 1, No. 10, October 1970, pp. 2833–2838.

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Table 2.—Mine production of recoverable silver in the United States, by months

(Thousand troy ounces)

Month	1969	1970
January	3,233	3,586
February	3,019	3,523
March	3,226	3,772
April	3,375	3,862
May	3,386	3,864
June	3,444	3,646
July	3,421	3,586
August	3,655	3,833
September	3,591	3,804
October	3,811	3,754
November	3,832	3,929
December	3,914	3,847
Total [1]	41,906	45,006

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

Table 3.—Twenty-five leading silver-producing mines in the United States in 1970, 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	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
4	Lucky Friday	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
5	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold-silver ores.
6	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore, lead-zinc tailings.
7	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
8	Crescent	Shoshone, Idaho	The Bunker Hill Co	Do.
9	Twin Buttes	Pima, Ariz	The Anaconda Company	Copper ore.
10	Burgin	Utah, Utah	Kennecott Copper Corp	Lead, lead-zinc ores.
11	White Pine	Ontonagon, Mich	White Pine Copper Co	Copper ore.
12	Copper Queen-Lavender Pit	Cochise, Ariz	Phelps Dodge Corp	Do.
13	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead, lead-zinc ores.
14	Butte Hill Copper Mines	Silver Bow, Mont	The Anaconda Company	Copper ore.
15	Pima	Pima, Ariz	Pima Mining Co	Do.
16	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
17	Mission Unit	Pima, Ariz	American Smelting and Refining Co	Copper ore.
18	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
19	Mayflower	Wasatch, Utah	Hecla Mining Co	Do.
20	Copper Canyon	Lander, Nev	Duval Corp	Copper ore.
21	Magma	Pinal, Ariz	Magma Copper Co	Do.
22	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
23	Mineral Park	Mohave, Ariz	Duval Corp	Do.
24	Sierrita	Pima, Ariz	Duval Sierrita Corp	Do.
25	Ray Pit	Pinal, Ariz	Kennecott Copper Corp	Do.

Table 4.—Production of silver in the United States in 1970, by States, types of mines, and classes of ore, etc. yielding silver, in terms of recoverable metal

State	Placer (troy ounces of silver)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	2,189	---	---	---	---	---	---
Arizona	---	144	85	(1)	(1)	[1] 89,599	[1] 94,862
California	182	990	311	[2] 104,125	[2] 393,218	---	---
Colorado	203	---	---	---	---	(3)	(3)
Idaho	---	240	48	(1)	(1)	[1] 543,883	[1] 13,688,684
Michigan	---	---	---	---	---	---	---
Missouri	---	---	---	---	---	---	---
Montana	---	(4)	(4)	(4)	(4)	[4] 39,338	[4] 462,740
Nevada	---	[5] 61,307	[5] 17,495	---	---	(5)	(5)
New Mexico	---	---	---	(1)	(1)	[1] 476	[1] 2,335
South Dakota	---	1,954,129	118,951	---	---	49	815
Utah	---	---	---	(2)	(2)	533	6,280
Other States [6]	---	75,105	275,981	300	3,470	78	1,963
Total	2,574	2,091,915	412,871	104,425	396,688	673,956	14,257,679
Percent of total silver	(7)	---	1	---	(7)	---	32

State	Lode—Continued					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	---	---	---	---	---	---
Arizona	134,968,089	7,130,261	360	2,277	450	27
California	62	61	---	---	---	---
Colorado	[8] 306,350	[8] 139,869	(8)	(8)	(8)	(8)
Idaho	1,601	2,378	36,085	325,979	15,825	16,735
Michigan	7,638,295	891,579	---	---	---	---
Missouri	---	---	8,815,825	1,816,978	---	---
Montana	[8] 18,736,890	[8] 3,832,799	(8)	(8)	(8)	(8)
Nevada	14,183,221	660,757	3,697	23,303	---	---
New Mexico	18,591,648	606,892	---	---	39,773	23,325
South Dakota	---	---	---	---	---	---
Utah	40,148,147	2,735,671	32,768	412,742	---	---
Other States [6]	186,638	22,108	---	---	363,038	5,810
Total	234,760,941	16,022,375	8,888,735	2,581,279	419,086	45,897
Percent of total silver	---	36	---	6	---	(7)

See footnotes at end of table.

Table 4.—Production of silver in the United States in 1970, by States, types of mines, and classes of ore, etc. yielding silver, in terms of recoverable metal—Continued

State	Lode—Continued					
	Copper-lead, lead-zinc copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	----------	----------	----------	----------	----------	2,189
Arizona	132,963	59,406	84,047	43,499	135,275,652	7,330,417
California	(2)	(2)	20	[9] 57,378	105,197	451,150
Colorado	[3] 826,161	[3] 2,790,077	709	3,214	1,133,220	2,933,363
Idaho	911,642	5,055,059	30,132	25,946	1,539,408	19,114,829
Michigan	----------	----------	----------	----------	7,638,295	891,579
Missouri	----------	----------	----------	----------	8,815,825	1,816,978
Montana	26	215	3,893	8,572	18,780,147	4,304,326
Nevada	1,229	10,585	2,292	[10] 5,871	14,251,746	718,011
New Mexico	122,417	148,222	810	1,178	18,755,124	781,952
South Dakota	----------	----------	----------	----------	1,954,178	119,766
Utah	[2] 682,662	[2] 2,869,016	1,004	[10] 6,028	40,865,114	6,029,737
Other States [6]	2,684,253	195,498	----------	[11] 6,478	3,309,412	511,308
Total	5,361,353	11,128,078	122,907	158,164	252,423,318	45,005,605
Percent of total silver	----------	25	----------	(7)	----------	100

1 Gold-silver and silver ores combined to avoid disclosing individual company confidential data.
2 Gold-silver and lead-zinc ores combined to avoid disclosing individual company confidential data.
3 Silver and lead-zinc ores combined to avoid disclosing individual company confidential data.
4 Gold, gold-silver, and silver ores combined to avoid disclosing individual company confidential data.
5 Gold and silver ores combined to avoid disclosing individual company confidential data.
6 Includes Maine, New York, Oklahoma, Oregon, Pennsylvania, Tennessee, and Washington.
7 Less than ½ unit.
8 Copper, lead, and zinc ores combined to avoid disclosing individual company confidential data.
9 Includes byproduct silver recovered from tungsten ore.
10 Includes byproduct silver recovered from uranium ore.
11 Includes byproduct silver recovered from magnetite-pyrite ore.

Table 5.—Mine production of recoverable silver in the United States, by States

(Troy ounces)

State	1966	1967	1968	1969	1970
Alaska	7,193	5,787	3,900	2,030	2,189
Arizona	6,338,696	4,588,081	4,958,162	6,141,022	7,330,417
California	189,989	144,515	597,961	491,927	451,150
Colorado	2,085,534	1,817,699	1,646,283	2,598,563	2,933,363
Idaho	19,776,785	17,033,330	15,958,715	18,929,697	19,114,829
Kentucky	1,086	568	----------	----------	----------
Maine	----------	----------	[1] 371,745	[1] 319,718	63,227
Michigan	483,000	301,992	472,813	1,009,022	891,579
Missouri	----------	226,168	340,856	1,442,090	1,816,978
Montana	5,319,785	2,066,464	2,132,571	3,429,314	4,304,326
Nevada	867,567	565,755	645,192	884,155	718,011
New Mexico	242,620	157,495	224,866	465,591	781,952
New York	21,590	31,103	27,615	31,755	23,830
Oklahoma	[2] 368,788	[2] 279,898	(1)	(1)	[2] 325,887
Oregon	343	31	335	4,749	3,594
Pennsylvania	(2)	(2)	(1)	(1)	(2)
South Dakota	109,885	121,258	137,668	124,497	119,766
Tennessee	100,716	130,078	89,525	78,614	94,770
Utah	7,755,411	4,874,640	5,120,772	5,953,567	6,029,737
Washington	(2)	(2)	(1)	(1)	(2)
Wyoming	----------	----------	----------	(1)	----------
Total	43,668,988	32,344,862	32,728,979	41,906,311	45,005,605

1 Production of Maine, Oklahoma, Pennsylvania, Washington, and Wyoming (1969) combined to avoid disclosing individual company confidential data.
2 Production of Oklahoma, Pennsylvania, and Washington combined to avoid disclosing individual company confidential data.

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1970 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	--------	--------	--------	--------	--------	--------	--------	--------
Arizona	150,549	150,025	--------	--------	3,371,204	7,013,794	524	316,623
California	105	102	5	--------	13,636	437,431	3	13,532
Colorado	1,133	1,133	1,175	--------	163,211	2,926,746	(3)	5,239
Idaho	1,540	1,536	43	--------	177,422	19,065,807	4	48,979
Michigan	7,638	7,638	--------	--------	229,564	891,579	--------	--------
Missouri	8,816	8,816	--------	--------	702,521	1,816,978	--------	--------
Montana	18,780	18,743	--------	--------	435,575	3,796,387	37	507,939
Nevada	14,252	14,070	5	--------	372,014	635,324	182	82,682
New Mexico	18,755	18,687	--------	--------	685,682	778,877	68	3,075
South Dakota	1,954	1,954	94,059	24,892	--------	--------	(3)	815
Utah	40,865	40,692	--------	--------	1,044,771	5,508,115	173	521,622
Other States [4]	3,309	3,309	--------	--------	564,721	505,869	(3)	5,439
Total	267,696	266,705	95,287	24,892	7,760,321	43,376,907	991	1,505,945

[1] Includes some nonsilver-bearing ore not separable.
[2] Excludes tonnage of magnetite-pyrite, tungsten, and uranium ores from which silver was recovered as a byproduct.
[3] Less than ½ unit.
[4] Includes Maine, New York, 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
1966	80,033	41,098	0.18	0.09	99.71	0.02
1967	84,290	47,054	.26	.15	99.57	.02
1968	92,021	53,666	.28	.16	99.55	.01
1969	83,775	49,812	.20	.11	99.68	.01
1970	95,287	24,892	.21	.05	99.73	.01

[1] Crude ores and concentrates.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

	1969	1970
From concentrates and ores:		
Domestic	r 43,769	49,451
Foreign	r 39,723	31,930
Total	r 83,492	81,381
From old scrap [1]	r 79,798	56,044
From new scrap	r 35,873	23,999
Total production	199,163	161,424

r Revised.
[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)

	1969	1970
Electroplated ware	12,706	11,437
Sterling ware	20,291	19,116
Jewelry	3,011	5,119
Photographic materials	41,380	38,044
Dental and medical supplies	1,591	1,804
Mirrors	1,510	1,386
Brazing alloys and solders	16,549	14,035
Electrical and electronic products:		
Batteries	3,799	6,342
Contacts and conductors	34,555	25,183
Bearings	481	383
Catalysts	4,081	1,999
Miscellaneous [1]	r 1,590	3,556
Total net industrial consumption	r 141,544	128,404
Coinage	r 19,407	709
Total consumption	r 160,951	129,113

r Revised.
[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
1968	$247,100	$137,800
1969	156,720	119,362
1970	49,139	103,757

Table 11.—U.S. exports of silver in 1970, by countries [1]

(Thousand troy ounces and thousand dollars)

Country	Ore and concentrates		Waste and sweepings		Refined bullion	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	---	---	---	---	2	$5
Belgium-Luxembourg	281	$509	5,222	$9,317	142	255
Bolivia	---	---	---	---	(2)	(2)
Brazil	---	---	---	---	37	68
Canada	572	1,053	2,961	4,833	254	465
Colombia	---	---	---	---	30	55
Costa Rica	---	---	---	---	4	4
Denmark	---	---	---	---	349	625
France	---	---	---	---	1,202	2,200
Germany, West	96	169	35	76	752	1,352
Ireland	(2)	(2)	---	---	---	---
Israel	---	---	---	---	2	2
Italy	---	---	---	---	1,463	2,622
Japan	1	1	12	17	3,182	5,774
Mexico	13	29	---	---	---	---
Netherlands	---	---	8	22	---	---
Norway	---	---	---	---	51	102
Spain	---	---	119	200	---	---
Sweden	---	---	180	323	---	---
Switzerland	19	25	545	950	8,088	14,432
United Kingdom	31	50	280	528	1,681	3,076
Total	1,013	1,836	9,362	16,266	17,239	31,037

[1] Does not include 3,000 troy ounces ($20,725) ore and concentrates reexported to Australia and 11,232 troy ounces ($18,000) waste and scrap to Switzerland.
[2] Less than ½ unit.

Table 12.—U.S. general imports of silver in 1970, by countries

(Thousands 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	258	$313	-------	-------	-------	-------	64	$113
Australia	1,769	2,742	-------	-------	-------	-------	1	2
Brazil	30	48	-------	-------	-------	-------	64	113
Bolivia	322	438	-------	-------	-------	-------	-------	-------
Canada	12,376	20,321	295	$475	2,480	$4,387	21,814	39,009
Chile	660	702	83	208	-------	-------	-------	-------
Colombia	52	44	(1)	1	-------	-------	-------	-------
Czechoslovakia	16	30	-------	-------	-------	-------	-------	-------
El Salvador	-------	-------	-------	-------	-------	-------	15	24
Ecuador	45	53	-------	-------	-------	-------	-------	-------
Germany, West	-------	-------	1	2	-------	-------	(1)	1
Guatemala	3	4	-------	-------	-------	-------	2	4
Honduras	3,148	2,994	-------	-------	479	782	53	95
Lebanon	(1)	9	-------	-------	-------	-------	-------	-------
Mexico	992	1,523	94	151	5	8	4,264	7,478
Nicaragua	41	43	-------	-------	37	60	-------	-------
Norway	31	41	-------	-------	-------	-------	-------	-------
Panama	-------	-------	-------	-------	-------	-------	5	9
Peru	8,009	13,096	-------	-------	-------	-------	3,223	5,657
Philippines	299	569	-------	-------	-------	-------	14	23
South Africa, Republic of	768	1,355	-------	-------	-------	-------	-------	-------
Switzerland	-------	-------	-------	-------	(1)	(1)	(1)	4
United Kingdom	427	715	-------	-------	1	2	50	105
Venezuela	-------	-------	10	4	-------	-------	-------	-------
Total	29,246	45,040	483	841	3,002	5,239	29,569	52,637

[1] Less than ½ unit.

Table 13.—World production of silver, by countries [1]

(Thousand troy ounces)

Country [2]	1968	1969	1970 [p]
North and Central America:			
Canada	[r] 45,013	43,531	44,615
El Salvador	----------	----------	154
Haiti [e]	17	17	17
Honduras	4,397	3,905	3,816
Mexico	40,031	42,904	42,889
Nicaragua	416	247	217
United States	32,729	41,906	45,006
South America:			
Argentina	2,422	3,109	2,051
Bolivia [3]	5,180	6,013	6,816
Brazil	464	360	357
Chile	3,739	3,133	2,393
Colombia	100	77	76
Ecuador	136	82	[e] 80
Peru	36,362	34,147	38,078
Europe:			
Austria	161	129	161
Czechoslovakia [e]	1,100	1,100	1,100
Finland	677	625	740
France	[r] 2,166	2,094	[e] 2,100
Germany:			
East [e]	4,800	4,800	4,800
West	1,769	1,684	1,773
Greece [4]	261	258	420
Hungary [e]	6	6	6
Ireland	1,913	1,866	2,171
Italy	1,156	1,832	1,061
Poland [e]	160	165	180
Portugal	327	339	247
Romania [e]	800	800	800
Spain [4]	[r] 1,704	1,823	[e] 1,640
Sweden	3,524	3,683	6,109
U.S.S.R. [e]	35,000	37,000	38,000
Yugoslavia	[r] 3,023	3,818	3,417
Africa:			
Algeria [e]	100	100	100
Congo (Kinshasa)	2,139	1,896	1,709
Ghana	----------	3	5
Kenya	3	2	----------
Morocco	920	861	681
South Africa, Republic of	3,337	3,335	3,527
South-West Africa, Territory of [5]	1,350	1,273	1,229
Tanzania	2	2	1
Tunisia	[e r] 37	[e] 43	58
Zambia [e 6]	768	768	768
Asia:			
Burma	[r] 790	902	572
China, mainland [e]	700	800	500
India	90	105	50
Indonesia	309	340	283
Japan	10,693	10,804	10,795
Korea:			
North [e]	700	700	700
South	[r] 637	906	1,494
Philippines	1,575	1,561	1,702
Taiwan	90	81	95
Oceania:			
Australia	[r] 21,394	24,457	26,126
Fiji	55	38	27
New Guinea and Papua	18	17	[7] 17
New Zealand	4	22	16
Total	[r] 275,264	290,469	301,745

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Recoverable content of ores and concentrates produced unless otherwise noted.
[2] In additicn to the countries listed Bulgaria, Guatemala, Thailand, Turkey, Southern Rhodesia, and several other African countries produce 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] Recoverable content of Tsumeb Corp. Ltd. concentrates, as reported for year ending June 30 of year stated.
[6] Includes recovery from copper refinery sludges.
[7] New Guinea only.

Slag—Iron and Steel

By Walter Pajalich[1]

The slag industry felt the effects of the sluggish economic conditions that prevailed in 1970. Reduced construction activity, especially in highway construction, decreased the demand for the iron-blast-furnace slag as a construction aggregate. In addition, a drop in pig iron production resulted in a corresponding decrease in output of blast-furnace slag by processors.

Although production of blast-furnace slag in 1970 was about 12 percent less than that for 1969, supply generally was sufficient to meet the demand. However, some local areas where slag is used extensively, demand greatly exceeded available supply. Generally, transportation charges prohibited shipping the product any great distance to equalize the supply and demand. Most of the slag was processed convenient to markets and shipped a short distance by truck. Production and consumption of steel slag remained about the same as those of the previous year.

Construction and maintenance were the prime, and nearly exclusive, markets for slag. No significant new uses for slag were developed.

[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 [1]	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value [2]	Quantity	Value	Quantity	Value
1966	19,925	$35,348	551	$588	3,749	$3,026	2,525	$7,860	26,750	$46,822
1967	22,326	39,204	1,052	800	3,760	2,834	2,456	7,262	29,593	50,101
1968	21,757	39,034	1,826	1,493	2,944	2,631	2,215	6,251	28,742	49,408
1969	22,295	41,388	2,239	2,525	2,818	3,174	2,422	6,985	29,774	54,074
1970	20,214	40,066	2,038	2,069	1,936	2,712	1,959	6,570	26,147	51,417

[1] Data may not add to totals shown because of independent rounding.
[2] Excludes value of slag used for manufacturing hydraulic cement 1966–70; and granulated aggregate for concrete-block manufacturing 1966–70.

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	Quantity	Value
1969				
Ohio	4,576	$9,024	6,806	$13,291
Pennsylvania	5,579	11,346	7,268	14,548
Illinois, Indiana, Michigan	4,277	7,767	5,922	r 10,682
Other States [1]	7,863	13,252	9,778	r 15,553
Total	22,295	[2] 41,388	29,774	r 54,074
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 [1]	6,787	12,351	8,649	14,905
Total	20,214	40,066	26,147	51,417

r Revised.
[1] Alabama, California, Colorado, Kentucky, Louisiana (1970), Maryland, Minnesota, New York, Texas, Utah, and West Virginia.
[2] Data may not add to total 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	1969		1970	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	4,610	14	4,725	18
Truck	24,425	83	20,992	80
Waterway	738	3	430	2
Total	[1] 29,774	100	26,147	100

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

Source: National Slag Association.

DOMESTIC PRODUCTION

Production of iron-blast-furnace slag is dominated by the air-cooled screened product, which totaled 20.2 million short tons valued at $40.1 million in 1970. Blast furnace and steel slag output was 9 percent less than the 1969 total. Most of the production centered in 11 States, with Pennsylvania and Ohio the leading States in quantity produced. A total of 1,557 plant and yard personnel worked 3,567,246 man-hours during 1970 in 56 air-cooled, 17 expanded, and 14 granulated slag plants. The quantity of slag-encrusted magnetic iron recovered at these operations was 3,897,000 tons.

CONSUMPTION AND USES

During 1970 most of the slag sold or used by processors was used for construction and maintenance of airports, buildings, highways, and railroads. The balance was used in the manufacture of glass, as a sewage trickling medium, and for agricultural purposes. Blast-furnace slag, in various forms such as granular, powder, or fibrous materials, was used as loose aggregate or recombined with some binding material. Screened air-cooled slag accounted for 77 percent of the total tonnage of iron-blast-

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	1969				1970			
	Screened		Unscreened		Screened		Unscreened	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Aggregate in—								
Portland cement concrete construction:								
Structures	2,010	$4,205	------	------	2,075	$4,405	------	------
Pavements	712	1,623	------	------	418	919	------	------
Bituminous construction (all types)	3,796	7,418	127	$228	3,838	7,819	------	------
Highway and airport construction [1]	10,086	18,198	446	432	8,291	17,057	1,475	$1,550
Manufacture of concrete block	430	792	------	------	371	730	------	------
Railroad ballast	3,403	5,047	------	------	3,420	4,682	------	------
Mineral wool	413	681	29	20	351	705	35	27
Roofing slag:								
Cover material	414	1,266	------	------	628	1,443	------	------
Granules	84	577	------	------	76	530	------	------
Sewage trickling filter medium	23	48	------	------	65	126	------	------
Agricultural slag, liming	8	20	------	------	7	14	------	------
Other uses	914	1,511	1,637	1,846	674	1,636	528	492
Total [2]	22,295	41,388	2,239	2,525	20,214	40,066	2,038	2,069

[1] Other than in portland cement concrete and bituminous construction.
[2] Data may not add to totals shown because of independent rounding.

Source: National Slag Association.

furnace slag sold or used during 1970. Although slag consumption for roofing and sewage-trickling medium increased, the total quantity of slag sold or used was less than that for 1969. The decline resulted from the drop in slag used as construction aggregates, reflecting the reduced construction activity during the year. Consumption of steel slag increased 3 percent, with the major gain in the quantity used for highway maintenance.

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	1969				1970			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value[1]	Quantity	Value	Quantity	Value[1]	Quantity	Value
Highway construction and fill (road, etc.)	1,707	$2,459	-----	-----	1,121	$1,639	-----	-----
Agricultural slag, liming	59	115	-----	-----	121	187	-----	-----
Manufacture of cement (all types)	680	NA	-----	-----	412	578	-----	-----
Lightweight concrete	-----	-----	222	$908	-----	-----	48	$156
Aggregate for concrete-block manufacture	174	366	1,955	5,733	151	208	1,781	6,033
Other uses	197	234	245	345	131	100	130	381
Total[2]	2,818	[r]3,174	2,422	6,985	1,936	2,712	1,959	6,570

[r] Revised. NA Not available.
[1] Excludes value of granulated slag used for hydraulic cement manufacture and concrete-block manufacture.
[2] Data may not add to totals shown because of independent rounding.

Source: National Slag Association.

Table 6.—Steel slag sold or used by processors in the United States, in 1970, by uses[1]

(Thousand short tons and thousand dollars)

Use	1969		1970	
	Quantity	Value	Quantity	Value
Railroad ballast	922	$941	840	$981
Highway base or shoulders	1,604	1,570	2,371	2,476
Paved-area base	1,063	889	1,346	1,343
Miscellaneous base or fill	2,381	2,723	1,419	1,651
Bituminous mixes	265	312	496	764
Agricultural	95	368	77	490
Other uses	969	882	990	1,127
Total	7,299	7,685	7,539	8,832

[1] Excludes tonnage returned to furnace for charge material.

Source: National Slag Association.

PRICES

The prices of iron-blast-furnace slag sold or used by processors for most uses in 1970 were higher than in 1969, and reflected the continued increase in labor and production costs. Air-cooled, screened slag increased approximately 12 cents to $1.98 per short ton. The average value of blast-furnace slag was $1.97 per short ton, and steel slag averaged $1.17 per short ton.

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					
	1969	1970	1969	1970	1969	1970	1969	1970
Aggregate in—								
Portland cement concrete construction	$2.09	$2.14	$0.45	----	----	----	----	----
Bituminous construction (all types)	1.95	2.04	1.79	----	----	----	----	----
Highway and airport construction [1]	1.80	2.06	1.26	$1.05	$1.44	$1.46	----	----
Manufacture of concrete block	1.84	1.97	----	----	2.10	1.38	$2.93	$3.39
Lightweight concrete	----	----	----	----	----	----	4.08	3.25
Railroad ballast	1.48	1.37	----	----	----	----	----	----
Mineral wool	1.64	2.01	.68	.77	----	----	----	----
Roofing slag:								
Cover material	3.05	2.30	----	----	----	----	----	----
Granules	6.84	6.97	----	----	----	----	----	----
Sewage trickling filter medium	2.04	1.94	----	----	----	----	----	----
Agricultural slag, liming	2.46	2.00	----	----	1.96	1.55	----	----
Other uses	1.65	2.43	1.12	.93	1.18	.76	1.40	2.93

[1] Other than in portland cement and bituminous construction.

Source: National Slag Association.

TECHNOLOGY

Changing metallurgical practices in 1970 continued to reduce the amount of slag per ton of metal produced. The use of higher-grade raw materials and the partial replacement of coke by low ash fuels are the two main factors that have reduced the slag-iron ratio. The quantity of blast-furnace slag produced per ton of pig iron varied from less than one quarter ton to more than one ton.

Continued application research, satisfactory performance, and availability of slag have resulted in more extensive use of slag in recent years. A cold mixture for roads to increase water and frost resistance as well as compression strength of highway coating was reported. The cold mixture consisted of crushed granite crumbs (40 to 50 percent) granulated blast furnace slag (50 to 60 percent) and viscous bitumen.[2]

Sound blast-furnace slags are being shaped by casting into components such as pipe-lining plates or large blocks. However, the quantity of slag used in this manner is limited.[3]

[2] Samodurov, S. I. Cold Mixture for Roads. U.S.S.R. Patent 261,236 (Cl. C 04b), Jan. 6. 1970.

[3] Klemantaski, S. Processing of Metallurgical Slags at Iron and Steel Plants. Steel Times Ann. Rev., 1969, pp. 158–167.

Sodium and Sodium Compounds

By Charles L. Klingman [1]

In 1970 overall domestic production of soda ash (sodium carbonate) and salt cake (sodium sulfate) from manufactured and natural sources decreased about 0.5 percent from 1969. Natural sodium carbonate showed an increase, but manufactured soda ash and high purity sodium sulfate showed decreases. The major source of natural soda ash continued to be the trona deposits of Green River, Wyo.

DOMESTIC PRODUCTION

Total production of soda ash in 1970 increased about 1 percent. Production of manufactured material (Solvay process) declined nearly 3 percent, whereas natural carbonate output increased by almost 8 percent. Except for the year 1967, in which natural soda ash production remained virtually the same as that of 1966, there has been an annual increase in the ratio between natural soda ash mined and the manufactured product every year for the past 18 years. In 1970 the production of natural soda ash amounted to 38 percent of the total sodium carbonate output.

Soda ash derived from natural sources was produced in California from dry lake brines and in Wyoming from underground trona deposits. The California producers were American Potash and Chemical Corp. and Stauffer Chemical Co. The Wyoming production, which accounted for a major part of the entire natural soda ash output, was contributed by the Allied Chemical Corp., the FMC Corp., and the Stauffer Chemical Co. of Wyoming. Stauffer announced plans to increase its natural soda ash production at Green River, Wyo., from 1 million to 1.5 million tons per year. At about the same time, FMC stated that it planned to increase its natural soda ash production from 1.25 million to 2.25 million tons per year. The new installations were scheduled for completion by the end of 1972.

Total production of manufactured and natural sodium sulfate declined about 8 percent in 1970. High-purity sulfate dropped 19 percent, and low-purity salt cake showed a 4-percent gain.

Salt cake was produced from dry lake brines in California by American Potash and Chemical Corp., the Stauffer Chemical Co., and by United States Borax and Chemical Co. In Texas, the Ozark-Mahoning Co. recovered salt cake from subterranean brine; and in Wyoming, the William E. Pratt Co. extracted a relatively minor quantity of sodium sulfate from dry lake beds. In October 1970, one small production facility of Ozark-Mahoning permanently closed because of declining profits.

Production of sodium sulfate by solar evaporation of the waters of Great Salt Lake in Utah began in 1970. The producing company, Great Salt Lake Chemical Corp., has an anticipated capacity of 150,000 tons per year.

[1] Chemical engineer, 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
1966	5,071	1,738	$40,674
1967	4,849	1,726	40,539
1968	4,596	2,043	42,104
1969	r 4,540	r 2,495	50,922
1970	p 4,414	p 2,688	56,320

p Preliminary. r Revised.
[1] 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).

Metallic sodium and its coproduct chlorine, were produced by electrolysis of molten salt by the following three companies at five plants: E. I. du Pont de Nemours & Co., Inc., with plants at Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp. with plants at Baton Rouge, La., and Houston Tex.; and Reactive Metals, Inc., at Ashtabula, Ohio. Sodium metal production increased 4 percent from 164,685 tons in 1969 to 171,220 tons in 1970.

Table 2.—Sodium sulfate produced and sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Year	Production (manufactured and natural) [2]		Sold or used by producers (natural only)	
	Lower purity [3] (99 percent or less)	High purity	Quantity	Value
1966	1,009	436	640	$11,271
1967	696	668	637	10,710
1968	758	725	700	12,729
1969	r 731	r 744	672	12,427
1970	p 761	p 602	598	10,932

p Preliminary. r Revised.

[1] All quantities converted to 100 percent Na_2SO_4 basis.

[2] Bureau of the Census.

[3] Includes glauber salt.

CONSUMPTION AND USES

The consumption and use pattern of sodium and its compounds remained relatively unchanged from previous years. About 50 percent of the soda ash produced was used in the making of glass; 40 percent in the making of chemicals; about 8 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 74 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 the threat of restricted use of lead in gasoline. Titanium producers utilized metallic sodium to reduce titanium tetrachloride to metallic titanium. An important potential market for metallic sodium may develop in the use of the liquid metal to cool nuclear reactors.

Union Carbide Co. has apparently discontinued experimental development of sodium-filled cables for transmission of electrical power.

PRICES

Market prices for sodium carbonate, sodium sulfate, and metallic sodium reported by the Oil, Paint and Drug Reporter follow:

		1969	*1970*
Sodium carbonate (soda ash, 58 percent Na_2O):			
Light, paper bags, carlots, works	per 100 pounds	$2.15	$2.35
Light, bulk, carlots, works	do	1.65	1.65
Dense, paper bags, carlots, works	do	2.25	2.40
Dense, bulk, carlots, works	do	1.65	1.65
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 [1]	do	28.00	28.00
National Formulary (N.F.XII), drums	per pound	.25½	.23½
Metallic sodium:			
Bricks, carlots, works	do	.24	.26
Fused, lots of 18,000 pounds and more, works	do	.22½	.24½
Bulk, tank, works	do	.17¾	.18¾

[1] Delivered east of the Mississippi River.

FOREIGN TRADE

The quantity of sodium sulfate exported in 1970 was only 60 percent of that exported in 1969 and was equivalent to 4 percent of the domestic sodium sulfate production. Three-fourths of the sulfate exported was accounted for by shipments to Canada, Australia, and South Vietnam.

Exports of sodium carbonate increased 3.7 percent over those of 1969. Soda ash exports represented 4.7 percent of the total soda ash output in 1970. About half of the export went to Canada, 19 percent to Argentina, and about 12 percent to Venezuela.

Imports of sodium sulfate declined about 6 percent as compared with those of 1969. Belgium-Luxembourg supplied about 54 percent of these imports and Canada, another 38 percent.

The tariff rates for sodium compounds during 1970 are tabulated below:

Sodium carbonate:	
Calcined (soda ash)	$3.40
Hydrated and sesquicarbonate	3.00
Sodium sulfate:	
Crude (salt cake)	Free
Anhydrous	.35
Crystallized (glauber salt)	.70

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
1968	288	$9,131	56	$1,844
1969	324	10,326	91	2,644
1970	336	12,007	55	1,668

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
1968	279	$4,721	25	$377	305	$5,108
1969	264	4,477	22	324	286	4,808
1970	243	4,224	26	529	269	4,753

[1] Includes glauber salt as follows: 1968, 1,277 tons ($10,107); 1969, 153 tons ($6,935); 1970, none.

WORLD REVIEW

Argentina.—In January 1970, the Government promulgated a "soda Solvay promotion" law which invited bids for building a 220,000-ton-per-year soda ash plant. Investment is estimated at $30 million, and the new plant will make importation of soda ash unnecessary.[2]

A $120 million petrochemical complex being built at Bahia Blanca in Buenos Aires Province, by The Dow Chemical Co. was scheduled to produce 100,000 tons of caustic soda per year. The operation will consume 200,000 tons of salt annually from La Pampa Province. An existing local plant was scheduled to increase its caustic soda production by 5,000 tons per year.[3]

Bulgaria.—A plant, under construction at Varna, was scheduled to produce 1.2 million tons per year of soda ash, which is intended primarily for export. Equipment for the plant came from Japan.[4]

Canada.—W. R. Grace Co. was building a plant in Ontario that was scheduled to produce 100 million pounds per year of sodium nitrilotriacetate. Production was due to start in December 1972.[5]

Chile.—A new industrial complex was dedicated in October 1970, which included a $10 million chlorine-caustic soda plant capable of producing 37,000 tons of caustic soda per year.[6]

Greece.—A contract was signed by the A. S. Onassis interest to build a $600 million industrial complex at Megara. A facility to produce 54,500 short tons of caustic soda per year was included.[7]

[2] U.S. Embassy, Argentina. State Department Airgram A-11, Jan. 14, 1970, Item 4, p. 3.
[3] Bureau of Mines. Mineral Trade Notes. V. 68, No. 5, May 1971, pp. 12, 13.
[4] European Chemical News. Bulgaria Plans Soda Ash Exports. V. 17, No. 439, July 3, 1970, p. 8.
[5] Oil, Paint and Drug Reporter. V. 198, No. 7, Aug. 17, 1970, pp. 3, 13.
[6] U.S. Embassy, Chile. State Department Airgram A-383, Nov. 9, 1970, p. 3.
[7] U.S. Embassy, Greece. State Department Airgram A-118, Mar. 28, 1970, pp. 1, 2.

An agreement was reached with the International Finance Corp. for financing a $19 million chemical complex at Messolonghi to produce, among other things, 60,000 tons per year of soda ash.[8]

Taiwan.—Expansion projects were underway to increase production capacity of the Southeast Soda Mfg. Co. Ltd. from 44,000 to 66,000 short tons per year of sodium carbonate and from 6,600 to 13,200 short tons per year of sodium bicarbonate. Two-thirds of the bicarbonate production was to be exported.[9]

Turkey.—Chlorine-caustic soda production at Izmit was doubled to 44,000 short tons per year.[10]

United Kingdom.—Construction was in progress on a new plant for the Imperial Chemical Industries (ICI), Mond Division, at Northwich, which was scheduled to produce 250,000 tons of dense soda ash per year. Production was scheduled to start during 1971.[11]

Venezuela.—A $400 million complex located at El Tablazo was scheduled to produce, among other things, 43,100-tons-per-year of caustic soda. Construction was due to be completed in July 1972.[12]

TECHNOLOGY

A patented process for recovering sodium carbonate and sulfur dioxide or sodium sulfite from pulping liquors was perfected at the Kemi pulp mill at Tampere, Finland. This system converts "green liquor" to hydrogen sulfide and sodium carbonate instead of caustic soda. The Kemi plant has a capacity of 7,000 tons per year of pure sodium carbonate.[13]

A new procedure for separating trona (sodium sesquicarbonate, $Na_2CO_3.NaHCO_3\text{-}2H_2O$) and sal soda (hydrated sodium carbonate, $Na_2CO_3.10H_2O$) from other components of natural brines by a special flotation process was patented.[14]

Caustic soda was manufactured in the form of smooth, dustless spheres either 0.055 or 0.040 inch in diameter. The new physical form was said to be free flowing, less subject to caking, and less irritating to the skin.

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[8] Bureau of Mines. Mineral Trade Notes. V. 67, No. 2, February 1970, p. 27.

[9] U.S. Embassy, Taiwan. State Department Airgram A-231, June 26, 1970, pp. 1, 2.

[10] Bureau of Mines. Mineral Trade Notes. V. 67, No. 11, November 1970, p. 35.

[11] European Chemical News. ICI Expands in Soda Ash and Caustic Potash. V. 17, No. 414, Jan. 9, 1970, p. 11.

[12] U.S. Embassy, Venezuela. State Department Airgram A-123, Mar. 24, 1970, p. 3.

[13] Chemical Engineering. Recover Chemicals From Sodium-Base Sulfite Pulping. V. 77, No. 20, Sept. 21, 1970, pp. 138–142.

[14] Garrett, D. E. and W. R. White. Froth Flotation. U.S. Patent 3,525,434, Aug. 25, 1970, 3 pp.

Stone

By Harold J. Drake [1]

Domestic production of stone in 1970 reached a total of 875 million tons valued at $1.47 billion. Although dimension stone accounted for only 0.2 percent of the total quantity produced, this type of stone represented 6.5 percent of the value, as unit values rose to meet increased production costs. Crushed and broken stone accounted for slightly more than 99 percent of the total production and 93.5 percent of the value.

Production of stone was reported in all States except Delaware. Ten States accounted for 53 percent of the domestic stone output and 48 percent of the total value. Pennsylvania led with 66 million tons of stone produced. Other major producing States, in order of tonnage, were Illinois, Ohio, California, Texas, Florida, Michigan, Missouri, New York, and Virginia.

The National Limestone Institute held its 25th anniversary convention in Washington, D.C.[2] Discussions at earlier conventions considered chiefly agricultural programs; however, the silver anniversary program embraced agriculture, highway construction programs, research on limestone products, tax legislation, environmental controls and important day-to-day operating factors in quarries and plants. The Limestone Producers Association held its 25th anniversary meeting in Jefferson City, Mo.[3] Subjects discussed included developments in Federal tax legislation, the Federal mine safety law, reclamation of quarrying and mining properties, the future of agronomy in Missouri, and the Missouri vehicle safety law. Major highlights of the program were discussions concerning proposed revisions to percentage depletion and application of the national mine safety legislation. The Iowa Limestone Producers Association held its 25th anniversary, convention in Des Moines, Iowa.[4] Subjects discussed included marketing factors, product research and promotion, national legislation, environmental control problems, and pros and cons of various types of equipment.

[1] Physical scientist, Division of Nonmetallic Minerals.
[2] Pit and Quarry. National Limestone Institute Celebrates 25th Anniversary. V. 62, No. 9, March 1970, pp. 130–138.
[3] Pit and Quarry. Missouri Association Marks 25th Anniversary. V. 62, No. 9, March 1970, pp. 139–141.
[4] Pit and Quarry. Iowa Limestone Producers Analyze Current, Future Factors. V. 62, No. 10, April 1970, pp. 136–141.

Table 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
Shipped or used by producers:					
Dimension stone	2,327	2,011	2,060	1,867	1,565
Value	$89,814	$95,472	$98,441	$98,547	$95,157
Crushed stone	811,047	783,581	817,537	861,021	872,947
Value	$1,170,901	$1,144,772	$1,219,469	$1,326,047	$1,379,761
Total stone	813,374	785,592	819,597	[2] 862,889	874,512
Value [2]	$1,260,715	$1,240,244	$1,317,911	$1,424,594	$1,474,917
Exports (value)	$11,134	$11,156	$9,969	$10,223	$10,396
Imports for consumption (value)	$20,739	$19,823	$24,629	$30,548	$35,674

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

DIMENSION STONE

DOMESTIC PRODUCTION

Reduced construction activity during 1970 resulted in a drop in output of dimension stone. Production decreased 16 percent from 1.9 million tons in 1969 to 1.6 million tons in 1970. Value, however, decreased only 3 percent, reflecting the current rising trend in prices.

Greater acceptance by consumers of foreign fabricated stone, higher building-site labor costs and lower amounts of financing adversely influenced the industry.[5]

Improvements to reduce costs of quarry operations and plant equipment were of great interest to the dimension stone industry. Channelling machines are standard equipment, and use of wire saws and quarry bar drills is increasing.

CONSUMPTION AND USES

Of the total quantity of dimension stone sold or used by producers, granite represented 37 percent, limestone and dolomite 31 percent, sandstone, quartz, and quartzite 19 percent, slate 6 percent, marble 4 percent, and other stone together with a minor amount of traprock, 3 percent.

Curbing and monumental stone represented the major uses of the dimension granite industry.

In the limestone industry architectural purposes lead all other categories in the consumption of stone. Greater interest has been created in this area as new building methods and systems have developed. Research is being conducted on a posttension method for application to limestone and broadening the technological aspects of quarrying.

Cut stone represents the major use for marble output. Although the desire for marble still prevails, the industry has been adversely affected by the economic slowdown.

Although slate production has shown a steady decline in recent years, the outlook for the industry appears good when monetary restrictions on the building industry are loosened.

PRICES

Average values for dimension stone in 1970, as reported to the Bureau of Mines, are listed below in dollars per ton:

	Building		Monumental, rough and dressed	Flagging
	Rough	Dressed		
Granite	$18.34	$76.81	$108.95	-------
Marble	42.48	260.20	------	-------
Limestone	17.90	48.51	------	$9.70
Sandstone	15.94	54.98	------	39.62
Slate	------	142.25	------	29.88
Miscellaneous	13.45	44.86	------	24.62

FOREIGN TRADE

U.S. building and monumental stone exports were valued at $2.3 million. In terms of value, 62 percent went to Canada, Japan received 10 percent, Mexico received 4 percent, the Bahamas received 3 percent, and the remainder went to other countries in minor amounts.

Imports of finished stone continued to supply a large percentage of the domestic market.[6] Although marble and travertine have been the most popular of the finished stone imports, granite imports were also sizable. Slate imports are increasing, but the demand is not as great as that for marble and granite. It is believed by some manufacturers that these imports have had a definite impact on the domestic marble industry—a number of plants and quarries have remained idle or have closed down in recent years.

Total U.S. imports of stone for consumption were valued at $35.7 million, of which 84 percent was dimension stone. Marble, breccia, and onyx chiefly from Italy and Portugal represented 45 percent of the value of dimension stone imported; monumental, paving, and building granite was furnished chiefly by Canada and Italy and comprised 27 percent; the slate imports accounted for 10 percent and were furnished mainly by Italy and the United Kingdom. Italy was the chief source of travertine, which represented 9 percent of the value of imports for consumption. The remaining percentage was comprised of values for limestone, quartzite, and miscellaneous stone.

WORLD REVIEW

Philippines.—The marble industry of the Philippines was discussed in a report that

[5] Mining Engineering. Industrial Minerals—1970 and Beyond. V. 23, No. 1, January 1971, 50 pp.
[6] Work cited in footnote 5.

detailed the distribution of deposits and the mining, processing, and marketing of marble.[7] Luzon and Mindoro are the principal sources of marble. The largest processing plant is situated at Maco, but several sizable plants are located in the Manila area.

Faced with rising labor costs, a shortage of skilled workers, and strong competition from other structural materials, the Philippine dimension stone industry is moving as rapidly as possible towards automation.[8]

Taiwan.—Production of marble has sharply accelerated in recent years with the discovery of large deposits of green serpentine and grey and black calcite marble.[9] The principal products currently are decorative items such as table tops and lamp bases, but output of architectural marble is accelerating.

Togo.—The marble deposit being worked by Société Togolaise de Marbrerie et de Materiaux is believed to contain over 550 million short tons—a virtually inexhaustible supply at the current rate of production of 10,000 tons a year. It was further noted that the company has expanded its processing facilities and plans to export block and finished marble products.

TECHNOLOGY

A new anchoring system has been developed that is expected to offset problems inherent in joining stone facing slabs to concrete in producing precast architectural units.[10] The use of a shear hub and slip anchor allows the stone slab to be retained on the concrete slab free of destructive stresses to both components.

Failure to achieve the maximum degree of mechanization possible and to resolve the manpower problem may lead to the demise of the dimension stone industry. The industry is beset, additionally, by municipal planning restrictions, particularly in densely populated areas.[11] In the past, the development of stone quarries was virtually unrestricted, but today many urban planning commissions carefully control mining operations by requiring mining companies to plan current and future operations in the manner described in the article.

CRUSHED STONE

DOMESTIC PRODUCTION

In 1970 production of crushed stone totaled 873 million tons valued at $1.4 billion, 1 percent and 4 percent, respectively, above the corresponding levels of 1969. Production was partially restrained during 1970 owing to a decline in industrial and construction activity. Approximately two-thirds of the crushed stone was used for construction and paving purposes.

Legislation and Government Programs.—Highway construction, a principal market for crushed stone aggregates, continued at the high rate begun by the Federal Government in 1956. The U.S. Department of Transportation announced that, as of December 31, 1970, 74 percent of the 42,500-mile National System of Interstate and Defense Highways was now open to traffic. An additional 10 percent was under construction, 12 percent was in the planning stage, and 4 percent was in a preliminary stage. Approximately 9 percent of the mileage now in service will need additional improvements in order to handle projected increased traffic in the future. In addition to the Interstate System, construction contracts involving 244,416 miles of primary and secondary highways had been completed at a cost of $22.6 billion. Contracts involving 13,917 miles at a cost of $4.1 billion were underway. An additional $1.8 billion of engineering and right-of-way acquisition work has been completed, and $879 milion worth of such work was underway.

The stone industry continued to expand and modernize facilities to meet increasing demand and to become more competitive. Quarry Products, Inc., Richmond, Calif., completed modernization of its quarry on San Francisco Bay.[12] The new complex includes a new automated plant that produces cement-treated base materials and additional crushing and screening equipment. Principal products include cement-treated

[7] Shadmon, Asher. Marble in the Philippines. Bureau of Mines, Manila, Philippines, 1969, 60 pp.
[8] Shadmon, Asher. Present Trends in the Fabrication of Marble and Stone. Philippine Architecture, Eng., and Construction Record. 9 pp.
[9] Modern Asia. Stoney Ground. V. 5, No. 2, Mar. 1971, pp. 12–14.
[10] Concrete Products. New System for Anchoring Stone to Precast Concrete. V. 73, No. 1, Jan. 1970, 70 pp.
[11] Shadmon, Asher. Quarry Site Surveys in Relation to County Planning. 23d., Internat. Geol. Cong. 1968, pp 125–132.
[12] Utley, Harry F. Pioneer Quarry on San Francisco Bay is Modernized. Pit and Quarry, v. 62, No. 8, February 1970, p. 126.

base materials, construction aggregates, and bituminized paving material. Rivergate Rock Products Co. Portland, Oregon, completed an expansion of its crushed stone plant.[13] The capacity of the new plant is more than double that of the old. Products include coarse riprap, asphalt rock, railroad ballast, and several sizes of base rock. Advance planning, continuous equipment rehabilitation, and proper maintenance programs are among the key factors that lead to rapid growth of small firms producing crushed stone.[14] The proper placement of new equipment and stockpile, in the quarry area cuts haulage distances and maintenance costs.[15] L. W. Rozzo, Inc., is using a portable plant and a stationary plant to exploit an oolitic limestone deposit near Hollywood, Fla.[16] Planned highway construction led to the formation in 1967 of the Elkhorn Stone Co. in eastern Kentucky, to supply crushed paving stone.[17] A rapidly growing chemical stone market led Texas Crushed Stone Co. to embark on a major expansion program that more than doubled existing capacity at its Georgetown, Tex. plant.[18] The problems of environmental pollution, and encroachment of urban areas were met and solved by Blue Rock Industries, Westbrook, Maine.[19]

The National Crushed Stone Association (NCSA) at its recent 53d Annual Convention made it obvious that there will be no letdown in its comprehensive program aimed at regaining old markets, developing present markets, and finding new uses and markets for crushed stone.[20] Also stressed at the convention were the efforts being made to solve environmental problems. A full-scale test of a limestone injection process for reducing sulfur dioxide emitted from the stacks of coal-burning power plants is scheduled for the near future.[21] Testing of concrete shoulders on highways was accelerated by the participation of the U.S. Bureau of Public Roads.[22] The Bureau's program calls for test projects in at least two States in each of nine regions.

CONSUMPTION AND USES

Although consumption of crushed stone increased slightly in 1970, not all major end uses recorded gains. Consumption of dense-grade road stone, the largest use of crushed stone, declined about 13 percent, and that for stone used in the manufacture of cement and lime fell about 6 percent. Use of flux stone and surface treatment aggregate also declined. Increases in consumption were recorded for stone used for agricultural purposes (9 percent), for concrete aggregate (7 percent), and for unspecified construction aggregate (9 percent); a large increase (38 percent) occurred in the use of riprap and jetty stone.

PRICES

Quotations in Engineering News-Record for carload lots of 1½-inch crushed stone in 1970 ranged from $5.75 per ton in Minneapolis to $1.55 per ton in Birmingham. The average price reported for 17 major cities was $2.98 per ton. The prices for ¾-inch crushed stone ranged from $5.75 per ton in Minneapolis to $1.60 per ton in Birmingham and St. Louis. The average price for 19 major cities was $3.04 per ton, an increase of 2 percent over the 1969 average.

Prices for industrial fillers and extenders per ton, as reported in the American Paint Journal, were as follows:

Silica, amorphous, ultra-fine-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

13 Trauffer, Walter E. Portland, Oregon, Crushed Stone. Pit and Quarry, v. 62, No. 10, April 1970, pp. 98–103.

14 Herod, Buren C. Planning Key to Growth of Ohio Quarry Operations. Pit and Quarry, v. 62, No. 11, May 1970, pp. 122–126.

15 Shannon, James J. Equipment Installation in Existing Quarry Cuts Costs for River Products Co. Rock Products, v. 73, No. 9, September 1970, pp. 114, 116.

16 Stearn, Enid W. Rozzo Hits Paydirt in Hardrock. Rock Products, v. 73, No. 4, April 1970, pp. 48–49.

17 Herod, Buren C. Elkhorn Stone Company—An impressive Newcomer. Pit and Quarry, v. 63, No. 3, September 1970, pp. 74–79.

18 Herod, Buren C. Steadily Improved Service—Texas Crushed Stone's Goal. Pit and Quarry, v. 63, No. 4, October 1970, pp. 80–85, 89.

19 Trauffer, Walter E. Maine's New Dust-Free Crushed Stone Plant. Pit and Quarry, v. 63, No. 2, August 1970, pp. 96–100.

20 Pit and Quarry. Selling Stone and Environmental Control Stressed at NCSA's 53rd Annual Convention. V. 62, No. 11, May 1970, pp. 140–147.

21 Rock Products. Kentucky Quarry Gets TVA Contract. V. 73, No. 2, February 1970 p. 18.

22 Roads and Streets. Concrete Shoulders Get National Evaluation. V. 113, No. 10, October 1970, pp. 74–75.

FOREIGN TRADE

U.S. exports of crushed stone in 1970 amounted to 2.1 million tons valued at $6.7 million. Approximately 82 percent of the quantity and 51 percent of the value of the exports was calcareous stone used as a flux or in manufacturing cement and lime. The bulk of the remainder consisted of unspecified types of stone used for various purposes. Canada was the principal recipient (89 percent of the quantity and 77 percent of the value), followed by the Bahamas, Mexico, Guyana, and Chile.

U.S. imports of crushed stone in 1970 amounted to 3.3 million tons valued at $5.9 million. Nearly all of the imported stone consisted of chips, spalls, and crushed or ground material. The remainder was rough, irregular pieces of broken stone. Canada was the principal source of the imports.

WORLD REVIEW

Bahama Islands.—The U.S. Department of State reported the passage by the Bahamian Government of a law encouraging the mining of aragonite by Ocean Industries Inc. of Fort Lauderdale, Fla. The law is unique in that it levies an operations tax on net profits of the company. Commercial development of the underwater aragonite deposits began after 5 years of intensive processing and marketing studies.[23] Conventional undersea mining methods are being employed to extract the aragonite.

Canada.—One of the most unusual and versatile crushed stone plants in Canada is that of Haverlock Lime Works, Ltd., at Haverlock, New Brunswick.[24] The company operates a new modern crushed stone plant, three agricultural-limestone-producing plants, and a pulverizing limestone plant that produces a wide variety of special products. New Brunswick is also the location of one of Canada's largest agricultural limestone producers, Brookville Manufacturing Co., Ltd., Brookville, New Brunswick.[25] The company, a pioneer agricultural stone producer in the Maritime Provinces, also produces aggregate stone and fertilizer filler stone.

Finland.—One of the largest limestone mining operations in Finland is located at Lohja, approximately 40 miles west of Helsinki.[26] About two-thirds of the 1-million-tons-a-year output is consumed as cement plant feed.

South Africa, Republic of.—Northern Lime Co., Ltd., reported increased sales and profits as a result of fuller utilization of its Silver Streams plant capacity.[27] The company produces limestone, unslaked lime, hydrated lime, and road lime; end uses cover a wide field that ranges from steel refining to agriculture. Richard's Bay Quarries (Pty) Ltd., Natal, commenced development of a dolerite property near Empangeni.[28] The company has been granted a renewable 25-year operating charter.

Sweden.—A major step was taken to solve the problem of environmental pollution inherent in stone-crushing plants.[29] Two firms, A. B. Mataki and Trelleborgs Gummifabriks, A. B., decided to sell all machinery in rubber in order to eliminate dust and reduce noise levels in its new crushing plant. Dust was virtually eliminated, and A. B. Mataki says it now needs only a tenth of the usual ventilation capacity.

TECHNOLOGY

Using special plastic materials that can greatly increase the strength of rock, scientists of the U.S. Bureau of Mines are working to develop a system that may ultimately make walls and roofs of mine tunnels completely self-supporting. Considerably more laboratory work is needed before any system employing the high-strength plastic can be readied for testing under actual conditions. Present testing involves impregnating rock specimens with a highly fluid form of plastic, which is forced into cracks, joints, and pores. In a subsequent step, heat is applied, in the presence of catalysts, which causes the molecules of

[23] Schmitz, Richard C., and William T. Aldrich. Underwater Mining of Aragonite Sands in the Bahamas. Marine Tech. Soc. 6th Annual Preprints, v. 2, 1970, 9 pp.

[24] Pit and Quarry. Haverlock (N.B.) Lime Works, Ltd., Continues Steady Growth. V. 62, No. 12, June 1970, p. 112.

[25] Trauffer, Walter E. Pioneer New Brunswick Agstone Producer Expands. Pit and Quarry, v. 62, No. 11, May 1970, p. 116.

[26] Gustafsson, Caj-Erik. Finns Quarry Limestone From Under Lake. Rock Products, v. 73, No. 4, April 1970, pp. 50–55.

[27] South African Mining Engineering Journal. In the N.W. Cape—Limestone Is Big Business, Part I. V. 81, No. 4013, January 1970, pp. 5–6.

[28] Holz, Peter. Nekwane – Natal's Largest Quarry. Pit and Quarry, v. 62, No. 8, February 1970, pp. 118–119.

[29] Pit and Quarry. Dust- and Sound-Proof Stone-Crushing Plant Protects Workers and Environment. V. 62, No. 8., February 1970, p. 134.

the plastic to link up into large complex molecules or polymers.

A two-way radio system was used by the United States Steel Corp. at its limestone quarry as means of keeping the complex operating at peak efficiency.[30] The principal effect of the system is to reduce downtimes resulting from mechanical failures, and to coordinate haulage and production equipment. Limestone was successfully and economically sorted electronically in a pilot installation at Colwyn Bay, North Wales.[31] Reduction of hauling costs was accomplished by using portable crushing and screening plants in supplying paving aggregates and crushed stone for road projects.[32]

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[30] Pit and Quarry. Two-Way Radio Speeds Communications at U.S. Steel Limestone Quarry. V. 62, No. 11, May 1970, pp. 150–151.

[31] Rock Products. Sorting Limestone Electronically. V. 73, No. 3, March 1970, pp. 76–79.

[32] Roads and Streets. Portability Means Profits to Road Stone Producer. V. 113, No. 10, October 1970, pp. 78–79.

Table 2.—Stone shipped or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1969 Quantity	1969 Value	1970 Quantity	1970 Value
Alabama	19,854	$37,512	[1] 19,882	[1] $37,166
Alaska	1,954	3,902	6,470	10,014
Arizona	2,827	5,812	3,511	7,094
Arkansas	16,463	23,134	15,284	22,786
California	38,033	57,757	46,399	66,950
Colorado	2,245	5,079	3,552	8,076
Connecticut	7,562	15,325	8,338	16,915
Florida [1]	42,332	56,611	43,089	61,302
Georgia	27,755	59,451	26,635	59,200
Hawaii	6,534	16,059	[1] 6,332	[1] 15,538
Idaho	3,750	6,426	[1] 4,240	[1] 6,368
Illinois	54,857	81,318	55,776	86,502
Indiana	25,559	45,400	25,818	45,215
Iowa	26,233	40,895	25,305	41,119
Kansas	15,828	22,645	15,161	22,406
Kentucky	[1] 30,158	[1] 44,644	29,311	[1] 45,208
Louisiana [1]	9,237	11,892	9,059	11,660
Maine	1,101	3,798	W	[1] 2,311
Maryland	15,067	30,504	16,015	32,783
Massachusetts	7,847	22,521	[1] 8,008	24,349
Michigan	39,186	43,572	41,687	49,501
Minnesota	5,035	14,253	4,579	[1] 7,000
Mississippi	W	W	W	W
Missouri	41,977	63,251	39,726	[1] 57,285
Montana	7,667	10,579	[1] 6,501	[1] 6,896
Nebraska	4,665	9,494	4,265	7,378
Nevada	1,494	2,433	1,860	2,722
New Hampshire	320	2,888	W	[1] 845
New Jersey	15,162	34,034	[1] 15,160	[1] 40,567
New Mexico	2,826	3,286	[1] 3,100	[1] 4,030
New York	37,561	66,839	37,616	68,118
North Carolina	26,812	47,829	30,363	54,121
North Dakota	72	99	103	126
Ohio	51,792	86,570	47,244	81,506
Oklahoma	18,799	23,650	18,177	23,701
Oregon	11,662	18,897	13,439	20,948
Pennsylvania	66,992	117,726	[1] 66,119	120,187
Rhode Island	W	1,417	W	W
South Carolina	8,846	13,506	9,710	[1] 14,734
South Dakota	2,092	10,839	1,979	13,375
Tennessee	33,265	46,192	35,374	50,013
Texas	[r] 46,632	[r] 64,886	45,557	64,422
Utah	2,582	4,434	1,650	4,320
Vermont	2,151	19,810	1,514	19,088
Virginia	33,461	58,713	35,415	60,477
Washington	15,742	21,069	13,701	19,100
West Virginia [1]	9,031	15,801	9,740	16,722
Wisconsin	18,954	27,571	17,577	25,167
Wyoming	1,584	3,012	1,266	2,758
Undistributed	1,331	1,260	2,906	16,850
Total [2]	[r] 862,889	[r] 1,424,594	874,512	1,474,917
Pacific Island Possessions	717	1,552	678	1,375
Panama Canal Zone	74	231	85	265
Puerto Rico	6,985	13,550	7,296	13,947
Virgin Islands	411	1,682	514	2,226

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] To avoid disclosing individual company data, certain State totals are incomplete, the portion not included has been combined with "Undistributed." The class of stone omitted from such State totals is noted in the summary chapter of this volume.

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

Table 3.—Stone shipped or used by producers in the United States, by kinds

(Thousand short tons and thousand dollars)

Year	Granite Quantity	Granite Value	Traprock[1] Quantity	Traprock[1] Value	Marble Quantity	Marble Value	Limestone and dolomite Quantity	Limestone and dolomite Value	Shell Quantity	Shell Value
1966	65,888	$128,558	88,623	$147,594	2,244	$36,203	569,577	$794,279	21,662	$32,783
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	r 2,342	r 34,689	628,937	937,179	19,731	27,933
1970	86,709	183,312	77,227	146,661	1,785	33,734	625,796	961,013	21,713	31,035

Year	Calcareous marl Quantity	Calcareous marl Value	Sandstone, quartz, and quartzite Quantity	Sandstone, quartz, and quartzite Value	Slate Quantity	Slate Value	Other stone[2] Quantity	Other stone[2] Value	Total[3] Quantity	Total[3] Value
1966	1,358	1,195	27,493	57,037	1,356	13,680	35,173	49,386	813,374	1,260,715
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	r 862,889	r 1,424,594
1970	1,739	1,554	24,059	59,185	1,241	13,367	34,244	45,056	874,512	1,474,917

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	1969 Short tons	1969 Cubic feet	1969 Value	1970 Short tons	1970 Cubic feet	1970 Value
GRANITE						
Rough:						
Architectural	28	326	$965	43	497	$1,255
Construction [1]	130	1,403	1,282	55	692	535
Monumental	201	2,155	12,333	200	2,386	17,160
Uses not specified [2]	4	50	23	3	25	17
Dressed:						
Cut	55	607	11,146	54	630	10,109
Sawed [3]	4	47	602	7	87	875
House stone veneer	5	57	138	7	74	602
Construction	14	170	1,101	19	234	1,774
Monumental	56	650	11,429	25	298	7,317
Curbing	190	1,973	5,666	159	1,870	5,762
Flagging	(4)	4	11	W	W	W
Paving blocks	6	67	161	W	W	W
Other dressed stone [5]	------	------	------	5	55	111
Total [6]	692	7,510	44,858	577	6,847	45,517
LIMESTONE AND DOLOMITE						
Rough:						
Architectural	224	2,643	4,262	161	2,081	3,402
Construction [1]	81	1,035	1,039	67	830	714
Flagging [7]	18	233	239	18	225	150
Other rough stone	------	------	------	6	77	39
Dressed:						
Cut	67	872	6,085	76	996	5,897
Sawed	64	813	2,734	47	611	2,194
House stone veneer	78	1,003	2,409	68	871	2,048
Construction [8]	13	166	435	13	154	453
Flagging	3	37	54	1	18	30
Other uses not listed	26	304	W	27	335	W
Total [6]	574	7,106	17,256	482	6,197	14,926
MARBLE						
Rough:						
Architectural	8	93	390	10	111	456
Construction [1]	W	W	W	W	W	W
Other rough stone [9]	10	123	93	3	33	72
Dressed:						
Cut	24	280	7,331	23	274	7,659
Sawed	8	100	1,407	8	92	1,485
House stone veneer						
Construction	[10] 20	233	3,468	20	237	3,381
Monumental						
Total [6]	r 71	r 829	r 12,689	63	746	13,053
SANDSTONE, QUARTZ, AND QUARTZITE						
Rough:						
Architectural	29	389	521	43	562	673
Construction [1]	92	1,238	1,340	83	1,132	1,178
Flagging [11]	20	207	W	18	223	W
Dressed:						
Cut	77	1,055	3,831	58	764	3,873
Sawed [12]	64	824	2,664	56	732	2,161
Flagging [13]	28	343	1,054	30	372	1,067
Other uses not listed or unspecified	2	32	1,569	4	52	1,706
Total [6]	311	4,088	10,979	291	3,837	10,658
SLATE						
Roofing slate [14]	16	------	1,698	22	------	1,842
Millstock:						
Structural and sanitary	18	------	2,734	18	------	3,137
Blackboards, etc.[15]	r 3	------	866	2	------	652
Total	21	------	3,600	20	------	3,789
Flagging	40	------	1,235	39	------	1,160
Other uses not listed or unspecified	64	------	2,679	18	------	1,897
Total	[6] 142	------	9,212	99	------	8,688

See footnotes at end of table.

Table 4.—Dimension stone shipped or used by producers in the United States, by use and kind of stone—Continued

(Thousands)

Kind of stone and use	1969 Short tons	1969 Cubic feet	1969 Value	1970 Short tons	1970 Cubic feet	1970 Value
OTHER STONE [16]						
Rough:						
Architectural	9	111	$86	W	W	$30
Construction [1]	39	469	484	27	337	365
Other rough stone [17]	1	7	21	W	W	W
Dressed:						
Cut [18]	2	22	W	1	24	W
House stone veneer	1	r 11	24	W	W	W
Construction [19]	5	62	W	5	76	W
Flagging	8	86	141	W	W	W
Total [6] [20]	65	767	2,682	43	543	2,044
TOTAL STONE						
Rough:						
Architectural	300	r 3,569	6,257	259	3,287	5,839
Construction [1]	r 350	r 4,257	r 4,261	239	3,086	2,908
Monumental	201	2,158	12,343	200	2,391	17,173
Flagging	37	419	886	34	428	903
Other rough stone [21]	13	158	133	10	128	100
Dressed:						
Cut	225	2,845	29,122	212	2,685	27,661
Sawed	118	1,515	6,822	89	1,162	5,946
House stone veneer	118	1,476	4,510	111	1,401	4,411
Construction	30	371	1,383	36	446	2,081
Roofing (slate) [14]	16	------	1,698	22	------	1,842
Millstock (slate)	21	------	3,600	20	------	3,789
Monumental	64	739	13,348	32	378	9,302
Curbing	191	1,996	5,741	161	1,886	5,822
Flagging	81	494	2,539	81	516	2,522
Miscellaneous uses [22]	103	458	5,904	58	506	4,857
Total [6]	r 1,867	r 20,455	r 98,547	1,565	18,299	95,157

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes irregularly shaped stone and rubble.
[2] Includes minor amount of flagging and other rough stone.
[3] Includes other uses not listed.
[4] Less than ½ unit.
[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] 1969 data includes small amounts of monumental and other rough stone; only small amount of monumental included in 1970.
[8] To avoid disclosing confidential data, figure shown includes value data for "Other uses not listed."
[9] Includes minor amount of flagging for 1969; also, construction stone for both years to avoid disclosing individual company confidential data.
[10] Data combined to avoid disclosing confidential data; also includes flagging and other uses not listed.
[11] Quantity data includes small amounts of other rough stone and monumental (1970); also, value figures withheld to avoid disclosing confidential data and 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 1970 in order of value of output and with number of quarries: Virginia (2); Maryland (3); New Jersey (1); Pennsylvania (4); Hawaii (2); California (7); West Virginia (1); Oregon (2); New Mexico (1); and Washington (4).
[17] Includes minor amount of rough stone used for flagging.
[18] Includes sawed stone.
[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.
[21] Includes 1969 data for unspecified uses of rough stone.
[22] Data includes stone used for paving blocks; structural and sanitary purposes (excluding slate); and other uses not listed or unspecified.

Table 5.—Granite (dimension stone) shipped or used by producers in the United States in 1970, by States

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
California	9	4,890	$515	South Carolina	5	11,604	W
Connecticut	4	W	71	South Dakota	7	63,167	$10,409
Georgia	26	137,961	5,267	Wisconsin	15	7,385	2,057
New York	4	18,771	776	Other States [1]	67	320,297	24,881
Oklahoma	8	8,949	1,014				
Oregon	2	295	W	Total [2]	148	576,519	45,517
Rhode Island	1	3,200	528	Puerto Rico	3	16,200	49

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes quarries in Colorado (3), Maine (2), Massachusetts (7), Minnesota (16), Missouri (1), New Hampshire (2), New Mexico (4), North Carolina (16), Pennsylvania (4), Texas (3), Vermont (7), and Washington (2).
[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 1970, by States

State	Active quarries [1]	Short tons	Value (thousands)	State	Active quarries [1]	Short tons	Value (thousands)
California	3	27,067	W	New York	1	500	W
Illinois	4	12,541	$126	Ohio	8	11,609	$142
Indiana	31	273,394	9,433	Oklahoma	3	1,550	23
Iowa	8	11,405	W	Wisconsin	39	67,119	1,263
Kansas	7	21,089	441	Other States [2]	13	37,797	1,932
Michigan	3	W	37				
Minnesota	5	14,399	1,483	Total	129	482,363	14,926
Missouri	3	3,473	43	Puerto Rico	11	101,200	292
Nebraska	1	420	3				

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-third of stone.
[2] Includes quarries in Alabama (1), Colorado (2), Florida (1), Rhode Island (1), South Dakota (1), Texas(5), and Virginia (2).

Table 7.—Sandstone, quartz, and quartzite, (dimension stone) shipped or used by producers in the United States in 1970, by States

State	Active quarries [1]	Short tons	Value (thousands)	State	Active quarries [1]	Short tons	Value (thousands)
Arizona	44	11,406	$186	Ohio	17	77,904	$3,476
Arkansas	4	6,293	129	Pennsylvania	26	54,926	1,255
Colorado	49	11,094	221	South Dakota	8	65	2
Connecticut	3	4,280	62	Tennessee	4	7,041	285
Indiana	6	6,314	154	Utah	4	2,953	104
Maryland	5	18,860	329	Virginia	3	2,449	W
Michigan	1	1,000	10	Other States [2]	45	40,850	2,456
Missouri	2	1,340	W				
New York	11	43,041	1,963	Total	234	291,066	10,658
North Carolina	2	1,250	26				

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-third of stone.
[2] Includes quarries in California (5), Georgia (3), Kansas (1), Massachusetts (2), Minnesota (1), Montana (2), New Jersey (1), New Mexico (8), Texas (1), Washington (2), West Virginia (1), and Wisconsin (18).

Table 8.—Crushed and broken stone shipped or used by producers in the United States, by kind of stone and use

(Thousand short tons and thousand dollars)

Kind of stone and use	1969		1970	
	Quantity	Value	Quantity	Value
CALCAREOUS MARL [1]				
Agricultural purposes [2]	141	$124	178	$181
Surface treatment aggregates	3	2	3	2
Cement manufacture [3]	2,346	2,391	1,558	1,372
Total [4]	2,490	2,516	1,739	1,554
GRANITE				
Agricultural purposes [5]	68	486	W	875
Concrete aggregate (coarse)	12,953	19,273	16,127	24,465
Bituminous aggregate	6,847	11,375	11,945	20,326
Macadam aggregates	2,208	3,680	2,820	4,207
Dense-graded road-base stone	34,428	54,429	28,162	46,072
Surface treatment aggregates	4,124	6,605	4,477	7,172
Unspecified construction aggregate and roadstone	6,531	8,016	12,609	19,569
Riprap and jetty stone	2,587	4,609	2,275	4,621
Railroad ballast	3,532	4,960	4,513	6,356
Filter stone	103	206	W	W
Manufactured fine aggregate (stone sand)	[6] 668	[6] 734	W	W
Special uses and products	250	W	------	------
Fill	136	123	W	W
Other uses	[7] 754	[7] 1,492	[8] 3,205	[8] 4,131
Uses not listed or unspecified	W	113	W	W
Total [4]	75,189	116,102	86,133	137,795
LIMESTONE AND DOLOMITE				
Agricultural purposes [5]	35,011	62,805	37,945	70,483
Concrete aggregate (coarse)	89,501	139,685	95,879	154,730
Bituminous aggregate	46,429	70,285	42,312	70,082
Macadam aggregates	23,422	34,730	24,573	37,390
Dense-graded road-base stone	142,271	188,966	124,897	171,019
Surface treatment aggregates	38,808	55,884	35,567	52,550
Unspecified construction aggregate and roadstone	53,641	78,680	57,694	89,118
Riprap and jetty stone	11,639	15,091	11,560	14,277
Railroad ballast	6,173	7,982	6,387	8,583
Filter stone	686	1,382	747	1,636
Manufactured fine aggregate (stone sand)	2,815	4,753	3,116	5,100
Terrazzo and exposed aggregate	164	984	82	767
Cement manufacture	97,632	108,992	95,946	104,928
Lime manufacture	29,565	53,248	25,989	47,440
Dead-burned dolomite	2,935	4,626	1,990	3,262
Ferrosilicon	148	202	714	1,032
Flux	30,360	45,673	29,462	45,262
Refractory	419	1,028	374	1,023
Chemical stone for alkali works	3,273	5,641	4,215	7,533
Special uses and products [9]	3,373	21,539	3,575	21,636
Fill	[r] 4,102	[r] 2,955	3,706	2,727
Glass	992	3,133	1,156	3,823
Other uses [10]	[r] 2,297	[r] 5,384	8,541	19,284
Uses not listed or unspecified	2,707	6,276	8,886	12,406
Total [4]	628,362	919,923	625,313	946,087
MARBLE				
Agricultural purposes [5]	W	W	72	247
Concrete aggregate (coarse)				
Dense-graded road-base stone				
Surface treatment aggregates				
Unspecified construction aggregate and roadstone	[11] 793	[11] 5,209	[11] 446	[11] 2,418
Riprap and jetty stone				
Filter stone				
Manufactured fine aggregate (stone sand)				
Terrazzo and exposed aggregate			157	2,436
Cement manufacture	W	W	------	------
Special uses and products [9]	[5] 1,378	[5] 15,678	966	14,564
Other uses	[12] 64	[12] 679	[13] 53	[13] 803
Uses not listed or unspecified	36	434	27	213
Total	2,271	22,000	[4] 1,722	20,681
SANDSTONE, QUARTZ, AND QUARTZITE [14]				
Concrete aggregate (coarse)	2,818	4,689	2,709	4,313
Bituminous aggregate	2,536	5,109	2,282	4,886
Macadam aggregates	358	530	429	578
Dense-graded road-base stone	8,703	12,722	8,082	12,902

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1969 Quantity	1969 Value	1970 Quantity	1970 Value
SANDSTONE, QUARTZ, AND QUARTZITE [14]—Continued				
Surface treatment aggregates	711	$1,279	510	$1,110
Unspecified construction aggregate and roadstone	3,006	5,716	2,871	5,123
Riprap and jetty stone	2,543	4,730	2,008	4,039
Railroad ballast	1,232	1,885	608	893
Filter stone	37	98	28	80
Manufactured fine aggregate (stone sand)	250	509	293	456
Terrazzo and exposed aggregate	71	1,240	75	1,370
Cement manufacture	994	1,244	698	1,053
Ferrosilicon [15]	254	1,172	337	1,473
Flux	896	3,574	870	3,370
Refractory	718	4,587	255	2,503
Special uses and products [9]	68	445	50	303
Other uses [16]	1,849	3,365	1,662	4,075
Uses not listed or unspecified	102	399	W	W
Total [4]	27,145	53,293	23,768	48,526
SHELL				
Concrete aggregate (coarse)	[17] 7,089	[17] 8,916	3,962	4,903
Dense-graded road-base stone	5,325	7,506	5,277	6,983
Other roadstone [18]	-------	-------	1,943	3,507
Cement manufacture	5,169	7,146	4,343	6,060
Lime manufacture	[19] 2,149	[19] 4,365	W	W
Other uses not listed	W	W	[20] 6,188	[20] 9,583
Total [4]	19,731	27,933	21,713	31,035
TRAPROCK				
Concrete aggregate (coarse)	8,343	18,332	9,702	20,894
Bituminous aggregate	10,999	21,622	12,047	25,059
Macadam aggregates	2,366	4,087	2,982	5,241
Dense-graded road-base stone	18,190	31,576	14,467	22,588
Surface treatment aggregate	8,488	12,226	9,042	13,314
Unspecified construction aggregate and roadstone	20,701	38,323	20,305	42,112
Riprap and jetty stone	2,603	5,071	1,983	3,704
Railroad ballast	1,350	2,119	1,496	2,430
Filter stone	104	195	W	W
Manufactured fine aggregate (stone sand)	91	313	162	W
Special uses and products [9]	133	312	W	W
Fill	[21] 5,534	[21] 3,321	1,941	1,651
Other uses	W	4,862	[22] 3,089	[22] 9,399
Total [4]	78,901	142,360	77,217	146,391
OTHER STONE				
Concrete aggregate (coarse)	737	1,478	869	1,498
Bituminous aggregates	2,770	4,813	2,453	4,797
Macadam aggregate	215	309	145	226
Dense-graded road-base stone	6,281	7,566	7,161	8,383
Surface treatment aggregates	469	567	1,301	1,761
Unspecified construction aggregate and roadstone	[23] 7,083	[23] 9,856	4,065	5,082
Riprap and jetty stone	3,962	5,721	14,338	16,653
Railroad ballast	[24] 1,654	[24] 1,270	2,027	1,968
Special uses and products [9]	[25] 411	[25] 839	65	65
Fill	1,659	W	1,107	1,120
Other uses [26]	524	4,881	670	1,331
Uses not listed or unspecified	W	W	W	131
Total [4]	25,766	37,301	34,201	43,013
TOTAL STONE				
Agricultural purposes [5]	35,881	67,066	38,985	74,786
Concrete aggregate (coarse)	120,805	191,872	129,532	211,411
Bituminous aggregate	69,580	113,205	71,554	126,013
Macadam aggregates	28,570	43,337	31,085	47,674
Dense-graded road-base stone	215,258	302,861	188,094	268,017
Surface treatment aggregates	52,692	76,692	50,938	75,971
Unspecified construction aggregate and roadstone	90,949	140,539	98,802	163,565
Riprap and jetty stone	23,334	35,222	32,178	43,317
Railroad ballast	13,841	18,091	15,032	20,229
Filter stone	975	1,926	838	1,828
Manufactured fine aggregate (stone sand)	3,899	6,684	4,081	8,298
Terrazzo and exposed aggregate	555	6,219	317	4,583
Cement manufacture	106,186	119,870	102,573	113,485
Lime manufacture	31,591	55,571	27,580	49,657
Dead-burned dolomite	2,995	5,016	2,050	3,652

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1969 Quantity	1969 Value	1970 Quantity	1970 Value
TOTAL STONE—Continued				
Ferrosilicon	342	$984	991	$2,115
Flux	31,257	49,247	30,332	48,632
Refractory	1,136	5,615	629	3,526
Chemical stone for alkali works	3,273	5,641	4,215	7,533
Special uses and products [9]	5,032	37,560	4,816	36,968
Fill	r 9,833	r 7,078	6,820	5,587
Glass	1,313	4,565	1,688	5,533
Other uses [27]	r 6,706	r 21,569	16,895	37,041
Uses not listed or unspecified	5,018	9,617	12,925	20,342
Total [4]	861,021	1,326,047	872,947	1,379,761

r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] Produced by the following States in 1970, in order of tonnage: South Carolina, Virginia, Texas, Mississippi, Michigan, Indiana, Minnesota, and Nevada.

[2] Includes marl used in agricultural limestone, other soil conditioners and nutrients, and a small amount of marl used in mineral fillers or extenders.

[3] Data includes small amount of fill and minor amounts of other uses not listed.

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

[5] Includes agricultural limestone, agricultural marl and other soil conditioners, and poultry grit and mineral food.

[6] Data include terrazzo and exposed aggregates.

[7] To avoid disclosing confidential data, includes quantity data for uses not listed or unspecified and value data for special uses and products.

[8] Includes stone used in terrazzo, cement, drain fields, roofing aggregate and minor amounts of other uses not listed, and any data represented by the symbol W in granite.

[9] Includes stone used for asphalt filler, other fillers, or extenders, and other uses in smaller quantities.

[10] Data includes some stone used for roofing aggregates, dam construction, chemicals, sugar refining, and other uses in smaller quantities.

[11] Data combined to avoid disclosing confidential data.

[12] Data include cement.

[13] Data include some stone used for roofing aggregates and other uses in smaller quantities.

[14] Includes ground sandstone, quartz, and quartzite.

[15] Includes small amount of dead-burned dolomite.

[16] Includes stone used for agricultural purposes, dam construction, roofing aggregates, fill, glass, and other uses in smaller quantities, and any data represented by the symbol W in sandstone, quartz, and quartzite.

[17] Includes asphalt filler and uses not specified.

[18] Includes bituminous, macadam, surface treatment, and unspecified aggregate and roadstone, and a smaller amount of riprap and jetty stone.

[19] Includes agricultural purposes.

[20] Includes stone used for agricultural purposes, asphalt fill and other uses not listed and unspecified; also, any data represented by the symbol W included in shell.

[21] To avoid disclosing confidential data, figure includes data for uses not listed; also includes quantity data for other uses.

[22] Includes stone used for agricultural purposes, drain fields, roofing aggregates, and other uses in smaller quantities. To avoid disclosing confidential data, figure includes filter stone, special uses and products, uses not listed, and the value data of manufactured fine aggregate.

[23] Includes cement and a small amount of flux stone.

[24] Includes filter stone, manufactured fine aggregate, and a small amount of terrazzo and exposed aggregate.

[25] Includes agricultural limestone and uses not listed or unspecified.

[26] Includes stone used for agricultural purposes, cement, roofing aggregates, other uses in smaller quantities, and, to avoid disclosing confidential data, quantity data for uses not listed or unspecified. To avoid disclosing confidential data, 1969 value figure includes value data for fill.

[27] Data includes roofing aggregates, dam construction, 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)	1969 Number of quarries	1969 Production Thousand short tons	1969 Production Percent of total	1970 Number of quarries	1970 Production Thousand short tons	1970 Production Percent of total
Less than 25,000	1,753	15,354	1.8	1,656	14,840	1.7
25,000 to 49,999	606	22,397	2.6	538	19,205	2.2
50,000 to 74,999	334	20,611	2.4	352	21,824	2.5
75,000 to 99,999	265	22,639	2.6	267	22,697	2.6
100,000 to 199,999	636	89,328	10.4	614	87,295	10.0
200,000 to 299,999	267	65,641	7.6	278	68,090	7.8
300,000 to 399,999	239	82,661	9.6	224	76,819	8.8
400,000 to 499,999	163	73,236	8.5	159	71,582	8.2
500,000 to 599,999	84	45,517	5.3	102	55,869	6.4
600,000 to 699,999	78	50,639	5.9	71	46,266	5.3
700,000 to 799,999	74	55,109	6.4	59	43,647	5.0
800,000 to 899,999	40	33,709	3.9	49	41,901	4.8
900,000 and over	172	284,182	33.0	181	302,913	34.7
Total [1]	4,711	861,021	100.0	4,550	872,947	100.0

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

Table 10.—Crushed stone shipped or used in the United States, by methods of transportation

Method of transportation	1969		1970	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	616,745	72	639,260	73
Rail	97,107	11	89,646	11
Waterway	75,343	9	79,572	9
Other	39,768	4	27,341	3
Unspecified	32,059	4	37,128	4
Total	[1] 861,021	100	872,947	100

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

Table 11.—Granite (crushed and broken stone) shipped or used by producers in the United States in 1970, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arkansas	3,957	$5,274	North Carolina	24,251	$39,741
California	4,526	7,630	South Carolina	7,112	10,914
Colorado	103	164	Virginia	10,675	18,290
Georgia	21,013	32,706	Washington	271	304
Idaho	2,753	W	Wisconsin	973	409
Maryland	584	W	Wyoming	W	77
Minnesota	491	943	Other States [1]	6,756	16,119
Montana	3	W			
Nevada	302	240	Total [2]	86,133	137,795
New Jersey	2,352	4,972	Puerto Rico	254	542
New Mexico	9	11			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alaska, Arizona, Connecticut, Maine, Massachusetts, Michigan, Missouri, New Hampshire, New York, 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 1970, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	83	$253	Oregon	12,234	$18,786
Arizona	418	W	Pennsylvania	3,844	8,147
California	2,216	2,998	South Dakota	3	8
Connecticut	7,408	13,678	Virginia	3,385	6,057
Hawaii	4,752	11,803	Washington	12,290	15,457
Idaho	516	782	Wisconsin	846	1,828
Maryland	5,260	10,965	Other States [1]	4,895	10,890
Massachusetts	4,872	9,625			
Michigan	10	18	Total [2]	77,217	146,391
Minnesota	62	124	Pacific Island Possessions	W	W
New Jersey	12,064	31,977	Panama Canal Zone	85	265
New Mexico	351	522	Virgin Islands	514	2,226
North Carolina	1,708	2,472			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Colorado, Illinois, Maine, Missouri, Montana, New Hampshire, New York, and Texas.
[2] Data may not add to totals shown because of independent rounding.

Table 13.—Limestone and dolomite (crushed and broken) shipped or used by producers in the United States in 1970, by States and uses

(Thousand short tons and thousand dollars)

State	Agriculture [1]		Aggregates		Riprap		Railroad ballast		Fluxing stone		Miscellaneous and undistributed		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,255	$2,772	7,678	$9,847	W	W	W	W	931	$1,602	6,753	$8,806	17,616	$23,026
Alaska	-------	-------	-------	-------	W	W	-------	-------	-------	-------	W	W	W	W
Arizona	W	W	107	173	-------	-------	-------	-------	166	349	2,035	3,419	2,308	3,941
Arkansas	588	1,274	2,958	6,165	W	W	-------	-------	W	W	2,708	1,927	6,254	9,366
California [3]	138	876	2,123	1,888	-------	-------	-------	-------	96	165	15,030	19,852	17,386	22,780
Colorado	34	W	415	700	W	W	W	W	432	1,294	1,352	2,947	2,233	4,941
Connecticut	66	355	-------	-------	-------	-------	-------	-------	W	W	W	W	W	W
Florida	375	1,353	30,742	43,702	-------	-------	120	$165	-------	-------	8,973	9,957	40,210	55,176
Georgia	445	W	2,661	5,373	-------	-------	-------	-------	-------	-------	1,301	3,213	4,407	8,586
Hawaii	25	107	628	2,267	(4)	$1	-------	-------	-------	-------	548	728	1,200	3,104
Idaho	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	W	W	W	W
Illinois	4,131	6,845	43,674	67,405	712	949	647	954	929	1,317	5,589	8,759	55,683	86,230
Indiana	1,980	3,422	19,438	27,393	136	454	434	591	35	52	3,485	3,684	25,508	35,597
Iowa	1,962	4,260	18,208	29,635	197	336	W	W	W	W	4,927	6,605	25,293	40,835
Kansas	861	1,274	10,053	15,517	716	809	W	W	-------	-------	2,922	3,576	14,552	21,176
Kentucky	1,883	3,303	22,068	34,682	W	3,618	404	560	-------	-------	4,906	3,045	29,261	45,208
Maine	W	W	382	1,068	-------	-------	-------	-------	-------	-------	W	W	W	W
Maryland	89	234	7,495	12,653	W	W	W	W	W	W	2,351	5,383	9,935	18,269
Massachusetts [5]	74	W	W	W	-------	-------	-------	-------	W	W	53	W	127	W
Michigan [6]	501	699	6,946	12,267	W	W	W	W	9,909	17,121	18,034	19,037	35,390	49,124
Minnesota [3]	217	408	2,581	3,602	W	W	W	W	(4)	1	130	181	2,928	4,191
Mississippi	W	W	-------	-------	-------	-------	-------	-------	-------	-------	W	W	W	W
Missouri	3,342	5,619	22,035	31,376	3,519	3,317	36	49	W	W	10,149	15,310	39,081	55,670
Montana	-------	-------	417	312	11	18	-------	-------	W	W	1,356	1,620	1,783	1,950
Nebraska	316	1,296	2,167	4,079	757	1,172	-------	-------	-------	-------	1,024	828	4,264	7,375
Nevada	-------	-------	96	72	-------	-------	-------	-------	117	291	W	W	W	W
New Jersey	254	1,591	140	383	-------	-------	-------	-------	W	W	W	W	W	W
New Mexico	-------	-------	774	717	9	10	-------	-------	18	W	481	949	1,282	1,675
New York	500	1,747	23,762	44,758	144	330	198	362	W	W	8,930	9,522	33,535	56,718
North Carolina	W	W	1,357	2,307	W	W	-------	-------	-------	-------	W	W	W	W
North Dakota	-------	-------	-------	-------	W	W	-------	-------	-------	-------	W	W	W	W
Ohio	1,825	3,564	28,409	43,712	339	489	991	1,337	3,911	6,084	10,645	20,353	46,120	75,538
Oklahoma [3]	W	W	6,355	7,764	144	183	W	W	-------	-------	9,814	12,514	16,314	20,462
Oregon	W	W	15	8	-------	-------	-------	-------	W	W	W	W	W	W
Pennsylvania [3]	1,633	5,159	31,894	49,864	110	173	272	389	5,328	10,302	14,955	24,405	54,192	90,292
Rhode Island	W	W	-------	-------	-------	-------	-------	-------	W	W	W	W	W	W
South Carolina	W	W	802	1,288	W	W	-------	-------	W	W	1,330	2,078	2,131	3,365
South Dakota	W	W	556	603	W	W	W	W	-------	-------	487	449	1,043	1,052
Tennessee [3]	2,716	3,805	24,709	33,669	88	107	W	W	W	W	7,664	10,931	35,177	48,512
Texas [3]	274	369	25,253	36,593	133	185	W	W	303	447	9,266	12,079	35,229	49,673
Utah [3]	W	W	105	165	-------	-------	-------	-------	W	W	1,059	2,197	1,164	2,361
Vermont [3]	69	307	721	946	-------	-------	-------	-------	-------	-------	186	2,466	976	3,719
Virginia	1,235	2,253	11,967	17,392	19	32	430	585	546	816	5,234	8,915	19,432	29,992

Washington [3]	10	41	-------	-------	1	2	-------	-------	W	W	729	957	740	999
West Virginia [3]	85	198	3,685	5,840	1	W	636	690	W	W	2,847	5,483	7,255	12,210
Wisconsin	797	1,436	13,859	16,515	90	259	W	W	28	36	548	813	15,321	19,060
Wyoming	-------	-------	40	83	W	W	W	W	-------	-------	596	1,243	636	1,326
Total	28,680	54,567	377,275	572,783	7,126	12,444	4,168	5,682	22,749	39,877	168,397	234,231	605,966	913,499
Undistributed	9,266	15,917	3,648	2,107	4,434	1,835	2,219	2,903	6,711	5,357	16,919	26,504	19,346	32,588
Pacific Island Possessions	-------	-------	647	1,320	7	10	-------	-------	-------	-------	21	22	675	1,352
Puerto Rico	44	128	2,692	7,097	-------	-------	-------	-------	-------	-------	2,813	2,553	5,549	9,777

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.
3 Limestone only; dolomite included with "Undistributed."
4 Less than ½ unit.
5 Dolomite quantity only; other data included with "Undistributed."
6 Limestone quantity only; dolomite quantity included with "Undistributed."

Table 14.—Shell shipped or used by producers in the United States in 1970, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value
Florida	2,339	$4,223
Louisiana	9,059	11,660
Washington	58	15
Other States [1]	10,258	15,138
Total [2]	21,713	31,035

[1] Includes Alabama, California, Maryland, North Carolina, Pennsylvania, Texas, and Virginia.
[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 1970, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value
Indiana	23	$23
Michigan	144	141
Minnesota	W	9
Other States [1]	1,572	1,380
Total [2]	1,739	1,554

[1] Includes Mississippi, Nevada, South Carolina, Texas, and Virginia.
[2] Data may not add to totals shown because of independent rounding.

Table 16.—Sandstone, quartz, and quartzite (crushed and broken stone) shipped or used by producers in the United States in 1970, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	W	W	Pennsylvania	4,404	$8,865
Arkansas	4,920	$6,747	South Dakota	844	1,804
California	3,883	8,090	Texas	2,166	3,583
Colorado	175	420	Utah	182	804
Illinois	1	3	Virginia	927	1,621
Kansas	457	W	Washington	229	1,527
Kentucky	50	W	West Virginia	600	1,406
Montana	310	512	Other States [1]	3,405	10,379
Ohio	1,035	2,350			
Oregon	182	416	Total [2]	23,768	48,526

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alabama, Arizona, Connecticut, Georgia, Idaho, Indiana, Maryland, Minnesota, Missouri, Nevada, New Hampshire, New Mexico, New York, North Carolina, Oklahoma, Tennessee, Wisconsin, and Wyoming.
[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 1970, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	2,453	W	Rhode Island	381	$599
Arizona	218	$321	South Dakota	20	50
California	17,396	20,059	Utah	180	439
Colorado	562	753	Washington	82	W
Hawaii	380	631	West Virginia	W	27
Kansas	131	101	Wyoming	545	805
Massachusetts	1,415	2,714	Other States [1]	6,011	10,587
New Mexico	994	1,501			
Oklahoma	1,298	1,045	Total [2]	34,201	43,013
Pennsylvania	2,134	3,381	Puerto Rico	1,272	2,962

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Arkansas, Idaho, Louisiana, Maryland, Missouri, Montana, Nevada, New York, North Dakota, Oregon, Tennessee, Texas, Vermont, and Virginia.
[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	
1968	102	$1,518	$849	1,297	$3,294	292	$3,278	$1,030
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

Table 19.—U.S. imports for consumption of stone and whiting, by classes

Class	1969 Quantity	1969 Value (thousands)	1970 Quantity	1970 Value (thousands)
Granite:				
Monumental, paving and building stone:				
Rough ---------- cubic feet --	178,442	$1,095	189,198	$1,147
Dressed, manufactured ---------- do ----	366,224	4,025	442,794	6,807
Not manufactured and not suitable for monumental, paving or building stone ---------- short tons --	755	25	656	13
Other, n.s.p.f ----------	---------	77	---------	141
Total ----------	---------	5,222	---------	8,108
Marble, breccia, and onyx:				
In block, rough or squared ---------- cubic feet --	38,638	333	37,465	389
Sawed or dressed over 2 inches thick ---------- do ----	3,416	38	15,560	129
Slabs and paving tiles ---------- superficial feet --	7,608,162	6,878	7,328,874	7,283
All other manufactures ----------	---------	5,214	---------	5,532
Total ----------	---------	12,463	---------	13,333
Travertine stone:				
Rough, unmanufactured ---------- cubic feet --	30,003	83	12,582	56
Dressed, suitable for monumental, paving and building stone ---------- short tons --	47,393	2,169	111,966	2,726
Other, n.s.p.f ----------	---------	51	---------	34
Total ----------	---------	2,303	---------	2,816
Limestone:				
Monumental, paving, and building stone:				
Rough ---------- cubic feet --	1,200	2	300	(1)
Dressed, manufactured ---------- short tons --	426	26	1,032	51
Crude, not suitable for monumental, paving, or building stone ---------- short tons --	19,752	72	19,250	78
Other, n.s.p.f ----------	---------	55	---------	47
Total ----------	---------	155	---------	176
Slate:				
Roofing ---------- square feet --	15,520	5	5,109	4
Other, n.s.p.f ----------	---------	2,876	---------	3,092
Total ----------	---------	2,881	---------	3,096
Quartzite ---------- short tons --	30,294	392	137,529	739
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures ----------	---------	251	---------	307
Stone, unmanufactured ---------- short tons --	38,849	147	6,145	107
Building stone, rough ---------- cubic feet --	3,867	8	3,799	5
Building stone, dressed ---------- short tons --	1,276	21	1,389	67
Other ----------	---------	r 1,478	---------	1,802
Total ----------	---------	1,905	---------	2,288
Stone, chips, spalls, crushed or ground:				
Marble, breccia and onyx chips ---------- short tons --	5,062	97	10,284	197
Limestone, chips and spalls, crushed or ground short tons --	1,720,936	3,254	1,649,484	2,943
Stone chips and spalls and stone crushed or ground, n.s.p.f ---------- short tons --	1,188,180	1,425	1,286,758	1,523
Slate chips and spalls and slate crushed or ground short tons --	22	(1)	54	4
Total ----------	2,914,200	4,776	2,946,580	4,667
Whiting:				
Whiting, dry, ground, or bolted ---------- short tons --	11,683	281	13,623	325
Chalk whiting, precipitated ---------- do ----	2,134	170	1,714	126
Total ----------	13,817	451	15,337	451
Grand total ----------	---------	r 30,548	---------	35,674

r Revised.
1 Less than ½ unit.

Sulfur and Pyrites

By Roland W. Merwin [1]

The U.S. production of native (Frasch) sulfur declined as a result of adverse market conditions and increased producers' stocks. However, increases in output of other types of sulfur resulted in a slight increase in total production of sulfur in all forms. Exports of sulfur declined because of increased competition in foreign markets. Total imports decreased. Imports from Mexico dropped sharply, but this was largely offset by imports of low-priced Canadian sulfur. Apparent consumption of sulfur in all forms decreased slightly. Sulfur prices continued to ease downward following the precipitous drop in 1969.

Table 1.–Salient sulfur statistics

(Thousand long tons, sulfur content)

	1966	1967	1968	1969	1970
United States production:					
Native	7,002	7,014	7,460	7,146	7,082
All forms	9,155	9,136	9,739	9,540	9,549
Exports, sulfur	2,373	2,193	1,602	1,551	1,433
Imports, pyrites and sulfur	1,674	1,639	1,712	1,795	1,667
Stocks Dec. 31: Producer, Frasch and recovered sulfur	2,704	1,954	2,790	3,461	4,038
Consumption, apparent, all forms [1]	9,145	9,301	9,007	9,171	9,132
World production:					
Sulfur, elemental	16,442	r 17,948	19,477	20,771	21,748
Pyrites	9,627	r 9,989	9,591	9,452	10,210

r Revised.
[1] Measured by quantity sold, plus imports, minus exports.

DOMESTIC PRODUCTION

Native Sulfur.—Native sulfur accounted for 74 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 1970, 19 Frasch mines produced sulfur; five of these were closed during the year. The producers and mines in Louisiana were Freeport Sulphur Co. at Garden Island Bay, Grand Isle, Grande Ecaille, and Lake Pelto; Jefferson Lake Sulphur Co. at Lake Hermitage; Texas Gulf Sulphur Co. at Bully Camp; Union Texas Petroleum at Sulpur (closed in February), and U.S. Oil of Louisiana, Ltd., at Chacahoula (closed in March). The producers and mines in Texas were Atlantic Richfield Co. at Fort Stockton; Duval Corp. at Fort Stockton (closed in April), Orchard Dome (closed in August), and Pecos; Jefferson Lake Sulphur Co. at Long Point Dome; Pan American Petroleum Corp. at High Island; and Texas Gulf Sulfur Co. at Boling Dome, Fannet Dome, Gulf (closed in December), Moss Bluff Dome, and Spindletop Dome.

Production of domestic Frasch sulfur continued to decline during 1970, and was 1 percent less than in 1969, and 5 percent lower than the alltime peak production in 1968. This reflected producers' efforts to overcome the current oversupply of this commodity.

Approximately 70 percent of domestic Frasch sulfur production was for domestic consumption, and 20 percent was for ex-

[1] Mining engineer, Division of Nonmetallic Minerals.

port. The remaining 10 percent was accounted for by increases and adjustments in producers' stocks.

There was a tendency to concentrate production in the larger low-cost mines to counteract the adverse effects of low sulfur prices. Five of the smaller high-cost mines were closed during the year, but the net effect on production was small. Their production during 1970 amounted to only 225,000 long tons, or 3 percent of the total for the year. For the final 12 months of their individual operations, they produced at the rate of 553,000 tons per year. The closures represented an apparent reduction in production potential of approximately 8 percent, based on the 1969–70 average annual production rates for all mines.

The 14 mines remaining in production at the end of 1970 increased their production over that of 1969 by 467,000 tons, or 7 percent, with half of the mines showing increases in their production rates and the other half registering decreases. Of these, the five largest mines, with production rates in excess of 500,000 tons each per year, accounted for 66 percent of the total Frasch sulfur production for the year. Three medium-sized mines, with production rates of more than 300,000 tons each per year, contributed an additional 16 percent of the year's production.

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Thousand long tons)

	1967		1968		1969		1970	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:								
Frasch-process mines	7,014	7,014	7,458	7,458	7,146	7,146	7,082	7,082
Other mines	1	(1)	3	2	-------	-------	-------	-------
Total	-------	7,014	-------	7,460	-------	7,146	-------	7,082
Recovered elemental sulfur	1,270	1,268	1,359	1,354	1,422	1,414	1,457	1,449
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,115	364	1,315	430	1,583	517	1,637	535
Other [2]	1,018	489	1,035	495	971	463	1,010	483
Total [3]	-------	9,136	-------	9,739	-------	9,540	-------	9,549

[1] Less than ½ unit.
[2] Pyrites combined with hydrogen sulfide and liquid sulfur dioxide to avoid disclosing individual company confidential data.
[3] Data may not add to totals shown because of independent rounding.

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]
1966	2,916	4,085	7,001	7,721	$201,292
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

[1] Data may not add to totals shown because of independent rounding.
[2] F.o.b. mine/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)
1966	557	143	557	143	$5
1967	568	284	568	284	3
1968	3,125	1,563	3,125	1,563	46
1969	-----	------	-----	------	------
1970	-----	------	-----	------	------

[1] California, Nevada, and Utah.

Two organizations accounted for approximately 79 percent of the domestic Frasch sulfur production during 1970. Freeport Sulphur Co., with four mines, reported production of approximately 3.3 million long tons.[2] Texas Gulf Suphur Co. reported that its six Frasch mines produced more than 2.3 million long tons of sulfur.[3] One of the mines was closed during 1970.

[2] Freeport Sulphur Co. Annual Report, 1970, p. 5.
[3] Texas Gulf Sulphur Co. Annual Report, 1970. Inner front cover.

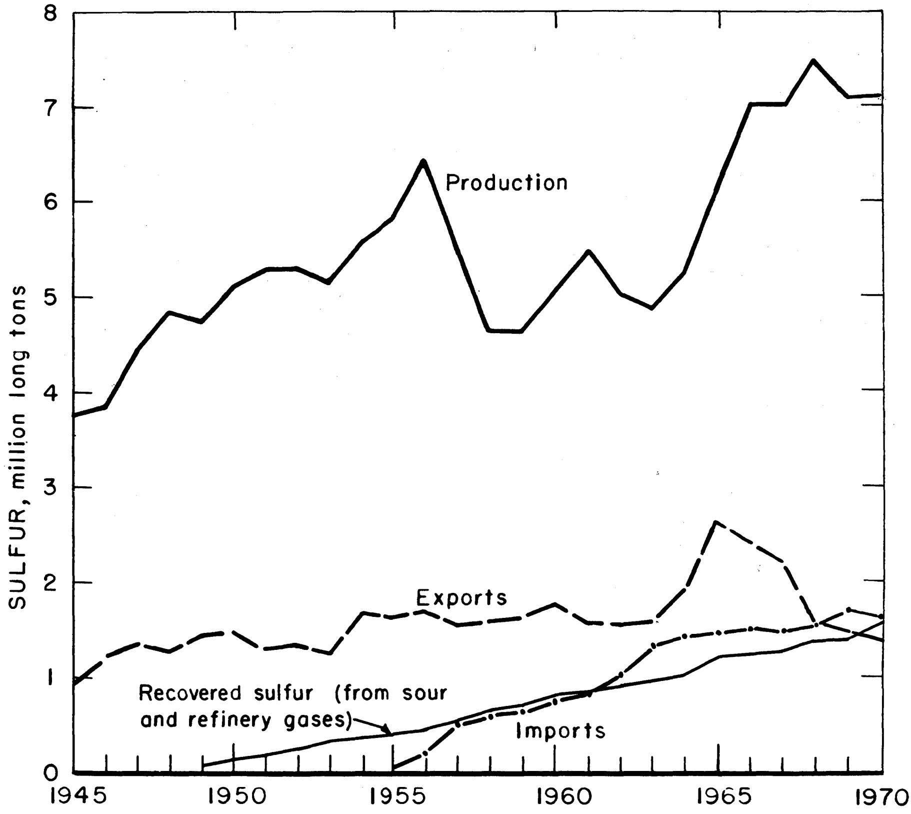

Figure 1.—Domestic Frasch and recovered sulfur production, and imports for consumption and exports of native sulfur.

Six other organizations, with a total of nine mines, accounted for the remainder of the domestic Frasch sulfur production. By the end of 1970, closures had reduced this to four producing companies with five mines. The 1970 output of these remaining five mines amounted to approximately 18 percent of the total domestic Frasch production.

Recovered Sulfur.—Production and shipments of recovered sulfur in 1970 reached alltime highs, with an increase of 2 percent and 4 percent, respectively, over those of 1969. Statistics on shipments of recovered sulfur and value for 1970 are as follows:

State	Quantity (long tons)	Value (thousands)
Arkansas	31,395	$819
California	208,647	4,792
Colorado	1,638	17
New Jersey	49,178	1,359
New Mexico	25,457	358
Pennsylvania	17,528	461
Texas	769,689	13,633
Wyoming	44,315	784
Other States [1]	315,397	8,500
Total [2]	1,463,244	30,725

[1] Combined to avoid disclosing individual company confidential data; includes Delaware, Illinois, Indiana, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Montana, North Dakota, Ohio, Oklahoma, and Virginia.
[2] Data may not add to totals shown because of independent rounding.

Elemental sulfur recovered from oil and gas operations accounted for 15 percent of the total domestic production of sulfur in all forms. It was produced at 99 plants in 21 States. The 10 largest of these plants accounted for 43 percent of the total.

The five largest producers of recovered sulfur were Cities Service Oil Co., Getty Oil Co., Pan American Petroleum Corp., Shell Oil Co., and Stauffer Chemical Co. Together, their 23 plants accounted for 43 percent of recovered sulfur production.

Shell Oil Co. announced plans to build a $10 million gas treatment and sulfur plant near Jackson, Miss. to produce elemental sulfur from a natural gas having a high hydrogen sulfide content. The rated capacity of the plant will be 1,250 long tons of sulfur per day. Upon expected completion of the plant in 1972, present domestic production of recovered sulfur will increase by approximately 30 percent.[4]

Byproduct Sulfuric Acid.—The sulfur contained in byproduct sulfuric acid produced at copper, lead and zinc roasters and smelters during 1970 amounted to 6 percent of the total domestic production of sulfur in all forms. It was produced at 18 plants in 14 States. The five largest of these plants accounted for 58 percent of the acid production, and the combined production of five States amounted to 74 percent of the total.

The five largest producers of byproduct sulfuric acid were American Zinc Co., Kennecott Copper Corp., New Jersey Zinc Co., Phelps Dodge Corp., and St. Joseph Lead Co. Together, their nine plants accounted for 72 percent of the production during 1970.

Copper smelters, with five acid plants, accounted for 41 percent of the production; the remaining 59 percent was produced at 13 plants operated in conjunction with lead and zinc roasting and smelting operations. Overall production was 3 per-

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]
1966	1,244	1,240	1,265	1,261	$30,166
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

[1] F.o.b. 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
1966	469,728	983,118	1,452,846
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	1,086,207	1,833,991

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter in 1966–68. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

[4] Chemical Week. V. 107, No. 16, Oct. 14, 1970, p. 14.

cent greater than in 1969. The value of the acid produced at the copper smelters was approximately $9.4 million, and at the lead and zinc operations was approximately $14.3 million.

Most nonferrous smelter operations announced plans for increasing their production of sulfur to meet environmental requirements. In most cases this will be in the form of sulfuric acid, although some operators are considering the production of elemental sulfur. It was anticipated that the long-range increase in byproduct sulfur recovery would be substantial, as only approximately 40 percent of the available sulfur is presently being recovered.

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 1970. Output was 4 percent greater than in 1969, but slightly less than in 1967 and 1968. Pyrites was produced at six mines in five States; hydrogen sulfide at five plants in two States; and sulfur dioxide at two plants in two States. The value of these combined products was approximately $12.2 million.

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 Tennessee Copper Co. (pyrites and sulfur dioxide). Together, the three mines and five plants accounted for 95 percent of the contained sulfur produced in the form of these products.

CONSUMPTION

The apparent consumption of sulfur, in all forms, decreased slightly from that of 1969, and was 2 percent less than the all-time peak consumption in 1967. This stable level of consumption reflected a continued weakness in the fertilizer trade.

Approximately 87 percent of sulfur consumption was in the form of sulfuric acid. The manufacture of fertilizers accounted for approximately 50 percent of all sulfur consumption, and an additional 25 percent was used by such industries as cellulosic fibers, pulp and paper, inorganic pigments, nonferrous ore leaching, and explosives. The remaining 25 percent was used for a large number of relatively small individual end uses.

Sulfur for domestic consumption was obtained mainly from domestic sources: Frasch, 55 percent; recovered, 16 percent; and combined byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 11 percent. The remaining 18 percent of the sulfur was obtained by substantial imports of Frasch and recovered sulfur, and by minor imports of pyrites.

Table 7.—Apparent consumption of native sulfur in the United States

(Thousand long tons)

	1966	1967	1968	1969	1970
Apparent sales to consumers	7,687	7,729	6,649	6,551	6,419
Imports	799	724	742	745	539
Total	8,486	8,453	7,391	7,296	6,958
Exports:					
Crude	2,326	2,043	1,549	r 1,549	1,429
Refined	47	150	53	r 2	4
Total	2,373	2,193	1,602	r 1,551	1,433
Apparent consumption	6,113	6,260	5,789	r 5,745	5,525

r Revised.

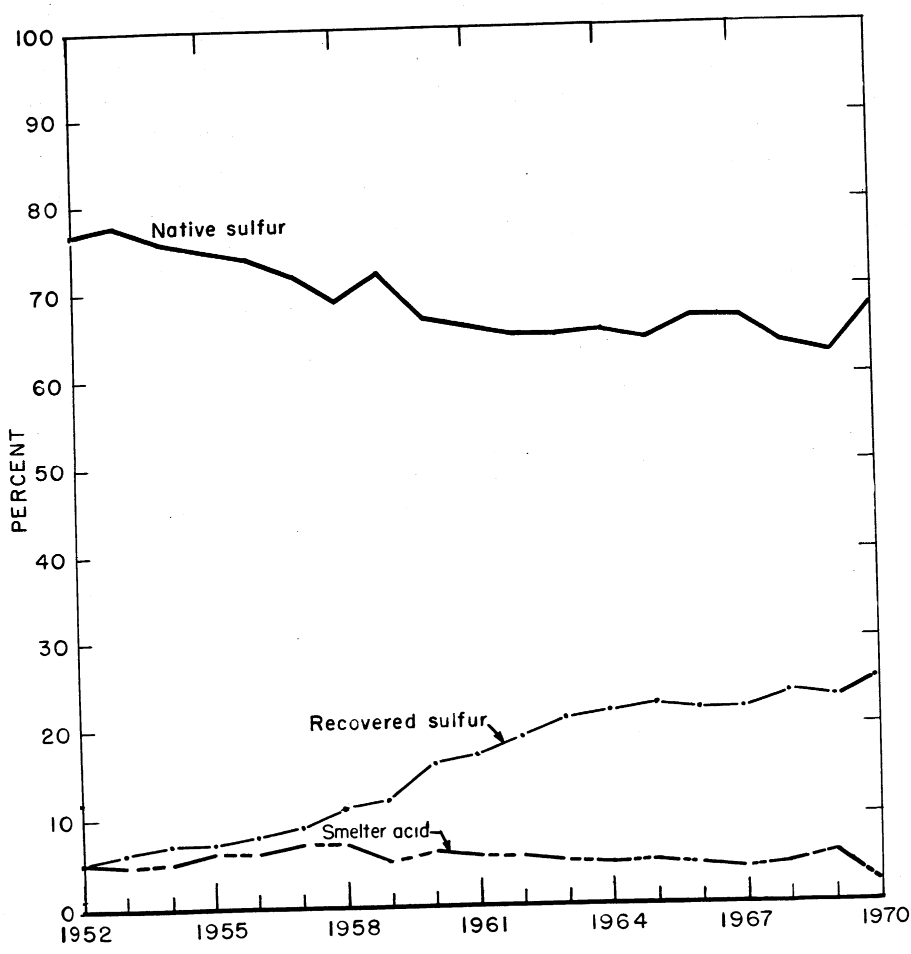

Figure 2.—Sulfur supply sources as a percent of total apparent consumption based on sulfur content.

Table 8.—Apparent consumption of sulfur in all forms in the United States [1]
(Thousand long tons)

	1966	1967	1968	1969	1970
Native sulfur	6,113	6,260	5,789	r 5,745	5,525
Recovered sulfur:					
Sales	1,258	1,287	1,332	1,400	1,463
Imports	715	750	830	929	998
Pyrites imports e	160	165	140	120	130
Smelter acid	424	364	430	517	535
Other [2]	475	475	486	460	481
Total	9,145	9,301	9,007	r 9,171	9,132

e Estimated. r Revised.
[1] Crude sulfur or sulfur content.
[2] Includes consumption of domestically produced pyrites and consumption of hydrogen sulfide and liquid sulfur dioxide. Figures for these categories have been combined to avoid disclosing individual company confidential data.

STOCKS

At yearend, producers' stocks of Frasch sulfur totaled 3,952,961 long tons, an increase of 586,874 tons, or 17 percent, over the stocks on hand at the end of 1969. These stocks were the largest since yearend 1964. Yearend stocks of recovered sulfur were 84,819 tons, compared with 95,312 tons for 1969. 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

The long-established price quotations by the Oil, Paint and Drug Reporter for crude, domestic, dark, bulk sulfur, f.o.b. cars, mines, and f.o.b. vessels, Gulf ports, were not available during the year. Formerly used as the basic reference for sulfur pricing, they no longer proved to be useful in this respect, having been supplanted by delivered prices ex-terminal near the points of major consumption, generally in the form of molten sulfur. These prices were reported bimonthly by the trade journal, Sulphur. It stated that delivered prices at the beginning of the year were as follows: Gulf region, $26 to $28 per long ton; Tampa, $28 to $30; and Atlantic East Coast, $35 to $37 per ton. Prices in the North Central States ranged widely from $21 per ton upward. By yearend these prices had declined moderately, and were reported as follows: Gulf region, $23 to $25 per ton; Tampa, $26 to $27; and East Coast, $27 to $31 per ton.

FOREIGN TRADE

U.S. exports and imports of sulfur during 1970 were both less than in 1969; moderately less in quantity, but very much lower in value. Both decreases, particularly value, reflected the depressed condition of the sulfur industry.

Exports were almost entirely in the form of elemental Frasch sulfur. The tonnage of elemental sulfur exported during 1970 was only 8 percent less than in 1969. However, the total value decreased by 42 percent, with an average reported value of $37.09 per ton in 1969 and $23.16 per ton in 1970. The Netherlands received 43 percent of these exports, mainly for transshipment to other European Economic Community (EEC) countries. Brazil was the second largest customer for these exports, followed by the United Kingdom.

Imports of sulfur consisted largely of recovered sulfur from Canada, which were greater in 1970 than in 1969, and of Frasch sulfur from Mexico, which were less than 1969. The total quantity of sulfur imported was only 8 percent less than in 1969, but the total value decreased by 40 percent. The average value reported in

1970 was $22.20 per ton, whereas in 1969 the average was $34.15.

Estimated imports of pyrites from Canada in 1970 were 260,000 tons, containing 130,000 tons of sulfur. (Bureau of Census data do not include all shipments.)

Table 9.—U.S. exports and imports for consumption of sulfur

(Thousand long tons and thousand dollars)

Year	Exports				Imports	
	Elemental, Frasch or sulfur recovered by any process		Processed, ground, screened, refined, sublimed, precipitated, colloidal, rolled flowers, and insoluble			
	Quantity	Value	Quantity	Value	Quantity	Value
1968	[1] 1,549	[1] $65,650	[2] 53	[2] $3,855	1,572	$64,277
1969	[r] 1,549	[r] 57,449	[r] 2	[r] 334	1,675	57,222
1970	1,429	33,096	4	955	1,537	34,149

[r] Revised.
[1] Formerly listed as "crude."
[2] Formerly listed as "crushed, ground, refined, sublimed, and flowers."

Table 10.—U.S. exports of sulfur, by countries

Destination	Elemental, Frasch, or sulfur recovered by any process				Processed, ground, screened, refined, sublimed, precipitated, colloidal, rolled flowers, and insoluble			
	1969		1970		1969		1970	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
Argentina	31,155	$1,114	27,628	$579	------	------	59	$29
Australia	57,262	2,493	31,665	977	49	$9	247	82
Belgium-Luxembourg	59,505	2,118	51,400	1,122	10	1	62	6
Brazil	124,057	4,233	229,102	5,223	763	206	248	104
Canada	47,310	1,961	54,414	1,593	260	27	900	122
Germany, West	5,627	336	2,827	142	35	5	824	229
India	17,340	800	---------	------	29	5	83	39
Indonesia	406	19	---------	------	45	5	101	11
Ireland	[r] 93,020	[r] 3,378	92,620	2,061	------	------	------	------
Israel	24,860	881	32,929	715	------	------	87	24
Italy	79,114	3,207	33,220	604	7	1	12	4
Japan	25	12	948	33	13	1	70	25
Mexico	913	106	2,727	111	309	31	221	79
Netherlands	609,806	21,857	614,759	13,316	------	------	47	5
New Zealand	53,792	2,101	60,373	1,769	63	9	19	8
Philippines	5,315	201	196	8	------	------	79	42
South Africa, Republic of	30,518	1,024	15,073	308	70	14	48	5
Switzerland	31,502	1,197	9,000	189	------	------	------	------
Trinidad and Tobago	17,861	588	16,716	488	------	------	------	------
Tunisia	34,100	1,524	---------	------	------	------	------	------
United Kingdom	201,077	7,236	131,325	3,203	------	------	67	20
Venezuela	334	46	1,023	37	27	3	181	41
Other	24,038	1,017	21,110	618	116	17	420	80
Total	[r] 1,548,937	[r] 57,449	1,429,055	33,096	1,796	334	3,775	955

[r] Revised.

Table 11.—U.S. imports for consumption of sulfur, by countries

Country	1969 Long tons	1969 Value (thousands)	1970 Long tons	1970 Value (thousands)
Belgium-Luxembourg	----------	----------	11	$1
Bolivia	88	$3	----------	----------
Canada	929,202	23,334	998,008	14,005
Chile	110	(1)	----------	----------
Guatemala	150	6	----------	----------
Germany, West	49	15	61	15
Mexico	745,178	33,850	538,985	20,115
Philippines	171	14	118	9
United Kingdom	----------	----------	22	1
Venezuela	----------	----------	276	3
Total	1,674,948	57,222	1,537,481	34,149

[1] Less than ½ unit.

WORLD REVIEW

Canada.—The output of sulfur continued to increase at a rapid rate, primarily because of the nondiscretionary production of recovered elemental sulfur as a consequence of increased demands for natural gas. It was announced that the total rated capacity of plants for the treatment of sour natural gases at the end of 1970 was approximately 5.63 million long tons of sulfur per year.[5] This was about one-fifth greater than the rated capacity of these plants at the end of 1969.[6] It was anticipated that new plants and the expansion of existing plants would raise the rated capacity of these types of operations to approximately 7.84 million tons per year by the end of 1971. Because of seasonal demands for gas, these plants do not always operate at full rated capacity. However, it has been projected that sulfur production from these sources might reach 6.3 million tons by the end of 1971, and 9 to 10 million tons per year by 1975.

Producers' stocks of recovered sulfur continued to increase, and by the end of 1970 amounted to approximately 3 million long tons. It was projected that these stocks could be double this quantity by the end of 1971, and might reach 50 million tons by the end of the decade.[7]

Unit train operations between the recovered sulfur plants and Vancouver, British Columbia were expanded and simplified.[8] A group of 24 individual shippers consolidated their sulfur movements under a Sulphur Solid Train Operating and Exchange Plan. These producers previously shipped from widely scattered points in Alberta. Under the new plan, only four of the largest plants will ship by unit-train to the west coast, where a common stockpile will be maintained from which all 24 sulfur producers may draw for export sales. The project was designed for an initial movement of more than 1.5 million long tons per year.

Provincial authorities have approved the plans of Syncrude of Canada, Ltd., for the construction of a large plant to process Athabasca tar sands in northeastern Alberta.[9] Proposed initial production will amount to 50,000 barrels of synthetic crude oil per day, and approximately 120,000 tons of elemental sulfur per year. This will be the second plant of its type for the exploitation of the tar sands. Though regarded as a source of oil, the tar sands contain about 4.5 percent sulfur, and are considered to be one of the largest potential deposits of recoverable sulfur in the world.

Germany, West.—It was projected that this nation's present position as one of the world's major importers of sulfur could change to that of a net exporter by the year 1974.[10] This would be accomplished by the scheduled installation of several large plants for the recovery of elemental sulfur from sour natural gas deposits in Lower Saxony. The plants are being developed by Mobil Oil Corp., and by companies owned jointly by Standard Oil Co. (New Jersey) and the Royal Dutch Shell Group.

[5] Cote, P. R. Sulfur. Canadian Min. J., v. 92, No. 2, February 1971, pp. 147–150.
[6] Cote, P. R. Sulfur. Canadian Minerals Yearbook 1969 (preprint) May 1970, 12 pp.
[7] Work cited in footnote 5.
[8] Chemical Age. New Sulphur Shipping System for Canada. V. 100, No. 2643, Mar. 13, 1970, p. 22.
[9] Industrial Minerals (London). Syncrude Plans Second Tar Sand Plant. No. 29, February 1970, p. 42.
[10] Oil, Paint and Drug Reporter. Sulfur Position of the Germans. V. 198, No. 24, Dec. 14, 1970, pp. 5, 51.

Table 12.—Elemental sulfur: World production, by countries

(Thousand long tons)

Country [1]	1968	1969	1970 [p]
Native sulfur:			
Frasch:			
Mexico	1,582	1,606	1,276
Poland	r 829	1,300	e 1,600
United States	7,458	7,146	7,082
Total	r 9,869	10,052	9,958
From sulfur ores:			
Argentina	33	34	e 34
Bolivia (exports)	35	36	16
Chile	62	97	107
China, mainland e	118	118	118
Colombia	28	e 26	e 29
Ecuador	(2)	5	e 5
Indonesia e	1	1	1
Iran [3]	1	1	1
Italy	r 78	53	47
Japan [4]	256	201	234
Mexico	24	26	24
Poland	r 487	650	e 1,067
Taiwan	4	5	6
Turkey	24	25	26
U.S.S.R. e	1,033	1,102	1,102
United States	r 2		
Total	r 2,186	2,380	2,817
Total native sulfur	r 12,055	12,432	12,775
Other elemental sulfur: Recovered:			
Austria [5]	r 3	3	e 3
Belgium [5]	r 9	10	e 10
Brazil [6]	7	7	9
Bulgaria [7]	9	5	e 7
Canada [8]	r 3,150	3,799	4,372
China, mainland e [6] [7]	128	128	128
Colombia e [6]	3	4	4
Finland	123	110	113
France [9]	r 1,609	1,705	1,706
Germany:			
East	118	108	e 108
West [5]	125	127	173
Hungary	r 2	2	e 2
Iran e [6]	37	39	39
Israel	6	e 8	e 8
Italy e [5]	r 51	69	69
Japan [10]	74	141	101
Kuwait	NA	15	20
Mexico [9]	52	57	59
Netherlands [5]	r 39	31	e 31
Portugal	4	8	e 8
Saudi Arabia e	2	4	5
South Africa, Republic of e [6]	6	12	12
Spain [11]	r 9	5	e 5
Sweden [12]	4	p 5	e 5
Taiwan e [6]	3	4	5
Trinidad	3	4	4
U.S.S.R. e	443	472	472
United Arab Republic [6]	3	1	e 1
United Kingdom [13]	46	42	e 45
United States	1,354	1,414	1,449
Total other elemental sulfur	r 7,422	8,339	8,973
Grand total	r 19,477	20,771	21,748

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

[1] In addition to countries listed, Uruguay produces less than 500 tons of sulfur annually as a byproduct of petroleum refining.

[2] Less than ½ unit.

[3] Year beginning March 21 of year stated.

[4] Includes an unreported quantity recovered from sulfide ores as well as that from sulfur ore.

[5] Includes (in part) sulfur content of H_2S converted directly into sulfuric acid.

[6] From petroleum refining.

[7] From sulfide ore.

[8] From natural gas, petroleum, tar sands, and smelting of sulfide ores.

[9] From natural gas.

[10] From petroleum refineries only. Excludes an unreported quantity recovered from sulfide ores, which is included above (see footnote 4).

[11] From distillation of petroleum, lignite, and from the reduction of SO_2 gas.

[12] From oil shale.

[13] Includes sulfur recovered from petroleum refineries and from other unspecified sources.

Table 13.—Pyrites (including cupreous pyrites): World production, by countries
(Thousand long tons)

Country [1]	1968		1969		1970 [p]	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:						
Canada (shipments)	281	[e] 136	336	[e] 168	291	[e] 145
United States [2]	872	362	W	W	W	W
Europe:						
Bulgaria	161	64	167	66	[e] 177	[e] 71
Czechoslovakia	374	[e] 158	351	[e] 148	[e] 354	[e] 149
Finland	762	365	841	387	948	489
France	81	33	84	[e] 34	84	[e] 34
Germany:						
East	138	57	[e] 138	[e] 57	[e] 138	[e] 57
West	606	[r] 247	630	262	545	238
Greece	[r] 208	96	242	112	266	116
Italy	1,384	623	1,451	638	1,494	658
Norway	682	309	754	346	735	[e] 411
Poland [e]	221	87	221	87	221	87
Portugal	552	[r] 254	523	235	468	206
Romania	[e] 354	[e] 138	[e] 354	[e] 138	794	[e] 341
Spain	2,365	1,132	2,436	1,131	2,693	1,253
Sweden	467	[r] 236	487	246	566	[e] 285
U.S.S.R. [e]	3,445	1,821	3,445	1,821	3,937	2,067
Yugoslavia	[r] 269	[e] 113	268	[e] 113	349	[e] 147
Africa:						
Algeria	45	22	45	20	32	15
Morocco (pyrrhotite)	411	123	385	116	286	86
South Africa, Republic of	693	[e] 277	824	[e] 330	854	[e] 342
Asia:						
China, mainland [e]	1,476	[r] 689	1,772	787	1,968	886
Cyprus	[r] 1,033	[r] 496	912	430	857	418
Japan [3]	[r] 2,870	[r] 1,321	2,919	1,344	2,707	1,265
Korea, North [e]	492	197	492	197	492	197
Philippines	179	[r] 85	198	93	270	125
Taiwan	38	[e] 14	38	[e] 14	39	[e] 15
Turkey	[r] 135	64	128	61	90	43
Oceania: Australia	[r] 165	[r] 72	158	71	[e] 155	[e] 64
Total	[r] 20,759	[r] 9,591	20,599	9,452	21,810	10,210

[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.
[3] Revised to show only pyrites and pyrrhotite. Data for years prior to 1968 included pyrites, pyrrhotite, sulfur ore used in acidmaking, copper concentrate, and zinc concentrate.

Iran.—A new elemental sulfur recovery plant for treating sour natural gas went into operation at Bandar Shaphur late in 1970.[11] The plant has a capacity of 500,000 long tons of sulfur per year, making it the sixth largest of its type in the world. It is part of a petrochemical complex operated by Shaphur Chemical Co., which is jointly owned by the Allied Chemical Corp. and the National Iranian Oil Co. A similar sulfur recovery plant at Karg Island, with a rated capacity of 200,000 tons per year, went into operation in late 1969.[12] Jointly owned by the American Oil Co. and the National Iranian Oil Co., it treats sour natural gas reported to have a hydrogen sulfide content of approximately 12 percent. These two plants represent the first attempts to recover elemental sulfur from the very large reserves of sulfur in the sour natural gas deposits in Iran.

Iraq.—Hydrokop, a Polish mining organization, commenced initial operations leading to the development of Frasch mines for the exploitation of the large known reserves of native sulfur in Iraq.[13] Funds for the project are being provided by Poland. The first mine to be brought into production will be located near Mishracq in north-central Iraq, with a planned output of 300,000 tons per year. If successful, it will be followed by another mine with a production capacity of 1 million tons per year. It is reported that Poland might participate in the marketing of the sulfur production.

Poland.—The state-owned sulfur industry was reorganized during 1970, and is

[11] Sulphur. Iran, Developing Trade in Recovered Sulphur. No. 91, November–December 1970, p. 15.
[12] Sulphur. Karg Island Complex On-Stream. No. 86, January–February 1970, pp. 27–28.
[13] Mining Journal. Sulphur Mine in Iraq. V. 274, No. 7018, Feb. 20, 1970, p. 158.

now grouped under the direction of a sulfur combine. This new organization took over control of all functions relating to production, shipping, and sales.[14]

Poland, ranked as the third largest exporter of sulfur, after Canada and the United States, was pressing to expand its exports even further as a source of foreign exchange. Operations were expanded at the newer Frasch Grzybow and Jeziorko operations, and work was well advanced on the construction of a large, modern liquid sulfur terminal near the port of Gdansk.[15] Completion of these shipping facilities was expected to reduce transportation costs to Western Europe and other world markets, making Polish sulfur more competitive in areas formerly dominated by exports from the United States and Mexico.

TECHNOLOGY

The Bureau of Mines reported research on the alkalized alumina process for removing sulfur dioxide from combustion gases. Fluidized-bed reactors were operated for the sorption of sulfur dioxide and the regeneration of the alkalized alumina, obtaining a 90-percent recovery of the sulfur in the feed gas.[16] Equations were developed for the design of commercial fluidized beds for both the sorption and regeneration steps of the process.[17] Studies were made on the effect of reducing gas composition, temperature, and superficial gas velocity on the regeneration rate of alkalized alumina.[18]

A review was made of 19 chemical processes for removing sulfur oxides from stack gases. The processes ranged from those still in the experimental stage to a few that are commercial. It was determined that more operating data are needed before judging which methods are most economical and effective.[19]

Consolidation Coal Co. announced the development of a process for the removal of sulfur dioxide from stack gases. It involves the use and regeneration of potassium formate, and yields elemental sulfur. A preliminary economic appraisal indicated that the process costs would be in the range of from $1.00 to $1.50 per ton of coal, for a coal-fired powerplant.[20]

The newly developed Bergbau-Forschung process for the removal of sulfur dioxide from flue gases was described. At a controlled temperature, sulfur dioxide, oxygen, and steam are absorbed by activated carbon and converted to sulfuric acid, which is retained by the carbon, the carbon being deactivated. The sulfuric acid may be recovered in a dilute form by water washing the carbon. Alternatively, the carbon may be regenerated by heating, and a concentrated sulfur dioxide gas recovered. The process was developed by the Research Center of the German Coal Mining Industry, with financial support from the Ministry of Health of West Germany.[21]

The Bureau of Mines investigated the feasibility of removing sulfur dioxide from gas streams by carbon monoxide reduction in a fixed-bed catalytic reactor. Kinetic studies determined the influence of various parameters on the catalytic reaction.[22]

It was reported that the high pressure gasification of fossil fuels, with the removal of sulfur before combustion, could be more financially attractive than the removal of sulfur dioxide from stack gases.[23] By integrating such a process with giant combined gas turbine and steam turbine power generation, cost could be held down. Additionally, the sale of byproduct sulfur would provide an offset against capital costs. Proposed schemes, with advantages and problems, were discussed.

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[14] Sulphur. Reorganization of Sulphur Industry. No. 89, July–August 1970, p. 41.
[15] Industrial Minerals. Sulphur to be Shipped in Liquid Form. No. 36, September 1970, p. 35.
[16] Paige, Jack I., Joseph W. Town, James H. Russell, and Hal J. Kelly. Sorption of Sulfur Dioxide and Regeneration of Alkalized Alumina in Fluidized-Bed Reactors. BuMines Rept. of Inv. 7414, 1970, 32 pp.
[17] Russell, James H., Joseph W. Town, and Hal J. Kelly. Mathematical Evaluation of Sulfur Dioxide Sorption-Regeneration Reactions With Alkalized Alumina. BuMines Rept. of Inv. 7415, 1970, 29 pp.
[18] Town, J. W., J. H. Russell, and H. J. Kelly Removing Sulfur Dioxide From Flue Gases: Regeneration Rates for Alkalized Alumina. BuMines Rept. of Inv. 7478, 1971, 24 pp.
[19] Maurin, P. G., and J. Jonakin. Removing Sulfur Oxides From Stacks. Chem. Eng., v. 77, No. 9, Apr. 27, 1970, pp. 173–180.
[20] Sulfur. Sulfur Dioxide Removal: Formates Involved in New Process From Consolidation Coal Co. No. 88, May–June, 1970, p. 50.
[21] Sulfur. Desulfurization of Flue Gases Using the Bergbau-Forschung Process. No. 88, January–February 1970, pp. 29–30.
[22] Haas, L. A., T. H. McCormick, and S. E. Khalafalla. Removing Sulfur Dioxide by Carbon Monoxide Reduction. BuMines Rept. of Inv. 7483, 1971, 18 pp.
[23] Squires, Arthur M. Keeping Sulfur Out of the Stack. Chem. Eng., v. 77, No. 9, Apr. 27, 1970, pp. 181–189.

Freeport Sulphur Co. developed a new process for the conversion of hydrogen sulfide and sulfur dioxide into elemental sulfur. The reaction is carried out in molten sulfur, and is catalyzed by a small concentration of amines.[24]

Papers and patents published in the past 60 years were reviewed as part of a project for determining the feasibility of recovering hydrogen sulfide from base metal sulfides as an alternate to pyrometallurgical smelting.[25]

The Bureau of Mines reported the development of a hydrometallurgical process for the recovery of copper, iron, and sulfur from chalcopyrite concentrate by means of a ferric chloride leach, with sulfur being recovered in the elemental form.[26]

An investigation provided the technical parameters of a hydrometallurgical process whereby copper sulfide concentrates are taken into solution with concentrated sulfuric acid, and elemental sulfur and sulfur dioxide are produced.[27] Sulfuric acid can be regenerated for use in the process.

The development of special procedures for drilling and completing very deep, extremely corrosive gas wells to recover natural gases containing a high percentage of hydrogen sulfide was reported.[28]

The Sulphur Institute reviewed the research on new end uses for sulfur, and reported that commercialization of new uses should open up multimillion-ton markets.[29]

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[24] Chemical and Engineering News. Sulfur Recovery Process Sweetens Sour Gas. V. 48, No. 18, Apr. 27, 1970, pp. 68–69.

[25] Parsons, H. W., and T. R. Ingraham. The Hydrogen Sulphide Route to Sulphur Recovery From Base Metal Sulphides: Part 1, The Generation of Hydrogen Sulphide From Base Metal Sulphides. Mines Branch, Department of Energy, Mines and Resources, Canada. Mines Branch Inf. Circ. 242, 1970, 61 pp.

[26] Haver, F. P., and M. M. Wong. Recovery of Copper, Iron, and Sulfur From Chalcopyrite Concentrate Using a Ferric Chloride Leach. J. Metals, v. 23, No. 2, February 1971, pp. 25–29.

[27] Prater, J. D., P. B. Queneau and T. J. Hudson. The Sulfation of Copper-Iron Sulfides With Concentrated Sulfuric Acid. J. Metals, v. 22, No. 12, December 1970, pp. 23–27.

[28] Grizzaffi, L. P., and B. M. Thompson. Completing Gas Wells That Produce High Hydrogen Sulfide. Oil World, v. 170, No. 7, June 1970, pp. 70–74.

[29] Platou, J., New Markets for Tomorrow's Sulphur. Min. Cong. J. v. 57, No. 2, February 1971, pp. 109–114.

Talc, Soapstone, and Pyrophyllite

By J. Robert Wells [1]

The talc, soapstone, and pyrophyllite industry, taken as a whole, successfully held its ground against the tendency toward slackness that characterized other parts of the industrial mineral field in 1970. Domestic producers, for the second year in succession, supplied to consumers more than a million tons of these materials, attaining an alltime high total value of $7.8 million. The United States remained securely in the position of being second only to Japan in tonnage of output of talc-group minerals. This overall strength of the industry in 1970 was sustained by three major producing States, California, Texas, and Vermont, each of which posted higher figures for talc-group tonnages and values than ever before in their mining history.

Table 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Mine production	895	903	958	1,029	1,028
Value	$6,479	$6,871	$6,656	$7,508	$7,773
Sold by producers	850	824	886	985	948
Value	$19,269	$20,488	$22,968	$26,294	$25,980
Exports [1]	70	66	66	69	105
Value [1]	$3,917	$3,450	$3,521	$3,713	$5,739
Imports for consumption	22	15	24	20	30
Value	$827	$653	$973	$749	$1,294
World: Production	4,093	4,369	4,796	5,137	5,306

[1] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

Domestic production of talc-group minerals in 1970 consisted of talc, soapstone, and pyrophyllite from about 60 mines in 15 States. New York, California, Vermont, Texas, and Montana, in that order were the leading producers, and jointly providing 84 percent of the national total. Total talc-group tonnage was virtually unchanged from 1969, although the total value reported by producers advanced by about 4 percent.

Talc, the dominant member of this mineral group, was mined in 10 States, among which New York, Vermont, Texas, California, and Montana, ranked according to tonnage, were the leaders. Total 1970 production of talc from U.S. mines was about 1 percent less in quantity than in 1969, but nearly 5 percent higher in total value.

Soapstone was mined in 1970 in six States led by Arkansas, Virginia, and Washington, the joint suppliers of about 87 percent of the total quantity. Domestic production of soapstone, compared with 1969 data, was 26 percent less in tonnage and 55 percent less in total value. North Carolina and California were the principal domestic producers of pyrophyllite in 1970.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
California	145,158	$2,329	184,660	$2,545
Georgia	47,790	301	45,900	289
Nevada	6,434	81	W	W
North Carolina	105,728	586	92,639	544
Oregon	W	W	W	W
Texas	163,812	668	171,420	878
Virginia	4,600	12	3,760	9
Other States [1]	555,716	3,531	529,550	3,507
Total	1,029,238	7,508	1,027,929	[2] 7,773

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Alabama, Arkansas, Maryland, Montana, New York, Pennsylvania, Vermont, Washington, and States indicated by symbol W.
[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 classes

Year	Crude Short tons	Crude Value at shipping point (thousands)	Ground [1] Short tons	Ground [1] Value at shipping point (thousands)	Total [2] Short tons	Total [2] Value at shipping point (thousands)
1966	[3] 110,856	$493	738,736	$18,776	849,592	$19,269
1967	[3] 42,758	280	780,998	20,208	823,756	20,488
1968	[3] 64,877	331	821,601	22,637	886,478	22,968
1969	[3] 81,015	362	904,318	25,931	985,333	26,294
1970	[3] 95,561	572	851,956	25,407	947,517	25,980

[1] Includes crushed, sawed, and manufactured material to avoid disclosing individual company confidential data.
[2] Data may not add to total shown because of independent rounding.
[3] Includes exports to grinders in Belgium and Mexico.

CONSUMPTION AND USES

Apparent consumption of talc minerals in the United States, as derived from total mine production and the balance of imports-exports, amounted to 953,000 short tons in 1970, or approximately 3 percent less than in 1969. Total tonnage of talc-group products (principally ground material) sold or used by producers was 4 percent less than in 1969, but the total value was lower by only 1 percent.

The dominant single end-use classification for talc minerals in the United States in 1970 was the manufacture of ceramics, which accounted for at least 26 percent of the total quantity of these materials sold or used by producers, even though data on use for floor and wall tile were not separately available. Approximately 18 percent of the year's supply of talc and soapstone was consumed in paints, 6 percent in the coating and filling of paper, 5 percent in roofing, and 4 percent in insecticides; this last item was down from 6 percent in 1969. The share of domestic talc consumed in toilet preparations remained low, less than 2 percent, following just over 1 percent in 1969, compared with 4 percent in 1967 and 1968, possibly a reflection of the markedly stepped-up importation of cosmetic-grade Italian material. Detailed end-use statistics for domestic pyrophyllite have not been published since the early 1960's, to avoid disclosing individual company confidential data.

Table 4.—Pyrophyllite [1] produced and sold by producers in the United States

Year	Production	Total sales	
	Short tons	Short tons	Value (thousands)
1966	125,202	126,874	$1,627
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

[1] Includes sericite schist.

Table 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Use	Talc and soapstone		Pyrophyllite	
	1969	1970	1969	1970
Ceramics	245,704	228,595	26,860	19,427
Insecticides	53,722	33,697	W	W
Paint	166,170	154,265	W	W
Paper	54,554	52,328	-------	-------
Roofing	30,526	44,997	W	W
Rubber	24,464	28,348	W	W
Textile	7,974	6,187	W	W
Toilet preparations	12,235	13,721	W	W
Other	[1] 279,168	[1] 289,644	[2] 83,956	[2] 76,308
Total	874,517	851,782	110,816	95,735

W Withheld to avoid disclosing individual company confidential data.
[1] Includes asphalt filler, crayons, exports, fertilizer, floor and wall tile, foundry facings, insulated wire and cable, joint cement, plastics, rice polishing, and miscellaneous products.
[2] Includes asphalt filler, brick, enamel coating, exports, foundry facings, joint cement, refractories, miscellaneous products, and items indicated by symbol W.

PRICES

For crude talc, soapstone, and pyrophyllite in 1970, the average value per ton reported by producers fell within the range established during the previous 10 years of $6.84 to $7.61 per ton. The average unit value for all talc-group minerals sold or used in 1970 by producers (that is, mostly processed material but exclusive of cosmetic powders) continued the persistently rising trend of recent years and reached the highest point on record, about 16 percent above the mean for the period of 1960–69.

Ceramic Industry Magazine, January 1971, showed $22 to $80 per ton as the price range for talc and steatite talc, presumably for the ground material. In more detail, the December 28, 1970, issue of Oil, Paint and Drug Reporter quoted prices for ground domestic talc that ranged (depending upon grade, point of origin, and degree of preparation) from $22.25 to $39.50 per ton for carload lots, and from $36 to $42 per ton for smaller quantities. Micronized talc in carload lots was quoted in the same issue at $42 per ton for 400-mesh product and at $85 per ton for 625-mesh. Quotations given for ground talc imported from Canada were in the range of $20 to $35 per ton.

Although such published quotations are probably indicative of the general tendency of current talc prices, actual sales in 1970 were arranged as usual at rates fixed upon by negotiation and not on public record.

FOREIGN TRADE

Exports.—U.S. exports in 1970 of talc minerals, both crude and ground, outstripped imports about four-fold with regard to tonnage and total value and attained the highest level on record—more than 50 percent above the 1969 total. Without exception, shipments of U.S. talc to all the major geographical divisions were substantially higher in 1970, 15 percent higher to Western-Hemisphere nations, 127 percent higher to Asia-Oceania, and 133 percent higher to Africa, than in 1969. The largest gain—23,496 tons more and 164 percent more than in 1969—was scored by exports to European markets.

Imports.—The total value of U.S. imports in 1970 of talc minerals in unmanufactured form amounted to $1.3 million, or about 18 percent more than the highest annual figure recorded previously—$1.1 million in 1963. Notably, 1970 imports from Italy were valued at $780,000, compared with only $280,000 in 1969, but still not quite up to the $860,000 that was reached in 1961, and again in 1962 and 1963.

Table 6.—U.S. exports of talc, soapstone, and pyrophyllite, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1968	66	$3,521
1969	69	3,713
1970	105	5,739

Tariffs.—Schedules in force during 1970 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, 8 percent ad valorem; cut or sawed, or in blanks, crayons, cubes, disks, or other forms, 0.3¢ per pound; and other, not specially provided for, 16.5 percent ad valorem. The rate applicable to talc, crude and not ground, remained the same after January 1, 1971, but those affecting the other three classes were reduced, as of that date, to 7 percent ad valorem, 0.2¢ per pound, and 14 percent ad valorem, respectively.

Table 7.—U.S. imports for consumption of talc and steatite or soapstone, by classes and countries

(Short tons and thousand dollars)

Year and country	Crude and unground		Ground, washed, powdered, or pulverized		Cut and sawed		Total unmanufactured	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value[1] (thousands)
1968	10,036	$134	14,055	$520	222	$319	24,313	$973
1969:								
Canada	5,899	55	2,281	54	3	2	8,183	111
France	------	------	5,046	124	2	1	5,048	125
Israel	------	------	14	2	------	------	14	2
Italy	3,293	137	2,265	144	2	1	5,560	282
Japan	------	------	------	------	258	159	258	159
Korea, Republic of	------	------	1,222	54	------	------	1,222	54
Mexico	1	(2)	------	------	------	------	1	(2)
Poland	------	------	33	3	------	------	33	3
United Kingdom	3	2	36	11	------	------	39	13
Total	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

[1] Does not include talc, n.s.p.f.: 1968, $12,722; 1969, $12,479; 1970, $5,651.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—Exploratory drilling proved the existence of recoverable talc amounting to hundreds of thousands of tons in a previously discovered deposit near Truro, in the Adelaide district of South Australia. The Truro ore body consists of bedded material near the surface that should be minable by open pit procedures. A study was begun to assess the site's potential as a source of talc in crude or processed form for the export market. In New South Wales, organization was completed of a new mining firm, Pyrophyllite Pty. Ltd. for the announced purpose of exploiting a pyrophyllite ore body formerly controlled by Eden Minerals Pty. Ltd. It is estimated that this deposit contains from 30 to 50 million tons of marketable pyrophyllite, and Japanese steel mills are expected to provide a large-scale outlet for the mineral for use in the manufacture of ladle brick.

Canada.—Baker Talc, Inc., operating talc mining and processing facilities near South Bolton, Quebec, announced that installation of an additional air compressor and of an enlarged hoisting system, coupled with the recent extension of the shaft to a deeper level, has provided substantially increased production capacity at the Van Reet mine. In continuation of a program for the improvement of the company's processing plant, a number of modifications were incorporated into the milling circuit that will make it possible to supply

Table 8.—Talc, soapstone, and pyrophyllite: World production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada (shipments)	[r] 80,589	75,850	74,957
Mexico	707	1,469	2,320
United States	958,262	1,029,938	1,027,929
South America:			
Argentina	[r] 23,442	23,934	[e] 24,000
Chile	3,101	892	705
Colombia	[r] 1,487	1,681	1,899
Paraguay	83	99	132
Peru (pyrophyllite)	6,967	8,618	[e] 8,800
Uruguay (ground talc)	2,434	2,542	1,801
Europe:			
Austria	[r] 93,205	104,277	110,406
Finland	[2] 5,300	31,680	69,140
France	[r] 271,262	271,168	256,838
Germany, West (marketable)	[r] 30,886	50,081	48,941
Greece	[r] 2,770	6,695	6,614
Italy	[r] 136,441	150,466	170,657
Norway (ground talc)	[r] 84,523	70,807	[e] 70,000
Portugal	[r] 1,609	1,323	1,992
Romania	[e r] 55,000	[e] 55,000	62,532
Spain	[r] 31,997	37,179	[e] 37,500
Sweden	[r] 26,834	31,300	35,600
U.S.S.R.[e]	408,000	419,000	419,000
United Kingdom	[r] 12,706	11,311	[e] 11,000
Africa:			
Morocco (talc)	---------	150	250
South Africa, Republic of	9,978	9,715	8,243
Swaziland	642	660	280
United Arab Republic	[e r] 5,000	4,740	[e] 5,000
Asia:			
China, mainland [e]	165,000	165,000	165,000
India	[r] 195,100	206,674	185,641
Japan	[r] 1,869,733	1,996,045	2,066,230
Korea, North [e]	66,000	77,000	88,000
Korea, Republic of	164,694	198,733	224,941
Pakistan (soapstone)	[r] 2,885	2,486	[e] 2,200
Philippines	[r] 961	1,038	1,753
Taiwan (soapstone)	32,027	26,867	42,678
Thailand (pyrophyllite)	3,707	2,185	---------
Oceania:			
Australia	42,873	60,704	72,568
Total	[r] 4,796,205	5,137,307	5,305,547

[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] Talc only.

a micronized talc of superior whiteness that is especially suitable for the manufacture of paint.

India.—Indian production of talc-group minerals in 1970 totaled 185,641 short tons, of which 8 percent was classified as pyrophyllite and 92 percent as "steatite" (probably talc by U.S. definition). The total value of the 1970 output amounted to Rs5.04 million, or approximately US$0.67 million, divided in the same proportion as the tonnage.

Indonesia.—The discovery of a lens of pure white talc 1 meter in thickness in West Irian, the western half of New Guinea, was reported in a recent survey of Indonesian minerals published by the Ministry of Mines in Djakarta. The new ore body lies between formations of peridotite and crystalline schist in a locality in the Cyclops Mountains north of Lake Sentani, where all previously known talc occurrences were so intermixed with iron oxides as to be of little commercial value. The potential economic significance of the newly found talc deposit is being investigated.

Norway.—An energetic rebuilding program at the Knarrevik site in Bergen where a previous plant was destroyed by fire in 1969, enabled A/S Norge Talc, a subsidiary of the Jacob Kjode A/S shipping firm, to resume the processing of ores mined in Norway and imported from abroad to produce high-quality micronized talc for world markets, especially the United Kingdom. Construction of expanded facilities continued throughout 1970, and plans were mentioned for the eventual installation of equipment for the production and storage of other mineral products in addition to a variety of grades and specifications of talc for a diversity of applications.

United Kingdom.—A British journal published a series of papers outlining the international ramifications of the major organizations that mine and process the world's industrial talc. One panoramic article sketched the talc position of the United Kingdom and gave an account of the activities of its principal foreign suppliers in Norway, France, Italy, mainland China, and India, together with a briefer view of talc operations in Australia, Austria, Belgium, Finland, Japan, and the Republic of Korea.[2] Two large producing firms, one in France and one in Norway, were dealt with more extensively in individual articles.[3] Details of the talc industry in the United States and of some of the international activities of a U.S.-based major world supplier were presented in four chapters of a subsequent issue.[4]

TECHNOLOGY

Some of the most widely serviceable mineral pigments used in modern paint technology were discussed, together with the characteristic properties that determine their performance in specific applications, in a two-part journal article.[5]

Exterior house paints that contain talc as the principal pigment, in addition to being resistant to discoloration by water drip from overhanging metallic objects, excel especially with regard to the qualities of viscosity, stability of suspension, ease of application, and durability in service. According to the 1969 data that were quoted, talc ranked third in both tonnage and value among the various mineral pigments consumed that year in the United States. Subsequent issues of the same magazine carried more extensive accounts of the principal ways in which talc serves many other needs of modern living and of the present state of the art of producing and preparing talc to meet those needs.[6]

Research conducted by the Bureau of Mines led to the publication of a report presenting new data on the thermody-

[2] Industrial Minerals (London). Talc: UK Consumption Shows Gradual Rise. No. 40, January 1971, pp. 19–23.

[3] ———. Pyrenean Producer: SA des Talcs de Luzenac. The Operations of A/S Norwegian Talc. No. 40, January 1971, pp. 25, 27–28.

[4] ———. Talc in USA: Producers Fine Grind and Upgrade. No. 41, February 1971, pp. 39–42.
Mulryan, H. T. World-Wide Operations of United Sierra. Industrial Minerals (London). No. 41, February 1971, pp. 43–45.
Industrial Minerals (London). Talc Operations of Engelhard Minerals & Chemicals Corp. No. 41, February 1971, p. 46.
———. Vanderbilt in Talc. No. 41, February 1971, pp. 47–50.

[5] Industrial Minerals (London). Functional Mineral Pigments: Part 1. No. 38, November 1970, pp. 35–40; Part 2. No. 39, December 1970, pp. 46–51.

[6] ———. Talc: Micronised Grades Lead the Way. No. 40, January 1971, pp. 9–17; also item cited in part 1 of footnote number 5.

namic properties of one of the talc-group minerals in the temperature range from 51° K to 298° K (−377° F to +122° F).[7]

A process was patented for improving the brightness of gray or off-white talc to render it suitable for use as a pigment in light-colored paints.[8] Patents were issued covering the use of talc in a mixture with wollastonite and kaolin to form a noncombustible covering material to be applied to the surfaces of less-refractory substances[9] and with an oxidized asphalt, organic-modified bentonite and other specified ingredients to undercoat vehicle bodies for corrosion control.[10]

Talc is used as a low-cost filler for mixing with a number of specified ingredients in a patented wettable insecticide powder[11] and as an essential component in an improved and easily workable grouting composition for filling joints, fissures, etc. With the specified ingredients, this preparation is said to be stable in storage.[12]

Talc, reduced to minus 50-millimicron particle size, was one of the substances specified for use in a patented method by which an electrically insulating surface layer can be induced by electrophoresis on the exterior of an article that, in itself, is electrically conducting.[13]

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[7] King, E. G., and W. W. Weller. Low-Temperature Heat Capacities and Entropies at 298.15° K of Goethite and Pyrophyllite. BuMines Rept. of Inv. 7369, 1970, 6 pp.

[8] Lundquist, J. D. (assigned to Georgia Kaolin Co., Elizabeth, N.J). Talc Treatment and Talc Containing Pigments. U.S. Pat. 3,533,821, Oct. 13, 1970.

[9] Schuti, J. B., and J. W. Stuart (assigned to U.S. National Aeronautics and Space Administration). Fire Resistant Coating Composition. U.S. Pat. 3,493,401, Feb. 3, 1970.

[10] Miller, C. R., and P. J. Holtzapfel (assigned to Ashland Oil, Inc., Houston, Tex.). Corrosion Proofing Composition and Method. U.S. Pat. 3,549,391, Dec. 22, 1970.

[11] Marrs, G. J. (assigned to Imperial Chemical Industries, Ltd.). (No title). British Pat. 1,209,996, Oct. 28, 1970.

[12] (Patentee not named, no title, assigned to BPB Industries, Ltd.). French Pat. 2,009,310, Jan. 30, 1970.

[13] Flatz, J., and H. G. Seipp (assigned to Brown, Boveri & Co., Ltd.). (No title). British Pat. 1,186,087, Apr. 2, 1970.

Thorium

By Walter C. Woodmansee [1]

Domestic thorium production and demand remained relatively unchanged during 1970. There were no demand pressures because available supply was well in excess of consumption, owing to the fact that monazite sands are processed primarily for their rare-earth-oxide (REO) content.

Private and Government research and development continued on thorium as a nuclear fuel. Construction was underway on the first fully commercial nuclear power reactor utilizing the Th_{232}-U_{233} fuel cycle. The Atomic Energy Commission (AEC) estimates that annual demand may reach 500 tons of ThO_2 by 1980 if this application proves to be an economic and technologic success and 3,000 tons ThO_2 by 1990 if thorium-fueled reactors effectively penetrate the nuclear power market.[2]

Legislation and Government Programs.—Effective January 1, 1970, ad valorem duties were reduced to 24 percent on thorium compounds, 8.5 percent on thorium metal, and 10 percent on thorium alloys under the "Kennedy round" schedule of tariff reductions.

The U.S. Government's supplemental stockpile in the form of thorium nitrate remained at 1,832 tons ThO_2 equivalent, almost 1,800 tons ThO_2 equivalent in excess of the reduced objective of 40 tons ThO_2 equivalent. Although stockpile reductions were authorized, no disposals were made in 1970. In addition, AEC maintained its inventory of 1,775 tons ThO_2 equivalent in concentrates, compounds, and metal for nuclear research.

DOMESTIC PRODUCTION

Mine Production.—Domestic thorium mine production was essentially all from the Humphreys Mining Co. placer operation near Folkston, Ga., where monazite is a byproduct of titanium and zirconium recovery. Although specific data are withheld, output of monazite, containing an estimated 55 percent REO and 5 percent ThO_2, increased substantially in 1970, owing mainly to growing demand for the REO. Minor production of a low-grade monazite concentrate by Climax Molybdenum Co. at Climax, Colo., was discontinued.

Kerr-McGee Chemical Corp. conducted pilot plant tests on a large heavy-mineral placer deposit, containing rutile, ilmenite, and zirconium, in addition to monazite, in Natchez Trace State Park, between Camden and Lexington, in western Tennessee. Recovery of byproduct monazite is scheduled from a similar deposit near Green Cove Springs, in northern Florida, by mid-1972. The operating company, Titanium Enterprises, is a joint venture of American Cyanamid Co. and Union Camp Corp. The latter company controls the reserves, which are in an area of its extensive forest holdings.

Refinery Production.—Domestic output of thorium compounds, derived from the processing of monazite concentrates, also is not divulged to avoid disclosing individual company confidential data. These thorium compounds continued to be produced by two firms—Lindsay Rare Earths (formerly American Potash & Chemical Corp.), a subsidiary of Kerr-McGee Chemical Corp., at West Chicago, Ill., and the Davison Chemical Division of W. R. Grace & Co., at Chattanooga, Tenn. A number of companies process and fabricate the various thorium compounds and thorium metal, mainly for use in nuclear fuel core components.

[1] Physical scientist, Division of Nonferrous Metals.
[2] U.S. Atomic Energy Commission. The Nuclear Industry, 1970. November 1970, pp. 46–47.

Table 1.—Principal companies with capacity for processing and fabricating thorium in 1970 [1]

Company	Location	Facilities [2]
The Dow Chemical Co	Midland, Mich	p.
Gallard-Schlesinger Chemical Manufacturing Corp	Carle Place, N.Y	p.
General Electric Co	San Jose, Calif	f.
Do	Wilmington, N.C	f.
W. R. Grace & Co	Chattanooga, Tenn	p.
Gulf General Atomic, Inc	San Diego, Calif	p,f.
Kerr-McGee Chemical Corp	Cimarron, Okla	p,f.
Lindsay Rare Earths [3]	West Chicago, Ill	p.
National Lead Co	Albany, N.Y	p,f.
Nuclear Chemicals and Metals Corp	Huntsville, Tenn	p,f.
Nuclear Fuel Services, Inc	Erwin, Tenn	p,f.
Nuclear Materials & Equipment Corp. (NUMEC)	Apollo, Pa	p,f.
Do	Leechburg, Pa	f.
Tennessee Nuclear Specialties, Inc	Jonesboro, Tenn	p,f.
United Nuclear Corp	Hematite, Mo	p,f.
Do	New Haven, Conn	p,f.
Ventron Corp	Beverly, Mass	p.
Westinghouse Electric Corp	Bloomfield, N.J	p.
Do	Columbia, S.C	f.

[1] Includes manufacturing of thorium-based nuclear fuels.
[2] p—processor; f—fabricator.
[3] Subsidiary of Kerr-McGee Chemical Corp.

Principal Source: U.S. Atomic Energy Commission. The Nuclear Industry—1970, November 1970, pp. 82–83, 94.

Table 2.—Principal producers and fabricators of magnesium-thorium alloys

Company	Plant location
American Light Alloys, Inc	Little Falls, N.J.
Controlled Castings Corp	Plainview, N.Y.
Hills-McCanna Co	Carpentersville, Ill.
R. C. Hitchcock and Sons, Inc	Minneapolis, Minn.
Howard Foundry Co	Chicago, Ill.
Phelps Dodge Aluminum Products Corp. [1]	Madison, Ill.
Rolle Manufacturing Co. [2]	Lansdale, Pa.
Wellman Dynamics Corp	Bay City, Mich.

[1] For The Dow Chemical Co., Midland, Mich.
[2] Ceased operations yearend 1970.

CONSUMPTION AND USES

Nonenergy.—Domestic monazite is processed primarily for its REO, and byproduct thorium therefore is produced in excess of demand, resulting in continued additions to stocks. U.S. industrial demand for thorium for nonenergy uses continued at an estimated 100 to 120 tons per year. The specialized nonenergy uses of thorium are limited by the fact that the metal and its alloys are vulnerable to substitution by other, less costly metals. Welsbach incandescent gas-light mantles continued to absorb an estimated 50 percent of total nonenergy demand. Thorium magnesium hardener alloys, containing about 40 percent thorium, for use in making magnesium-base alloys (3 percent thorium) were the dominant nonenergy use for several years prior to 1966, but their use has dropped off to an estimated 30 percent of nonenergy demand in 1970. Dispersion-hardened alloys, where 2 percent ThO_2 provides superior strength and corrosion resistance to such metals as nickel, cobalt, tungsten, and molybdenum at elevated temperatures, accounted for about 10 percent of 1970 demand. Miscellaneous chemical, refractory, electronic, and other uses for the oxide and the metal accounted for the remainder during 1970.

Energy.—AEC continued to provide support in research and development of converter and breeder reactor concepts utilizing the Th_{232}-U_{233} fuel cycle. Small capacity, thorium-fueled experimental or prototype reactors continued to generate electric power at Elk River, Minn. (20-megawatt, water-cooled reactor) and Peach Bottom, Pa. (40-megawatt, gas-cooled reactor). The first fuel core of the Peach Bottom reactor was replaced with an improved second core in 1970.

Construction continued near Platteville, Colo., on the Fort St. Vrain, 330-megawatt, high-temperature, gas-cooled reactor (HTGR), designed by Gulf General Atomic, Inc., for the Public Service Co. of Colorado. This plant, scheduled for completion in 1972, is the first fully commercial application of the HTGR concept and the Th_{232}-U_{233} fuel cycle. A 1,000-megawatt HTGR is in the design stage.

PRICES

The domestic nominal price on carload lots of monazite sand concentrate remained steady at $180 to $200 per long ton (based on REO only), equivalent to about 8 to 9 cents per pound. The average price of imported monazite was $123.96 per short ton in 1970, compared with $117.50 in 1969.

Prices listed for thorium compounds by the Davison Chemical Division, W. R. Grace & Co., Chattanooga, Tenn., in May 1970 were in the following ranges, per pound, depending on quantity of purchase: Thorium nitrate, wire grade, 47 percent ThO_2, $2.45–$2.50; thorium nitrate, mantle grade, 47 percent ThO_2, $2.50–$2.55; ThO_2, ceramic grade, 99.9 percent ThO_2, $5.80–$10; and ThO_2, refractory grade, 99.9 percent ThO_2, $7–$11. Lindsay Rare Earths, West Chicago, Ill., quotations for 1970–71 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. Thorium-magnesium hardener alloys (40 percent thorium) sold for about $5 per pound, based on thorium content at 40 percent and prevailing magnesium prices.

FOREIGN TRADE

Exports.—Shipments of thorium ores and concentrates, listed in terms of ThO_2 content, dropped markedly in 1970. Foreign shipments of thorium compounds, metal, and alloys are not differentiated from uranium in official trade statistics; the latter probably constitutes the bulk of these exports.

Imports.—Australia and Malaysia remained the principal foreign sources of monazite during 1970; these two countries accounted for 95 percent of U.S. imports of monazite during the year. Among the compounds, thorium nitrate in incandescent gas mantles was the most significant import; a modest price increase was indicated for this product.

Table 3.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in pounds unless otherwise specified)

	1968		1969		1970		Principal sources and destination, 1970
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Ore and concentrate (ThO_2 content)	1,476	$11,201	1,544	$11,181	81	$1,296	Japan 77; West Germany 4.
Metals and alloys [1]	6,235	125,686	788	26,182	5,503	86,021	Japan 4,885; Canada 335; Italy 189.
Compounds [1]	113,283	322,062	105,620	316,561	4,045,549	24,579,293	United Kingdom 2,007,967; Switzerland 1,066,924; Canada 555,954.
IMPORTS							
Ore and concentrate:							
Monazite (short tons)	4,367	562,725	4,206	493,802	3,448	427,411	Australia 1,977; Malaysia 1,307.
ThO_2 content [e]	524,000	--------	504,700	--------	413,800	----------	
Compounds:							
Nitrate	--------	--------	--------	--------	5	382	All from United Kingdom.
Oxide	705	5,216	442	2,514	10	280	Do.
Oxide equivalent, in gas mantles [e 2]	3,400	329,814	4,100	398,414	4,100	409,110	United Kingdom 3,650; West Germany 350.
Other	68	9,947	236	25,848	252	23,253	Switzerland 214; West Germany 20; United Kingdom 18.
Metal	50	700	--------	--------	----------	----------	

[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 accounted for almost all the estimated world production of monazite concentrates in 1970, exclusive of U.S. output, data on which are withheld.

Canada.—Although thorium production was suspended by the Nuclear Products Dept., Rio Algom Mines Ltd., with closure of the Nordic mill at Elliot Lake, Ontario, in 1968, small quantities of a thorium sulfate concentrate, called "thorium cake", were subsequently transferred from inventory to the Quirke refinery, which produced a metallurgical-grade ThO_2 (99+ percent purity). This product was shipped to Dominion Magnesium, Ltd., Haley, Ontario, where 98-percent thorium sintered pellets and 99.5-percent thorium powder were produced. Output was limited (only 919 pounds in 1969), because of weak demand.

India.—The Minerals Division, Indian Rare Earths Ltd., produced 2,708 tons of monazite concentrate at Quilon during fiscal 1969–70. The Alwaye monazite plant was operated at partial capacity, based on markets for the rare-earths. Sales improved later in the year, and plant No. 2 at Manavalakurichi was reopened. Monazite sales during the fiscal year totaled 3,270 tons, valued at the equivalent of $1,375,600. The Indian Government paid $90,500 for thorium hydroxide, derived from the monazite.[3]

Table 4.—Monazite concentrates: World production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
Australia	[r] 3,590	4,397	[e] 4,400
Brazil	[r] 1,864	2,204	[e] 2,200
Ceylon	46	62	18
Congo (Kinshasa)	NA	196	158
India [2]	3,789	2,708	[e] 3,800
Malagasy Republic	2	2	------
Malaysia [3]	[r] 2,357	2,264	1,827
Nigeria [2]	7	14	1,400
Thailand	44	72	119
United States	W	W	W
Total	[r] 11,699	11,919	13,922

[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, Indonesia and North Korea produce monazite, but information is insufficient to make reliable estimates of output levels.

[2] Year beginning April 1.

[3] Exports.

WORLD RESERVES

Noncommunist world resources of thorium have been reevaluated for the Organization for European Cooperation and Development.[4] "Reasonably assured" resources total more than 500,000 tons ThO_2, and "estimated additional" resources are slightly below 1 million tons ThO_2, at less than $10 per pound ThO_2 and present thorium technology. Most of these resources are in monazite placer deposits, chiefly in India and Australia.

The United States and Canada have large resources of nonmonazite thorium. An AEC report, published by the Idaho Bureau of Mines and Geology, describes the Lemhi Pass deposits. Reserves are estimated at 100,000 tons "reasonably assured" and several hundred thousand tons "estimated additional" to depths of 3,000 feet.[5]

TECHNOLOGY

Nonenergy.—Systematic studies continued on the thermodynamics of formation of thorium-nickel alloys.[6] Research involved the use of electromotive force cells with solid CaF_2 as the electrolyte.

Research at National Lead Co., resulted in a modification to the Ames process for production of thorium metal by reduction of ThF_4, which reportedly makes the operation safer and produces a higher quality metal.[7] A dense, crystalline ThF_4, amena-

[3] Indian Rare Earths Ltd. 20th Annual Report, 1969–70, 38 pp.

[4] European Nuclear Energy Agency and the International Atomic Energy Agency. Uranium Resources, Production and Demand. September 1970, p. 39.

[5] Engineering and Mining Journal. V. 171, No. 5, May 1970, p. 132.

[6] Skelton, W. H., N. J. Magnani, and J. F. Smith. Thermodynamics of Formation of Th-Ni Alloys. Met. Trans., v. 1, No. 7, July 1970, pp. 1833–1837.

[7] Briggs, G. G., and J. H. Cavendish. Thorium Metal Production. Journal of Metals. V. 22, No. 12, December 1970, pp. 25a–26a.

ble to rapid filtration and efficient washing, was produced by precipitation. The use of nonhygroscopic ZnF_2 rather than $ZnCl_2$ as the source of zinc in the reduction charge reduced the potential for hydrogen generation by reaction between moisture and calcium metal, thereby reducing the explosion hazard. The use of ZnF_2 in the reduction process also permitted the use of CaF_2 slag from the reaction as liner material for the reduction vessels. This development reportedly improved the purity of the metal produced.

A recent U.S. Bureau of Mines publication contains data on U.S. and world thorium resources, technology, economics, and statistics.[8]

Energy.—Except for the HTGR, studies on the technology of thorium-based nuclear fuels have been limited to research and development. The AEC continued to provide support in research on and development of converter and breeder concepts utilizing the Th_{232}-U_{233} fuel cycle. Fuel preparation, core development, materials irradiation, reprocessing, and equipment design and engineering were under investigation at the AEC's Oak Ridge National Laboratory (ORNL), Tenn., and by private industry. Irradiated thorium fuels were processed at AEC's Savannah River and Hanford chemical separation plants to recover U_{233}, the fissionable isotope.

In addition to work at ORNL, Gulf Energy and Environmental Systems, San Diego, Calif., continued its research on the HTGR, which operates on the thorium-uranium fuel cycle and uses helium as a coolant. Because of its high-efficiency, high-temperature steam cycle, the HTGR offers the near-term prospect for substantial improvement in fuel utilization.

The 40-megawatt, gas-cooled power plant at Peach Bottom, Pa., which was successfully refueled during the year, has operated continuously since the refueling.

According to Gulf Energy, the HTGR under construction at Fort St. Vrain, near Platteville, Colo., will produce 840 megawatts of thermal energy steam at 2,400 pounds per square inch and 1,000° F with reheat to about 1,000° C for generation of 330 megawatts (net) electric power, or net plant efficiency of 39 percent. The quantity of U_{233} bred is expected to equal about one-third the initial U_{235} charge.[9]

An HTGR design, capable of producing sufficient high-quality steam to generate 1,100 megawatts in a conventional reheat steam cycle, was described at a recent conference.[10] This concept is based on technology similar to the HTGR under construction in Colo., but several improvements in design improve safety and efficiency of operation and maintenance.

At AEC's Bettis Atomic Power Laboratory, work continued on development of a fuel core to demonstrate potential for breeding in the light-water reactor (LWR), based on seed-blanket technology with the thorium-uranium fuel cycle, used at the Shippingport Atomic Power Station in Pennsylvania. This concept offers the prospect of LWR fuel utilization improved beyond the 1 to 2 percent of operating LWR's. Successful LWR breeding, with breeder cores installed in existing and future LWR's, would probably provide incentives for development of the extensive thorium resources in the western United States.[11]

AEC also requested proposals for a design study of a 1,000-megawatt molten-salt breeder reactor (MSBR). There was also a significant increase in private efforts involving this concept. The Molten Salt Breeder Reactor Associates, an association of five electric utility companies and a consulting engineering firm, completed Phase I of their study of the MSBR. In addition, 15 utility companies and six major industrial companies formed the Molten Salt Group, which will jointly study MSBR technology, including the feasibility of thorium as a fuel.[12]

The solubility of thorium in liquid bismuth over a temperature range of 450° C to 900° C was investigated in connection with research on the processing of MSBR fuels.[13] Thorium acts as a selective reductant of actinide and lanthanide elements,

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[8] Parker, John G., and Charles T. Baroch. The Rare-Earth Elements, Yttrium, and Thorium. A Materials Survey. BuMines Inf. Circ. 8476, 1971, 92 pp.

[9] Gulf General Atomic, Inc. Power for the World. 20 pp.

[10] Gulf General Atomic, Inc. Large HTGR Design Status. Proceedings of the Gas-Cooled Reactor Information Meeting, Oak Ridge National Laboratory. Conf.-700401, Apr. 27–30, 1970, pp. 195–213.

[11] U.S. Atomic Energy Commission. Annual Report to Congress. January 1971, pp. 158–160.

[12] Wall Street Journal. V. 176, No. 29, Aug. 10, 1970, p. 17.

[13] Schilling, C. E., and L. M. Ferris. The Solubility of Thorium in Liquid Bismuth. J. Less-Common Metals (Amsterdam, Netherlands), v. 20, No. 2, February 1970, pp. 155–169.

and its solubility governs the reductant concentration.

Technical data on thorium and its applications to fuel technology were compiled recently.[14] Similar publications were planned on other ceramic compounds of thorium.

[14] U.S. Atomic Energy Commission, Oak Ridge National Laboratory. Thorium Ceramics Data Manual. V. 1, Oxides. ORNL-4503, September 1970, 74 pp.

Tin

By John R. Lewis [1]

Free world tin supplies and demand were fairly close to balance in 1970. U.S. consumption of primary and secondary tin combined was off about 8.6 percent for the year, but greater use elsewhere helped to bring about the approach to a world balance.

In the United States, primary tin consumption was off 8.1 percent while secondary was off 9.8 percent. Declines were most severe in the heavier tin-consuming sectors: tinplate (off 6.5 percent) bronze and brass (off 17 percent), and solder (off 5 percent). Exclusively as the mineral cassiterite (SnO_2), tin is mined and smelted at many places around the world, mainly outside the United States. Most of the nation's primary tin metal came from Malaysia and Thailand in 1970 while less than 100 long tons were mined domestically from widely scattered mines in the western States and Alaska. The United States continued to lead the world in the recovery and use of reclaimed (secondary) tin during 1970, and around one-third of the national supply came from scrap smelted in about 85 smelters located all across the country.

After a year of primary tin smelting inactivity, the only major smelter-refinery in the United States, Gulf Chemical and Metallurgical Corp. at Texas City, Tex., began the smelting of Bolivian tin concentrates under a toll agreement with the Bolivian Mining Corp. (COMIBOL). COMIBOL, in turn, offered the tin to U.S. consumers through its New York City office.

Legislation and Government Programs.— There was no legislation directly affecting tin during 1970.

No strategic stockpile tin was disposed of by the General Services Administration (GSA) through commercial channels during the year. Slightly more than 3,065 long tons were shipped by GSA; some were in small, intragovernmental transfers, but the bulk was shipped under programs of the Agency for International Development (AID). The stockpile objective remained at 232,000 long tons, and at the end of the year there was an excess of about 20,000 long tons on hand.

On December 9, 1970, a U.S. House of Representatives Armed Services Subcommittee held a factfinding hearing on the excess of tin in the stockpile. The Subcommittee chairman stated that no new legislation or new commitments were under consideration, and he pointed out that GSA already had authority to sell the excess. The witnesses, from Government, tinplate mills, and the Texas City tin smelter, were divided in their points of view. By the end of 1970, no subsequent action had been taken by the Subcommittee, nor did any appear imminent.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient tin statistics

(Long tons)

	1966	1967	1968	1969	1970
United States:					
Production:					
Mine	97	W	W	W	W
Smelter	3,825	3,048	3,453	345	NA
Secondary	25,349	22,667	22,495	22,775	20,001
Exports (exports and reexports)	2,847	2,479	4,495	2,903	4,452
Imports for consumption:					
Metal	41,699	50,223	57,358	54,950	50,554
Ore (tin content)	4,372	3,255	2,439	-------	4,467
Consumption:					
Primary	60,185	57,848	58,859	57,730	53,027
Secondary	25,277	22,790	23,102	23,060	20,802
Price: Straits tin, in New York, average cents per pound	164.02	153.405	148.111	164.435	174.135
World production:					
Mine	208,071	214,233	228,332	224,079	226,569
Smelter	200,510	219,175	229,564	223,426	222,206

NA Not available. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Annual production of tin in the United States was again in 1970 somewhat less than 100 long tons. Most of the year's output came from Colorado, a byproduct of the mining of molybdenum.

A Toronto-based exploration firm, P.C.E. Explorations, with an interest in Lost River Mining Corp.'s fluorite-tin-tungsten acreage on the Seward Penninsula west of Nome, Alaska, spent the summer on an extensive core-drilling program. Although the major effort was in search of fluorite, at least one multimineral reserve (10 million tons of fluorite-tin-tungsten ores) was established. Based upon tests, tin concentrates of 70 percent with overall recoveries of 80 to 85 percent appeared feasible from this area, and fluorite possibilities far outshone others.

Smelter Production.—The only tin smelter in the United States is the Texas City, Tex., facility of Gulf Chemical and Metallurgical Corp. In 1970 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 of Bolivia's state-owned COMIBOL, and the resulting metal was then sold by COMIBOL to U.S. consumers. A total of 6,000 long tons of tin were involved in the contract but only about half was processed by yearend. Thus, to all intents and purposes, U.S. consumers were wholly dependent upon foreign tin in 1970.

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 1970 did not exist as bar, pig, or other types of actual metal, but as an alloy constituent of bronzes, brasses, solders, bearing and type metals, etc. A small amount also remains in chemical compounds. Only about 15 percent of the recycled tin, mostly from new tinplate scrap, finds its way to market as metal. It accounts for only four percent of the total tin supplied to U.S. consumers in 1970, a proportion which does not vary appreciably from year to year.

Secondary tin furnishes 28 to 30 percent of the total tin supplied to U.S. markets each year. However, secondary tin pro-

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1969	1970
Tinplate scrap treated [1] ---------long tons--	831,713	771,415
Tin recovered from tinplate scrap in the form of—		
Metal ---------long tons--	2,420	1,988
Compounds (tin content) -----do----	560	620
Total [2] ----------do----	2,980	2,608
Weight of tin compounds produced -----do----	r 990	1,104
Average quantity of tin recovered per long ton of tinplate scrap used--pounds--	8.03	7.57
Average delivered cost of tinplate scrap----per long ton--	$26.35	$36.28

r Revised.
[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.
[2] In addition, detinners recovered 489 long tons (413 tons in 1969) of tin as metal and in compounds from tin-base scrap and residues in 1970.

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

(Long tons)

Form of recovery	1969	1970
Tin metal:		
At detinning plants-------	2,813	2,397
At other plants-----------	209	177
Total-----------------	3,022	2,574
Bronze and brass:		
From copper-base scrap----	11,513	9,191
From lead and tin-base scrap-----------------	146	86
Total-----------------	11,659	9,277
Solder----------------------	4,645	4,898
Type metal------------------	1,497	1,517
Babbitt---------------------	817	683
Antimonial lead-------------	510	351
Chemical compounds----------	584	700
Miscellaneous [1]---------------	41	1
Total-----------------	8,094	8,150
Grand total------------	22,775	20,001
Value (thousands)---	$83,825	$77,956

[1] Includes foil, cable lead, and terne metal.

duced in this country was off in 1970 by some 2,774 long tons (12 percent), probably due to reduced overall tin consumption.

In the United States, there are five companies, located in 11 States, engaged in the detinning business. At least one firm occasionally detins used cans supplied by nearby social, religious, or community service groups, but normally the raw materials used are tinplate scrap and spent chemicals or tinning solutions.

CONSUMPTION

Consumption of primary and secondary tin, taken together, was off 8.6 percent in 1970. Secondary tin consumption dropped 9.8 percent, while primary tin was off 8.1 percent. A general slowdown in utilization of most of the major tin alloys, such as brass and bronze (off 17.3 percent), babbitt (off 7.6 percent), collapsible tubes and foil (off 24.8 percent), and solder (off 5.2 percent) was a contributing factor. Imports of some of these alloys, notably brass, also contributed to the downtrend. The tinplate industry, by far the largest consuming sector, showed a 6.5 percent drop in tin consumed in 1970. Mostly primary tin is used in the making of tinplate, which accounted for 47 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 1970. It should be pointed out that aluminum cans comprised 10.2 percent of the total cans shipped in 1970, up from 8.1 percent the year before. As 1970 began, there were nine steel companies engaged in the making of tinplate in 16 mills. During the year, Inland Steel Co. and Republic Steel Corp. announced their intention to phase themselves out of the tinplate business as a matter of profitability, and by yearend had almost completed the process.

Consumption of tin for use in chemicals, tin oxide, and in a few minor miscellaneous applications improved during 1970, but the tonnages involved were minimal. Use of tin in chemicals was expected to grow as tin is substituted for mercury in many chemicals, particularly insecticides, fungicides, and the like. It is estimated that 1970 American-built autombiles contained an average of 1½ pounds of tin per vehicle, from ½ to 1 pound of which was used as solder alloy in the copper radiator. Body solders, wire coating, engine bearings, fuel tank coatings, air cleaners, and oil filters were also uses of tin by the automotive sector.

A detailed study, "Trends in the Use of Tin," was released by the National Materials Advisory Board (NMAB) in March 1970. Consumption of tin, by major use categories, in 1970 and 1977, as compared with 1968, are set forth and are based upon presently-known trends and impending developments.[2]

[2] Trends in the Use of Tin. A Report of the National Materials Advisory Board of the National Research Council. National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151, March 1970.

Table 4.—Shipments of metal cans [1]

(Thousand base boxes)

Type of can	1969 r	1970 p	1970 change, percent
FOOD AND BEVERAGES			
Fruit and fruit juices	15,304	13,337	−12.8
Vegetables and vegetable juices	23,365	24,058	+3.0
Milk, evaporated and condensed	2,939	2,534	−13.8
Other dairy products	593	585	−1.3
Soft drinks	23,527	26,197	+11.3
Beer	33,416	37,593	+12.5
Meat and poultry	3,862	3,713	−3.9
Fish and other seafoods	2,653	3,450	+30.0
Coffee	4,215	3,766	−10.7
Lard and shortening	1,658	1,734	+4.6
Baby foods	1,009	1,053	+4.4
Pet foods	6,162	6,524	+5.9
All other foods, including soups	13,846	14,017	+1.2
Total	132,549	138,561	+4.5
NONFOOD			
Oils	2,954	3,108	+5.2
Paint and varnish	4,845	4,886	+0.8
Antifreeze	890	816	−8.3
Pressure packing (valve type)	5,105	5,432	+6.4
All other nonfood	6,274	6,481	+3.3
Total	20,068	20,723	+3.3
Grand total	152,617	159,284	+4.4
BY METAL			
Steel base boxes [2]	140,248	143,049	+2.0
Short tons (thousand)	5,587	5,699	+2.0
Aluminum base boxes	12,369	16,235	+31.3
Short tons (thousand)	270	354	+31.1

r Revised. p Preliminary.
[1] Includes tinplate and aluminum cans.
[2] The base box, a unit commonly used in the tinplate industry, equals 31,360 sq. in. of plate or 62,720 sq. in. of total surface area.

Sources: U.S. Department of Commerce; The Malayan Tin Bureau, Washington, D.C.

Table 5.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1970

(Long tons)

Type of scrap and class of consumers	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)	2,287	43,121	--------	44,071	44,071	1,337	--------	1,895	1,895
Brass, composition or red	3,515	69,460	17,287	52,780	70,067	2,908	651	1,963	2,614
Brass, low (silicon bronze)	479	4,385	3,177	872	4,049	815	--------	5	5
Brass, yellow	6,279	50,402	6,555	45,882	52,437	4,244	24	456	480
Bronze	2,277	25,009	4,121	20,600	24,721	2,565	320	1,623	1,943
Low-grade scrap and residues	5,365	41,098	33,514	6,776	40,290	6,173	15	--------	15
Nickel silver	506	3,659	649	2,953	3,602	563	6	23	29
Railroad-car boxes	147	1,966	--------	1,881	1,881	232	--------	89	89
Total	20,855	239,100	65,303	175,815	241,118	18,837	1,016	6,054	7,070
Brass mills: [1]									
Brass, low (silicon bronze)	3,346	39,679	39,679	--------	39,679	4,079	4	--------	4
Brass, yellow	22,663	230,320	230,320	--------	230,320	22,507	168	--------	168
Bronze	700	5,301	5,301	--------	5,301	725	253	--------	253
Mixed alloy scrap	1,196	--------	1,196	--------	1,196	--------	--------	--------	--------
Nickel silver	2,868	16,861	16,861	--------	16,861	2,618	--------	--------	--------
Total	30,773	292,161	293,357	--------	293,357	29,929	425	--------	425
Foundries and other plants: [2]									
Auto radiators (unsweated)	725	6,369	--------	6,566	6,566	528	--------	295	295
Brass, composition or red	504	5,272	1,388	3,781	5,169	607	66	180	246
Brass, low (silicon bronze)	17	388	202	176	378	27	--------	--------	--------
Brass, yellow	574	5,264	2,412	2,752	5,164	674	5	19	24
Bronze	238	767	356	445	801	204	31	37	68
Low-grade scrap and residues	412	741	279	371	650	503	--------	--------	--------
Nickel silver	7	23	21	6	27	3	--------	--------	--------
Railroad-car boxes	447	23,078	--------	23,184	23,184	341	--------	1,101	1,101
Total	2,924	41,902	4,658	37,281	41,939	2,887	102	1,632	1,734
Total tin from copper-base scrap	--------	--------	--------	--------	--------	--------	1,543	7,686	9,229

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 1970—Continued

(Long tons)

Type of scrap and class of consumers	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31	New	Old	Total
			New	Old	Total				
Lead-base scrap: Smelters, refiners, and others:									
Babbitt	324	10,661	--------	10,535	10,535	450	--------	511	511
Battery lead plates	37,746	452,713	--------	457,170	457,170	33,289	--------	487	487
Drosses and residues	r 19,969	112,821	108,720	--------	108,720	24,070	2,269	--------	2,269
Solder and tinny lead	340	9,517	--------	9,500	9,500	357	--------	1,474	1,474
Type metal	2,928	27,061	--------	28,572	28,572	1,417	--------	1,357	1,357
Total	r 61,307	612,773	108,720	505,777	614,497	59,583	2,269	3,829	6,098
Tin-base scrap: Smelters, refiners, and others:									
Babbitt	34	235	4	244	248	21	3	204	207
Block-tin pipe	10	166	--------	167	167	9	--------	165	165
Drosses and residues	160	3,051	2,684	--------	2,684	527	1,197	--------	1,197
Pewter	2	8	--------	9	9	1	--------	8	8
Total	206	3,460	2,688	420	3,108	558	1,200	377	1,577
Tinplate scrap: Detinning plants	--------	--------	771,415	--------	771,415	--------	3,097	--------	3,097
Grand total	--------	--------	--------	--------	--------	--------	8,109	11,892	20,001

r Revised.
1 Brass mill stocks include home scrap; purchased scrap consumption assumed equal to receipts; therefore, lines and totals 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)

	1966	1967	1968	1969	1970
Stocks Jan. 1 [1]	37,277	32,718	30,087	28,152	23,441
Net receipts during year:					
Primary	56,869	56,324	59,018	55,125	52,166
Secondary	2,713	2,884	2,101	2,325	2,424
Scrap	23,654	21,492	21,919	21,624	19,748
Total receipts	83,236	80,700	83,038	79,074	74,338
Total available	120,513	113,418	113,125	107,226	97,779
Tin consumed in manufactured products:					
Primary	60,185	57,848	58,859	57,730	53,027
Secondary	25,277	22,790	23,102	23,060	20,802
Total	85,462	80,638	81,961	80,790	73,829
Intercompany transactions in scrap	2,333	2,693	3,012	2,995	2,785
Total processed	87,795	83,331	84,973	83,785	76,614
Stocks Dec. 31 (total available less total processed)	32,718	30,087	28,152	23,441	21,165

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1966—135 tons; 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)
1966	42,290	366	19.4	5,154,550	28,194	12.3	675,558	5,872,398	28,560	10.9
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

[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.—Consumers receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Straits	Thaisarco	Others	Total
1966	709	433	95	30,560	9,815	[1] 15,257	56,869
1967	404	704	91	31,980	13,400	[1] 9,745	56,824
1968	305	950	12	41,048	11,600	5,103	59,018
1969	95	1,275	30	37,350	13,200	3,175	55,125
1970	1,320	315	10	32,385	15,300	2,836	52,166

[1] Includes GSA receipts not reported under specific brands.

Table 9.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

	1969			1970		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	477	192	669	407	133	540
Babbitt	2,128	1,378	3,506	1,944	1,297	3,241
Bar tin	1,009	34	1,043	1,019	33	1,052
Bronze and brass	4,155	12,371	16,526	3,387	10,279	13,666
Chemicals including tin oxide	1,857	1,250	3,107	1,671	1,524	3,195
Collapsible tubes and foil	1,114	29	1,143	855	5	860
Pipe and tubing	43	5	48	23	3	26
Solder	14,936	6,347	21,283	13,910	6,274	20,184
Terne metal	207	181	388	222	47	269
Tinning	2,238	51	2,289	2,080	63	2,143
Tinplate [1]	26,886	--------	26,886	25,127	--------	25,127
Tin powder	1,213	61	1,274	1,011	48	1,059
Type metal	116	994	1,110	145	964	1,109
White metal [2]	1,266	118	1,384	1,156	40	1,196
Other	85	49	134	70	92	162
Total	57,730	23,060	80,790	53,027	20,802	73,829

[1] Includes secondary pig tin and tin acquired in chemicals.
[2] Includes pewter, britannia metal, and jewelers' metal.

STOCKS

The tinplate mills of the United States 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 began to manifest themselves by yearend when primary tin stocks were found to be 23 percent below stocks 1 year previously.

An overall downward trend in industrial stocks of tin in the United States, which began in 1966, persisted in 1970. The grand total of stocks of all tin in the hands of, or enroute to, U.S. industrial consumers was off 14 percent on December 31, 1970, from stocks at yearend 1969, which in turn were off 14.8 percent from the year before that. In addition to the 23-percent reduction of primary metal stocks, the volume afloat at yearend 1970 was down. However the volume afloat at yearend 1969 was abnormally high, and shipments in December 1970 from Malaysia, principal supplier to the United States, were temporarily very low. On the other hand, stocks of secondary tin on hand at the end of 1970 appeared to be about 5 percent higher than those of a year earlier, probably reflecting slightly reduced demand with an accompanying inventory buildup.

An important factor in increased stocks of tin in process in 1970 was the greater use of tin in the making of float glass (plate). Tin in the float glass vats is arbitrarily carried as "in process". Losses from the vats are minimal.

Table 10.—U.S. industry yearend tin stocks

(Long tons)

	1966	1967	1968	1969	1970
Plant raw materials:					
Pig tin:					
Virgin	20,531	17,044	15,975	12,281	9,451
Secondary	276	283	215	253	222
In process [1]	11,911	12,760	11,962	10,907	11,492
Total	32,718	30,087	28,152	23,441	21,165
Additional pig tin:					
In transit in United States	90	20	1,185	80	10
Jobbers-importers	[2] 1,790	1,315	1,182	1,210	1,635
Afloat to United States	3,415	4,890	5,390	5,865	3,500
Total	5,295	6,225	7,757	7,155	5,145
Grand total	38,013	36,312	35,909	30,596	26,310

[1] Tin content, including scrap.
[2] Includes GSA as follows: 1,539 tons end of December 1966, sold but not delivered; 428 tons end of December 1967, sold but not delivered.

PRICES

The world metal markets saw London tin prices go from around £1,535 per metric ton in an erratic and generally slow January to £1,649 per ton around April 20, 1970. A surge of buying began to be obvious around April 10, when the price reached the International Tin Council (ITC) "must sell" level of £1,605; London Metal Exchange sources maintained that it was caused by speculators. On the afternoon of April 16, 1970, the Chairman of the ITC issued this communique from London: "The Buffer Stock Manager has, in accordance with Article XI 3 (a) of the (Third International Tin) Agreement, offered available cash tin for sale on the London Metal Exchange at the ceiling price. The cash tin at the Manager's disposal at present is exhausted, but the Manager still has, as a result of the nature and location of his holdings, tin metal at his disposal." It was speculated that he had between 500 and 1,500 tons, possibly in transit or so located that it was not immediately available for delivery.

Table 11.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1969			1970		
	High	Low	Average	High	Low	Average
January	165.000	160.000	162.500	184.500	174.000	179.169
February	167.500	164.000	165.184	177.250	170.000	174.910
March	162.500	152.500	155.524	179.250	175.500	177.125
April	159.250	154.250	156.810	188.000	178.750	183.875
May	158.000	155.500	156.666	185.500	172.500	180.538
June	160.000	157.500	159.000	175.000	166.250	170.227
July	166.000	159.250	162.000	166.250	163.750	164.773
August	167.250	163.000	165.905	178.500	165.000	174.512
September	167.000	163.750	165.643	177.250	173.500	174.738
October	168.250	163.000	166.707	174.500	171.750	173.648
November	186.750	168.500	175.956	174.000	169.000	172.250
December	187.500	179.500	181.321	170.250	160.500	163.852
Average	187.500	152.500	164.435	188.000	160.500	174.135

Source: American Metal Market.

FOREIGN TRADE

For the most part during 1970 the United States continued to depend 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 1970 some Bolivian tin which was toll-smelted in the United States went to U.S. consumers. Malaysia furnished 63 percent of the tin imported into the United States in 1970 against 69 percent 1 year earlier. The Phuket smelter, Thailand's only smelting facility, furnished 30 percent of the U.S. imports of primary tin in 1970 against 25 percent in 1969. Five other nations—Australia, Brazil, Indonesia, Nigeria, and the United Kingdom—combined to furnish 6.1 percent of U.S. tin requirements in 1970. Reductions in imports of primary tin metal were very nearly parallel to reductions in consumption in 1970; imports were off 8 percent from the previous year, while U.S. primary tin consumption was off 8.1 percent in the same period.

A table, "U.S. imports for consumption of tin concentrate, by countries," is usually included at this point in this discussion. However, there were no imports of tin concentrate in 1969. In 1970, a total of 4,667 long tons of tin concentrate, valued at $13,987,000, arrived from Bolivia. This was all that was imported, and it was involved in the toll-smelting agreement between Bolivia's COMIBOL and the Texas City tin smelter. Details of the agreement are presented in the section entitled "Smelter Production." Imports of tin concentrate in 1968 totalled 2,439 long tons of which 2,337 tons came from Bolivia. The balance came from Australia, 96 tons, and the Congo (Kinshasa), 6 tons.

Table 12.—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)
1968	3,813	$12,734	682	$2,267	249,392	$41,898	203,269	$39,156	13,631	$1,405	15,827	$541
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

Minor 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. That tin which 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 13.—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)		
1968	$2,742	487	$532	$2,676	39	$81
1969	3,458	948	1,052	4,825	22	71
1970	4,311	776	275	2,466	272	817

Table 14.—U.S. imports for consumption of tin [1], by countries

Country	1969		1970	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Australia	330	$1,346	441	$1,505
Belgium-Luxembourg	31	106	11	42
Brazil	-------	--------	388	1,452
Canada	r 24	r 89	2	15
Germany, West	-------	--------	(2)	1
India	25	80	--------	---------
Indonesia	205	745	1,360	4,985
Malaysia	r 37,945	r 127,857	31,819	118,619
Netherlands	267	901	70	283
Nigeria	170	590	481	1,885
Norway	-------	--------	5	19
Portugal	40	132	--------	---------
Singapore	20	68	72	280
South Vietnam	50	159	--------	---------
Spain	24	89	98	402
Thailand	13,946	46,206	15,395	56,678
United Kingdom	1,873	6,669	412	1,496
Total	54,950	185,037	50,554	187,662

r Revised.
[1] Bars, blocks, pigs, grain, or granulated.
[2] Less than ½ unit.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The International Tin Council met four times during 1970, a year which saw unusual activity and some changes in the operational procedures of the Council. Because of an outdated range of prices under which the Buffer Stock Manager bought and sold, his function had been restricted late in 1969. This restriction was continued at the 15th Council meeting of the Third International Tin Agreement in London on January 13–14, 1970. Late in February, at the 16th meeting, it was determined that the restrictions were no longer needed, and they were rescinded effective March 1, 1970. At the 18th meeting on October 19–21, the Council agreed to revise all prices in the Tin Agreement as follows:

	Prices in dollars per long ton	
	Old	New
Floor price	2,976	3,188
Lower sector	2,976 to 3,259	3,188 to 3,448
Middle sector	3,259 to 3,519	3,448 to 3,637
Upper sector	3,519 to 3,790	3,637 to 3,897
Ceiling price	3,790	3,897

Purchases continued at a rapid pace until about April 20th when the London spot prices was up to £1,649 per ton and the New York price was at $1.87 per pound. In early May, profit taking forced prices into a retreat culminating in a sharp break in New York on May 26 when the spot price went down to $1.73 per pound. By mid-June, prices had begun to firm, but the world markets grew nervous on rumors of a possible sale of tin by GSA from the strategic stockpile, which did not materialize.

By mid-August, tin prices had again gone up into ITC's upper range, and clamour became intense for new ITC floor and ceiling prices. An increase of £100 per metric ton to a floor of £1,360 and ceiling of £1,705 was one suggestion from Malaysian interests. On October 21, 1970, ITC, at its regular quarterly meeting, raised its price structure as tabulated above. Prices then moved more or less quietly down for the remainder of 1970.

The average price paid on the New York metal market for prompt delivery of Straits (Malaysian) tin during 1970 was about $1.74 per pound. This was the highest annual average price since 1965. Throughout 1970, the New York monthly average price did not deviate more than 10 cents per pound for the $1.74 annual average. The only spectacular fluctuation was that at mid-April, which was short-lived enough not to be a big factor in the monthly average.

There were no adjustments during 1970 in the number of votes held by each of the seven producing members of the Council. However, Israel withdrew from among the 20 consuming members, and their reallocated votes at yearend were as follows:

Australia	44	Japan	229
Austria	10	Korea	8
Belgium-Luxembourg	32	Mexico	21
Canada	49	Netherlands	49
Czechoslovakia	36	Poland	39
Denmark	12	Spain	24
France	108	Turkey	14
Hungary	16	United Kingdom	177
India	46	Yugoslavia	20
Italy	66		1,000

The Third Agreement, under which the Council operated in 1970, was to expire on June 30, 1971. In preparation for the continuation of this unique arrangement, a United Nations sponsored group convened in Geneva, Switzerland, on April 13, 1970, to draw up a fourth 5-year agreement. Thirty-eight nations were represented at the conference including such nonmember consumer nations as the United States, U.S.S.R., and the Federal Republic of Germany. Agreement was reached on May 15, 1970, and the document was circulated for ratification by participating tin consuming and producing nations prior to its taking effect July 1, 1971.

The Fourth Agreement will be in effect until June 30, 1976. The objectives remain basically unchanged: maintenance of a balance between world tin production and consumption, prevention of excessive price fluctuations, and increased export earnings for producer countries. A combination of the buffer stock and export controls provides the mechanism for achieving these objectives. In the new agreement, greater flexibility in buffer stock operations is provided for through wider price ranges. The buffer stock remains unchanged at 20,000 metric tons, with continued compulsory contributions by the producing member nations only. Provision is made for voluntary contributions from any country so inclined.

Among modifications to be incorporated in the fourth version were those recognizing certain criteria of the International Monetary Fund (IMF) under which appropriate facilities of the Fund might be used by ITC member nations in connection with the financing of their contributions to the buffer stock. To be eligible, IMF emphasized, a member country must have a balance of payments need for assistance.

In June 1970 the Council agreed to hold, in cooperation with the Tin Research Institute, an international conference on tin consumption in London in March 1972.

For a discussion of action by the ITC's Buffer Stock Manager, see section on "Prices."

Bolivia.—The three groups of mining enterprises (small, medium, and COMIBOL) produced a very slightly smaller amount of tin concentrates in 1970, reversing a 7-year growth trend. However, the nation had no difficulty in maintaining its position as the world's second largest tin producer.

COMIBOL, the State-owned mining company and Bolivia's leader in the field, experienced an increase in effective costs to place a pound of tin on the market from $1.329 per pound during the first half of 1969 to $1.465, a rise of 13.6 cents per pound. An increase in the labor force at work in the tin mines from 20,736 workers in June 1969 to 21,709 workers 1 year later was held largely responsible for the increase.

Under Governmental decrees, Bolivia's tin producers must offer all tin concentrates first to Empresa Nacional de Fundiciones (ENAF), the State smelting enterprise. Producers must also obtain permission from the Ministry of Mines before they may export concentrates. In 1970, ENAF lit the reverberatory furnace in its

Table 15.—Tin (content of ore): World mine production, by countries [1]

(Long tons)

Country	1968	1969	1970 [p]
North America:			
Canada	[r] 115	120	354
Mexico	518	[e] 502	594
United States	W	W	W
South America:			
Argentina	701	855	[e] 900
Bolivia [2]	[r] 29,101	29,572	28,916
Brazil [e]	[r] 2,824	2,458	2,798
Peru (recoverable)	99	83	104
Europe:			
Czechoslovakia	162	155	163
France	[r] 368	252	283
Germany, East [3]	1,000	1,000	1,000
Portugal [4]	[r] 624	438	374
Spain	[r] 120	125	200
U.S.S.R.[5] [6]	26,000	27,000	27,000
United Kingdom	1,798	1,622	1,695
Africa:			
Burundi	116	83	98
Cameroon	41	29	35
Congo (Brazzaville)	26	20	20
Congo (Kinshasa)	[r] 6,165	6,542	6,345
Morocco	[r] 12	12	14
Niger	[r] 74	34	21
Nigeria	9,649	8,603	7,833
Rhodesia, Southern [e]	600	600	600
Rwanda [e]	[r] 1,396	1,323	1,320
South Africa, Republic of	1,837	1,847	1,981
South-West Africa, Territory of [e]	[r] 720	720	710
Tanzania	[r] 323	136	49
Uganda	[r] 169	163	109
Asia:			
Burma [4]	[r] 430	360	380
China, mainland [e] [5]	20,000	20,000	20,000
Indonesia	[r] 16,671	17,138	18,761
Japan	931	727	780
Korea, Republic of	[r] 35	----------	----------
Laos	[r] 500	621	629
Malaysia	75,069	72,167	72,628
Thailand	[r] 23,601	20,759	21,140
Oceania: Australia	[r] 6,537	8,013	8,735
Total [7]	[r] 228,332	224,079	226,569

[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 mines and smelters.
[3] Estimate, according to the 57th annual issue of Metal Statistics (Metallgesellschaft) through 1969.
[4] Includes tin content of mixed concentrates.
[5] Estimated smelter production.
[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[7] Totals are of listed figures only.

Table 16.—Tin: World smelter production, by countries [1]
(Long tons)

Country	1968	1969	1970 p
North America:			
Mexico	317	139	e 140
United States [2]	[3] 3,453	345	NA
South America:			
Bolivia	59	85	295
Brazil	r 1,716	2,245	2,982
Europe:			
Belgium	4,799	4,444	4,190
Czechoslovakia	48	69	e 70
Germany:			
East [4]	1,200	1,200	1,200
West	r 1,504	1,446	2,167
Netherlands	r 7,983	5,298	5,937
Portugal	r 618	494	384
Spain	r 2,166	2,068	2,328
U.S.S.R. e [5]	26,000	27,000	27,000
United Kingdom	24,933	25,982	21,687
Africa:			
Congo (Kinshasa)	1,892	1,851	1,374
Morocco e	15	12	12
Nigeria [6]	r 9,843	8,839	7,400
Rhodesia, Southern e	600	600	600
South Africa, Republic of	686	738	593
Asia:			
China, mainland e	20,000	20,000	20,000
Indonesia	r 3,558	5,900	5,108
Japan	r 1,863	1,378	1,356
Malaysia	r 88,185	87,089	90,652
Thailand	r 24,434	22,048	21,692
Oceania: Australia	3,692	4,156	5,129
Total [7]	r 229,564	223,426	222,296

e Estimate. p Preliminary. r Revised. NA Not available.
[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] Imports into the United States of tin concentrates (tin content).
[4] Estimate, according to the 57th annual issue of Metal Statistics (Metallgesellschaft) through 1969.
[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Including a small amount smelted from imported concentrates.
[7] Totals are of listed figures only.

new 7,500-metric-ton tin smelter at Vinto, near Oruro, on September 30. Capacity output did not appear likely until some time in 1972 however. Built by West Germany's Klockner-Humboldt-Deutz, the plant was opened behind schedule, and various technological difficulties were encountered during the test runs. Actual production did not begin during 1970. The tin smelter is the first stage in a large Bolivian Government project to establish local metal smelting facilities, thus eliminating export of some of Bolivia's large volumes of untreated ores. Total cost of the tin smelter was said to be around $23 million. As development permits, capacity will be increased, first to 15,000 tons annually, and later to 22,500 tons. Originally, charcoal was selected as the source of fuel and carbon in the metallurgical furnaces, but a switch to petroleum coke was made at the last minute. Denmark supplied about 300 tons of tin anodes for the electrolytic refining process.

First sales of around 800 tons of 99.95-percent pure tin metal from the Vinto plant were to go to the U.S.S.R. Small amounts were shipped to several European countries but delays necessitated smelting some 260 long tons for the Russian commitment at the small and outdated unit at Oruro. This proved to be expensive and, therefore, was terminated. This tonnage, so far as is known, is all the metal that was sent to the U.S.S.R. in 1970, and Bolivia was seeking to arrange extension for the terms of the contract. A small, indeterminate volume of concentrate, for use in tin smelters in Siberia, also was shipped to the U.S.S.R. during the year.

After approval by the Government of Bolivia in Supreme Resolution 152,157 in April of 1970, COMIBOL negotiated an agreement with Gulf Chemical and Metallurgical Corp., Texas City, Tex., for the toll-smelting of 15,000 tons of Bolivian 40 to 50-percent concentrates. By August 1970, about 3,100 long tons of tin in concentrates had been brought to the United States, and a fine tin product had been produced at Texas City. It was being offered to purchasers in the United States by the COMIBOL office in New York City, and modest amounts were moving to U.S. tinplaters and other consumers.

Burma.—Production of tin in Burma remained relatively low in 1970, around 380 long tons. An indeterminate quantity of tin each year is affected by unauthorized activity in the mining areas, including smuggling. Tin and tungsten are produced together in Burma, and output of the mixed concentrates showed no important change during the year. Under Government policy, which discourages private investment, and with the prevailing pick-and-shovel operations, it appears unlikely that any increased output could be sustained. Exploitation tends to be of existing properties by loosely organized, Government-supervised mining cooperatives. Ore must be sold at Government-established prices to the purchasing depots of the State-owned Mineral Development Corp. Whatever increases in production occurred stemmed from a higher purchase price initiated in 1970. An indeterminate amount of tin, in company with other minerals, is smuggled to black-market operations in nearby Thailand, because prices there are attractive. Major Burmese mines were nationalized some years ago. In 1970, all remaining private leases were withdrawn, and over 100 small tin/tungsten mines in the Yamethin and Tenasserim Regions were closed.

Limited assistance from the United Nations in rehabilitation of tin/tungsten production in the Tenasserim area was underway in 1970. West German aid in improving mining techniques in existing mines also was going forward. Under an agreement signed in 1969, five Soviet technicians arrived in 1970 to assist with redevelopment of the once lucrative Machwi mines in Kayah State. Production target was 100 tons per month but at yearend was behind schedule.

Malaysia.—Tin is second in importance only to rubber in the economy of Malaysia which continued to lead the world in production and smelting of tin in 1970. As usual, about 40 percent of the free world's supply came from this southeast Asian source. A total of 72,628 long tons of tin in concentrate was mined, which is a 0.6 percent increase over output of 1969 when Malaysia, along with other producer members of the ITC, was under tin export restrictions.

At yearend there were 61 tin dredges, 979 gravel pump mines, and 43 opencast, underground, and other miscellaneous mines in operation, a slight increase from a year earlier.

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. Eight opencast mines brought in 3 percent of the ore produced; underground mines accounted for 3 percent, and the remaining 7 percent came from miscellaneous sources. The commissioning, on July 18, 1970, of the new multimillion dollar Petaling Dredge No. 7 was cause for optimism by Malaysian tin interests; however, this one dredge cost 30 percent more than the combined investment of its owner, Petaling Tin Berhad, in seven dredges bought by Petaling before World War II. Several other dredges were converted from steam to electric power during the year while assorted older machines were retired. There was a net loss by the end of 1970 of four dredges.

Generally speaking, tin mining tends to reshape the surface of the tin-rich river valleys rendering them mostly unfit for further use without costly rehabilitation. As tin mining progresses, tailings and pools of water remain. The pools assumed new commercial importance in Malaysia during the year. About 4,000 such pools in one area alone were being profitably used as fish hatcheries and fish farms. A turnover of more than $3.3 million in fish crop profits was estimated, partly because the ready availability of fresh water pools made expensive excavation unnecessary.

All tin mined in Malaysia is smelted within the country and exported as top quality Straits tin. Much Indonesian concentrate, together with small amounts from Thailand, Cambodia, Laos, Australia, Kenya, Tanzania, and several countries of Central and South America also were smelted in Malaysia in 1970. Two very large smelters, the Butterworth smelter of the Straits Trading Co., Ltd., and the Penang smelter of the Eastern Smelting Co., Ltd. (Consolidated Tin Smelters, Ltd.), handle all of Malaysia's tin metal production.

Thailand.—At 21,140 long tons, Thailand's tin production in 1970 did not approach the record high of 1968, 23,601 long tons, however, the 1970 figures was slightly better than that of 1969, a year of export control under the ITC.

Placer deposits provided most of Thailand's tin ores, and many of these are on or near Phuket Island just off the west coast in the Andaman Sea. Although alluvial deposits in this region have been productive, their submarine extensions were attracting more interest in 1970. Floating dredges, including huge new vessels, were being brought into recently won concessions in the sea off Phuket and the mainland Provinces of Ranong and Phangnga where exploratory work was well underway by yearend. At least one production operation was going forward in open water and could be carried on only from November through April. Dredges are moved to more protected waters during the monsoon season.

The largest U.S. firm with interests in Thai tin was Union Carbide Corp. The Phuket tin smelter, fourth largest in the world, was brought into operation on July 1, 1965. Although ultimately it will be capable of turning out 40,000 tons of tin per year, it did not operate at more than about 55 percent capacity in 1970. At the outset, the smelter was owned by Union Carbide Corp. (70 percent) and Eastern Mining Development Co. (Emco) (30 percent). The two companies formed Thailand Smelting and Refining Co. (Thaisarco) to operate the smelter. In 1970, N.V. Billiton Maatschappij, of the Netherlands, acquired Emco's interest in Thaisarco, and additional arrangements were being made for various Thai interests to acquire a significant part of the share capital of Thaisarco. Meanwhile, the Billiton organization was merged into the Royal Dutch Shell firm during the year.

Under Thai Government decree, Thaisarco has sole smelting rights for all concentrates produced in the country. Under the new Billiton agreement, the newcomer further agreed to assume the responsibility for marketing the entire Thaisarco tin metal output, nearly all of which is exported. Thaisarco also is required to pay cash upon delivery of concentrates to the smelter, or the seller can wait 2 weeks, which may work to his advantage in a fluctuating market.

In 1970 Union Carbide's offshore exploration and development company, Thailand Exploration and Mining Co. (Temco), ordered from Japan what was reported to be the largest dredge ever built. Delivery was scheduled for late 1971. As with the smelter, Billiton acquired part (40 percent) of the interest in Temco, which was active in new exploration off the northern and western coasts of Thailand.

Two other firms, Tongkah Harbour Tin Dredging and Aokam Tin, were also actively dredging offshore areas. A novel suction dredge of Southern Kinta Consolidated, Ltd., working in shallow waters, showed encouraging improvement in its operation.

United Kingdom.—The first stage of the new Kirkby plant of Williams, Harvey & Co. Ltd., started up in late 1969. Initial difficulties were numerous, and efficient operation was not achieved during 1970. Meanwhile, stocks of Bolivian concentrates, delivered in excess of expectations, accumulated rapidly and were not worked off in 1970. The combination of excess stock and high interest rates was a financial strain on the firm. The plant was not expected to operate economically until at least late in 1971.

Table 17.—The world tin smelting position [1]

Country	Location	Smelter name	Ownership	Annual capacity (metric tons)	Brand names produced	Estimated current output (metric tons)	Sources of concentrates or remarks
Australia	Alexandria, New South Wales.	Associated	Associated Tin Smelters Pty. Ltd.	e 6,000	A.T.S.	4,500	Local.
Belgium	Hoboken	Hoboken	Societé Generale Metallurgique de Hoboken.	18,000	U.M.H.K.	5,000	Congo and Rwanda.
Bolivia	Oruro	Fundición de Estaño.	COMIBOL	5,000		(2)	Local.
	do	Metabol	do				Used for volatization research only.
	Vinto	Vinto	National Smelting Enterprise (ENAF).	8,000		(2)	Local.
Brazil	Manaos						
	Rio de Janeiro	Volta Redônda	Cia. Estanifera do Brasil (CESBRA).	7,000		2,200	Local, Bolivia, and Thailand.
China (mainland)	Kochiu, Yunnan	Kochiu	Yunnan Tin Corp.	e 30,000 to 40,000 (both smelters)	P.K.M.A.	35,000	
	Papu, Ho-hsien Kwangis.	Kwangsi	Ping Kwei Mining Administration.				
Congo (Kinshasa)	Manono, Katanga	Manono	Géomines	4,000	Géomines	1,500	Local.
Denmark	Glostrop	Bergsøe	Paul Bergsøe & Son		Lion & Ox-head Refined Tin.		
Germany, West [3]	Diusberg-Wanheim	"Berzelius" Metalhutten, A.G.	Berzelius Metalhutten-Gesellschaft-G.m.b.h.	3,600		1,600	Bolivia.
Hong Kong			Chee Hing & Co.	1,000	Chee Hing		
Indonesia	Muntok, Bangka Island.	Peltim	P. N. Timah, the Indonesain State Tin Enterprise.	13,000	Banka	5,300	Local ore, expansion to 27,000 tons planned.
Japan	Naoshima	Naoshima	Mitsubishi Metal Mining Co. Ltd.	2,500		1,000	Mainly domestic ore.
Malaysia	Oita	Oita	Rasa Kogyo K.K.	1,000		500	Australian ore.
	Butterworth, Penang.	Butterworth	Straits Trading Co., Ltd.	36,000	Straits Trading Co., Ltd.	30,000	Domestic, Indonesian and other ore.
	Penang Island	Penang	Eastern Smelting Co., Ltd.	60,000	Penang or E.S. Coy. Ltd.	50,000	Do.
Mexico	Tlalnepantla, State of Mexico.	Estaño Electro	Privately held	1,300	Zeta	900	Local ores, concentrates, etc.
	San Luis Potosi	Estanera Mexicana	Cia. Estanera Mexicana	300		300	Local ores.
Netherlands	Arnhem	Billiton	N.V. Hollandsche Metallugische-Industrie Billiton.	30,000	Tulip Billiton Windmill I-II-III Windmill Star.	6,000	Operating on wide variety of ores.
Nigeria	Jos, Northern Nigeria.	Makeri	Makeri Smelting Co., Ltd. (Consolidated Tin Smelters, Ltd.).	17,000	Makeri	9,600	Local ores.
Rhodesia	Bulawayo, Southern Rhodesia.	Kamativi Mine, (near Wankie).	Kamativi Smelting & Refining Co., Ltd. (Billiton).	1,100	Jupiter	600	Own ores from Kamativi Tin Mines, Ltd.

See footnotes at end of table.

Table 17.—The world tin smelting position [1]—Continued

Country	Location	Smelter name	Ownership	Annual capacity (metric tons)	Brand names produced	Estimated current output (metric tons)	Sources of concentrates or remarks
Spain	Salamanca	Agueda	Electrometalurgia del Agueda, S.A.	1,000	Lamb and Flag	NA	Own and other local ores.
	Barcelona	Carim	Refinerias e Industrias Metalúrgicas, C.A.	NA	Carim	NA	Local ores.
	Medina del Campo (Valladolid).	Fesa	Ferroaleciones Españolas, S.A.	1,500	Reina Isabel B	700	Do.
	Bilbao	Indumetal	Industrias Reunidas Minero-Metalúrgicas, S.A.	1,000	Indumetal	NA	Do.
	Villaverde Alto (Madrid).	Mesae	Minero Metalúrgica del Estaño, S.A.E.	2,000	Mesae	e 1,000	Do.
	Villagarcia de Arosa (Pontevedra).	Noroeste	Metalúrgica del Noroeste, S. A.	3,000	Concha	1,800	Do.
South Africa, Republic of.	Potgietersrus, Transvaal.	Zaaiplaats	Zaaiplaats Tin Mining Co., Ltd.	3,000	Z.T.M	1,200	Southern Africa ores.
Thailand	Phuket	Thaisarco	Thailand Smelting and Refining Co., Ltd.	40,000	Thaisarco	25,000	Thai and Indonesian ore.
U.S.S.R	Novosibirsk, Siberia	Novosibirsk	State-owned	30,000	XXX		Siberia and Soviet Far East.
	Ryazan', European Russia.	Ryazan'	do	NA		e 26,000	Domestic.
	Podol'sk (near Moscow).	Podol'sk	do	2,000			Do.
United Kingdom	No. Ferriby, Yorkshire (near Hull).	Melton Works	Capper Pass & Son, Ltd	10,000	Pass No. 1, Pass Electrolytic, Pass River, Pass "S".	8,000	Low grade ores, including about 4,000 tons Bolivian ore per year.
	Kirkby, Lancashire	Williams, Harvey	Williams, Harvey & Co., Ltd.	20,000–25,000	Mellanear, Cornish.	17,000	Handles mostly Bolivian ores. Encountering startup troubles at new location.
United States	Texas City, Tex	Texas City	Gulf Metallurgical and Chemical Corp.	10,000	Double Circle	6,000	Toll-smelting for COMIBOL of Bolivia.

e Estimate. NA Not available.
[1] In addition to the tin smelters listed, there are a number of very small plants around the world which operate on primary concentrates and secondary materials. Total contribution of all of these smelters to world supplies is not thought to be more than about 150 long tons of primary tin metal per year.
[2] Negligible.
[3] Germany, East: Minor refining capability, probably in conjunction with smelting of other metals.

TECHNOLOGY

The nature of tin and copper in the ferrous material separated from municipal incinerator residues, and methods of removing these residual elements are discussed in a paper presented before the Second Mineral Waste Utilization Symposium in Chicago, Ill., in March 1970.[3]

Improved recoveries of very fine grained tin ore (cassiterite) by flotation methods continued to be a focal point for several research groups during the year. Development of more effective chemical collectors, particularly among the alkyl-phosphonic acids, was one approach in which there was considerable activity. Tests conducted by Great Britain's Warren Spring Laboratory for Consolidated Gold Fields' Wheal Jane mine in Cornwall were outlined.[4] Several British and Canadian patents aimed toward improvement in recovery techniques were issued during the year.[5]

Development of improved measurements of the surface tension of high-purity tin was undertaken by the Bureau of Mines in 1970. The objective was realistic values for use in studies on tin-lead solders, and the published results are considered to be equal in value to any data presently available.[6]

In a highly technical application announced during the year, a superconductive niobium-tin alloy plays a vital role in operation of a device for controlled thermonuclear fusion studies. A niobium-tin ribbon which is 12.5 miles long is wound around the rim of a 5-foot wheel. When immersed in liquid helium and activated, these windings produce a magnetic field so strong and stable that the entire 270-pound assembly will float in space in its own magnetic field. This field will be used to trap a high-energy plasma of electrons and ions during studies of controlled thermonuclear fusion. The device was constructed by the Radio Corp. of America for use in the Plasma Physics Laboratory of Princeton University. This source of energy could, experts believed, supply unlimited supplies of cheap electric power in the future.[7]

A tin-silver soldering filler metal (96.5 percent tin and 3.5 percent silver), said to be a good electrical conductor, free-flowing. of good wetability on most base metals, and offering greater strength than tin-lead soldering filler metals, was announced in 1970. Since it contains no lead, the material can be used where lead contamination must be avoided, as in food-handling vessels and containers. High melting temperatures permit use in assemblies which must function at high ambient temperatures, and when soldering copper, brass, mild steels, and most plated surfaces, a strong acid flux is not required.[8]

Organotin compounds were bases for continued research and promising technological development in 1970. Two processes were available commercially, for example, for impregnating wood with organic solvents containing tributyltin oxide. The techniques ensured long-term protection from wood-destroying fungi and insects, it was said.[9]

Organotin biocides, in the forms of triethyltin and triphenyltin compounds proved important because they possess properties similar to the organo-mercurials except that they break down when so used into harmless residues which are nontoxic inorganic tin compounds.

When tin is added to titanium alloys (most frequently aluminum), the strength of such alloys is increased, yet ductility and hot workability are not impaired. Tin additions can vary widely, thus these and other titanium alloys can meet the requirements of aerospace technology.[10]

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[3] Cammarota, V. Anthony. Refining of Ferrous Metal Reclaimed From Municipal Incinerator Residues—A Progress Report. In Proc. Second Mineral Waste Utilization Symp., cosponsored by the U.S. Bureau of Mines and the Illinois Institute of Technology Research Institute, Mar. 18–19, 1970, Chicago, Ill., pp. 348–353.

[4] Mining Journal. Tin Recovery by Flotation. V. 274, No. 7021, Mar. 13, 1970, p. 221.

[5] Arbiter, N. Froth Flotation Beneficiation of Cassiterite Containing Iron Minerals, etc. Canadian Pat. 833,608, Feb. 3, 1970.

Bushell, C. H. G., and D. L. Johnston (assigned to Cominco, Ltd.). Froth Flotation of Low-grade Cassiterite Ore. British Pat. 1,212,496, Nov. 18, 1970; Canadian Pat. 854,248, Oct. 20, 1970.

[6] Schwanke, Alfred E., and Wilbert L. Falke. Surface Tension and Density of Liquid Tin. BuMines Rept. of Inv. 7372, April 1970, 9 pp.

[7] Tin Research Institute. Niobium-Tin in Plasma Physics. Tin and Its Uses, Quart. Rev. Tin Res. Inst., No. 86, 1970, p. 9.

[8] Chemical Engineering, v. 77, No. 13, June 15, 1970, p. 105.

[9] Tin Research Institute. Treating Timber with Organotins: The Vac-Vac and Drilon Processes. Tin and Its Uses, Quart. Rev. Tin Res. Inst., No. 84, 1970, p. 5.

[10] Evans, D. J. Tin-Containing Titanium Alloys in the Aerospace Industry. Tin and Its Uses, Quart. Rev. Tin Res. Inst., No. 83, 1970, pp. 13–15.

Titanium

By Frank E. Noe [1]

After a good first quarter in 1970, cutbacks in space and aircraft programs and the general weakness of the economy had a pronounced effect on the titanium metal industry during the last 9 months of the year. Although sponge metal production declined only slightly, consumption dropped about 19 percent and stocks of sponge increased about 30 percent. Imports of titanium sponge and waste and scrap from Japan, the United Kingdom, and the U.S.S.R. were slightly higher than in 1969.

Ilmenite production in the United States dropped to the lowest level since 1962, but world output of both ilmenite and rutile increased significantly.

Titanium pigment production and consumption decreased slightly. A new chloride-process plant went on stream, and the planned closing in mid-1971 of a domestic plant utilizing the sulfate process was announced, thus continuing the trend of recent years toward greater use of the chloride process for pigment.

Legislation and Government Programs.—The stockpile objectives for rutile and titanium sponge metal remained at 100,000 tons and 33,500 tons, respectively. The contract entered into on July 1, 1969, for furnishing 5,600 short dry tons of rutile, was completed on April 14, 1970. The Government inventory of rutile at yearend was 56,525 tons. Total stockpile inventories of sponge metal increased 4,277 tons to 35,015 tons at yearend; of that total, 8,514 tons are of substandard grade and are 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. Numerous inquiries were received, but no applications for financial assistance to explore rutile deposits were submitted, and no contracts were executed for this purpose during the rutile program.

Investigation of a columbium-bearing rutile deposit in Hot Springs County, Ark., was completed by the Battelle Memorial Institute, under contract with the Office of Minerals and Solid Fuels U.S. Department of the Interior. Conclusions from the investigation were that there is no present or likely near-term economic potential for developing the columbium-bearing rutile deposit of Magnet Cove, Ark.

The Bureau of Mines concluded a project to determine the near-term feasibility of commercial recovery of rutile as a byproduct from phosphate mining operations in Florida. A study of the recovery of heavy minerals from sand and gravel operations in the southeastern United States continued. The Bureau completed its review and assessment of the available information on proposed techniques for producing rutile substitutes and published a comprehensive report [2] that groups the major processes according to the technology.

[1] Physical scientist, Division of Nonferrous Metals.

[2] Henn, John J., and James A. Barclay. A Review of Proposed Processes For Making Rutile Substitutes. BuMines Inf. Circ. 8450, 1970, 27 pp.

Table 1.—Salient titanium statistics

	1966	1967	1968	1969	1970
United States:					
Ilmenite concentrate:					
Mine shipments short tons	868,436	882,414	960,118	893,034	920,964
Value thousands	$17,608	$18,519	$19,484	$18,636	$18,626
Imports short tons	r 173,786	r 170,585	178,154	110,853	231,119
Consumption do	962,706	919,206	959,558	1,003,501	968,926
Titanium slag: Consumption do	132,233	122,926	142,168	138,553	129,247
Rutile concentrate: [1]					
Imports do	151,482	167,100	174,366	204,907	243,269
Consumption do	135,883	153,457	160,273	185,432	188,290
Sponge metal:					
Imports for consumption do	5,225	7,144	3,443	6,332	6,543
Consumption do	19,677	20,062	14,237	20,124	16,414
Price: Dec. 31, per pound	$1.32	$1.32	$1.32	$1.32	$1.32
World: Production:					
Ilmenite concentrate short tons	2,886,937	3,036,517	3,222,247	3,541,769	3,941,574
Rutile concentrate do	275,198	310,752	332,792	436,819	460,084

r Revised.
[1] Mine shipments withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Concentrates.—Production of ilmenite concentrates dropped almost 7 percent, the lowest level in 8 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.; National Lead Co., Tahawus, N.Y.; and American Cyanamid Co., Piney River, Va. No domestic production of rutile concentrate was reported.

The American Cyanamid Co. and the Union Camp Corp. formed a joint mining venture, Titanium Enterprises, to produce titanium minerals from a large deposit near Green Cove Springs, Fla. Facility engineering and mine-site development were in progress at yearend; initial production is scheduled for mid-1972. Late in the year, American Cyanamid announced plans to close its ilmenite mine and titanium dioxide plant at Piney River, Va., in June 1971. Depletion of the most usable source of the ilmenite ore and problems of ecology figured strongly in the decision to close the plant.

Several concerns investigated or reinvestigated sand-ilmenite deposits in various east coast States and in Tennessee, without any definite plans for production having been announced.

Metal.—Production of titanium sponge was about 2 percent lower than in 1969. The producing companies were Titanium Metals Corporation of America (TMCA), Henderson, Nev., owned by National Lead Co. and Allegheny Ludlum Steel Corp.; Reactive Metals, Inc., 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. Early in 1970, Oremet completed new facilities representing an investment of approximately $9 million, which just about doubles the size of the company. The new facilities consist of three separate plants—titanium tetrachloride, sponge, and magnesium. The sponge-production capacity of the three producing companies was about 25,000 tons per year.

Production of titanium ingot, including alloys, was 24,331 tons, a decrease of about 15 percent from 1969 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.
Reactive Metals, Inc	Niles, Ohio
Teledyne Titanium, Inc	Monroe, N.C.
Titanium Metals Corporation of America.	Henderson, Nev.
Titanium Technology Corp	Pamona, Calif.
Titanium West, Inc	Reno, Nev.

Teledyne Titanium installed at its Monroe, N.C., plant a new titanium-melting arc furnace with a nonconsumable electrode, claimed to be the first of its type in the titanium industry. One of the chief advantages claimed for the process is the elimination of the sponge-compacting stage in the melt. Titanium West installed at its Reno plant a third 1,200-ton-capacity furnace capable of producing 5,800-pound, 23-inch titanium ingots. Harvey Aluminum, Inc., announced plans to triple its titanium melt and product capabilities in a major expansion of its Torrance, Calif., facilities. Included in the modernization program are new furnaces capable of producing 16,000-pound ingots. The Alloy Division of Howmet Corp. melted the world's largest titanium ingot, measuring 40 inches in diameter and weighing 21,539 pounds.

Pigment.—The gross weight of titanium dioxide (TiO_2) pigment produced domestically was about 1 percent greater than that of 1969, with the average TiO_2 content of the rutile-, anatase-, and composite-type pigments being slightly lower than in the previous year. Rutile-type pigment, produced by the nine pigment companies, was about 60 percent of the total on a TiO_2 content basis. Most of the remainder was anatase-type pigment, produced by six companies, and composite-type produced by one company.

Companies producing titanium pigments and plant locations are as follows: American 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.; National Lead Co., 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, Balitmore, Md.; and Sherwin Williams Chemical, a subsidiary of Sherwin-Williams Co., Ashtabula, Ohio.

American Cyanamid completed a new chloride-process titanium dioxide plant at Savannah, Ga. The plant was placed in commercial operation during the fourth quarter. Also in the fourth quarter, American Cyanamid announced that it would close its old sulfate-process dioxide plant at Piney River, Va., in June 1971, because of increased pollution-control costs and obsolescence. E. I. du Pont announced that it would expand its chloride-process titanium dioxide pigment plant at New Johnsonville, Tenn., by approximately 20 percent. The New Johnsonville facility has been expanded several times and now has a capacity of approximately 95,000 tons per year. The new expansion will raise capacity to about 120,000 tons per year and is scheduled for completion in late 1971. The Glidden-Durkee Division of SCM Corporation commissioned a new 25,000-ton-per-year chloride-process plant alongside an existing 53,000-ton-per-year sulfate-process plant at Hawkins Point, Baltimore, Md. The new chloride plant will employ the American Potash & Chemical Corp. process.

Welding Rod Coating.—A total of 212,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output, 31 percent contained rutile; 36 percent, ilmenite; 17 percent, a mixture of rutile and manufactured titanium dioxide; 11 percent, manufactured titanium dioxide; and 5 percent, miscellaneous mixtures and titanium slag.

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)
1966	965,378	868,436	451,132	$17,608
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

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite. Production of rutile concentrate in the United States was discontinued in 1968; data for previous years are withheld to avoid disclosing individual company confidential data.

Table 3.—Titanium-metal data

(Short tons)

	1966	1967	1968	1969	1970
Sponge metal:					
Imports for consumption	5,225	7,144	3,443	6,332	6,543
Industry stocks	800	2,900	2,600	r 1,909	2,495
Government stocks (DPA inventories)	21,416	20,711	20,711	20,385	19,994
Consumption	19,677	20,062	14,237	20,124	16,414
Scrap-metal consumption	4,857	5,822	4,701	7,566	7,242
Ingot: [1]					
Production	24,253	25,960	19,234	28,490	24,331
Consumption	22,317	25,386	18,323	27,082	23,687
Net shipments of mill products [2]	13,996	13,634	11,900	15,940	14,499

r Revised.
[1] Includes alloy constituents.
[2] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDSAF-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)	Shipments [1] Value, f.o.b. (thousands)
1966	594,486	593,933	$303,902
1967	589,449	582,325	297,283
1968	623,691	632,106	323,216
1969	r 660,002	652,271	333,323
1970	p 655,394	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 and titanium slag, both of which are used chiefly for making titanium dioxide pigment, declined 3 and 7 percent, respectively. Rutile consumption, which is used principally for producing titanium dioxide pigment, titanium metal, and also in welding rod coatings, increased slightly despite a sharp drop in the production of rutile-based welding rod coatings and fluxes. A significant amount of unbeneficiated ilmenite ore was marketed for use in concrete aggregate for oil and gas pipeline coating; ilmenite is used for such coatings because of its density rather than for its titanium content.

Metal.—The spectacular growth that characterized the titanium metal industry in 1969 was reversed in 1970. Consumption of titanium sponge and ingot declined 18 and 13 percent, respectively. Consumption of titanium metal as gauged by shipments of mill products fell 9 percent from the previous year. All this reflected a decreased use of the materials in Government and commercial aerospace programs as a result of increased public opposition to aerospace and military spending. Titanium consumption in commercial aircraft during the year again surpassed that in military aircraft, comprising about 50 percent of total end use. Military aircraft took less than 30 percent. Industrial applications, however, grew by 3 percent.

A large domestic producer of titanium metal estimated the end-use distribution of titanium mill products as follows:

	Consumption, percent 1968	1969	1970
Jet engines	54	54	53
Airframes	33	28	25
Space and missiles	8	8	9
Industrial	5	10	13
Total	100	100	100

Nonaerospace applications are diverse. The unique corrosion resistance of titanium in many environments has resulted in a growing number of applications where a strength-to-weight ratio is of secondary importance. The use of titanium tubing is becoming increasingly important. Titanium tubing, already proven in desalinization of sea water, is now being seriously considered for applications in the recovery of mercury from chlorine brines. Tubing is also used to advantage for such items as heat exchangers and various process piping and vessels. A new technique calling for the replacement of copper cathode starter sheets by about 1/8-inch-thick titanium sheets is being investigated. Other nonaerospace uses include plating racks, marine hardware, ordnance equipment, mufflers, pistons, batteries, and medical prothesis.

Pigments.—In 1970 titanum pigment consumption on a gross weight basis, using shipments as a gage, was 1 percent less than that of 1969.

Table 5.—Consumption of titanium concentrates in the United States, by products

(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)
1966	962,706	507,379	132,233	93,683	135,883	130,191
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:						
Pigments	1,000,874	540,403	138,553	98,075	r 129,398	r 124,718
Titanium metal	--------	--------	--------	--------	(2)	(2)
Welding-rod coatings	343	208	(3)	(3)	22,001	20,987
Alloys and carbide	r 2,234	r 1,199	(3)	(3)	(3)	(3)
Ceramics	(2)	(2)	--------	--------	472	451
Glass fibers	--------	--------	--------	--------	(2)	(2)
Miscellaneous	50	30	--------	--------	33,561	31,934
Total	r 1,003,501	r 541,840	138,553	98,075	r 185,432	r 178,090
1970:						
Pigments	966,350	515,860	129,247	91,639	140,790	135,350
Titanium metal	--------	--------	--------	--------	(2)	(2)
Welding-rod coatings	510	356	(3)	(3)	15,634	14,917
Alloys and carbide	2,045	1,027	(3)	(3)	79	75
Ceramics	(2)	(2)	--------	--------	378	362
Glass fibers	--------	--------	--------	--------	(2)	(2)
Miscellaneous	21	13	--------	--------	31,409	29,938
Total	968,926	517,256	129,247	91,639	188,290	180,642

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 industries

(Percent)

Industry	1966	1967	1968	1969	1970
Distribution by gross weight:					
Paints, varnishes, and lacquers	61.6	61.9	60.7	58.5	59.6
Paper	13.9	14.6	14.9	17.0	17.0
Floor coverings	3.4	2.7	2.4	2.3	1.8
Rubber	4.2	2.8	2.9	2.6	2.6
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.4	1.4	1.4	1.3	1.3
Printing ink	1.9	2.0	2.1	2.3	2.2
Roofing granules	1.2	1.1	.8	.9	.9
Ceramics	1.7	1.9	2.1	2.0	1.8
Plastics (except floor covering and vinyl-coated fabrics and textiles)	3.8	5.1	6.0	6.2	6.6
Other (including export)	6.9	6.5	6.7	6.9	6.2
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, and lacquers	56.4	57.5	56.5	54.3	55.8
Paper	16.7	17.2	17.4	19.5	19.3
Floor coverings	3.9	3.1	2.7	2.6	2.1
Rubber	4.9	3.2	3.3	3.0	3.0
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.6	1.6	1.6	1.4	1.4
Printing ink	2.2	2.3	2.4	2.6	2.5
Roofing granules	1.5	1.4	1.0	1.1	1.0
Ceramics	2.1	2.2	2.4	2.4	2.1
Plastics (except floor covering and vinyl-coated fabrics and textiles)	4.6	6.0	6.9	7.1	7.6
Other (including export)	6.1	5.5	5.8	6.0	5.2
Total	100.0	100.0	100.0	100.0	100.0

STOCKS

Industry stocks of rutile increased 9 percent, to 211,683 tons, equivalent to more than a year's supply at the 1970 consumption rate. Ilmenite inventories decreased 6 percent, but stocks of titanium slag increased 11 percent. Yearend stocks of titanium sponge metal held by producers, melters, and semifabricators totaled 2,495 tons, compared with 1,909 tons on hand at the end of 1969. Titanium metal scrap held by melters and semifabricators at yearend was 4,377 tons, 400 tons less than that at the end of 1969. Stocks of composite and pure TiO_2 held by producers were 6 percent more than the previous year—106,858 tons compared with 100,846 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)
1969:						
Mine	(1)	(1)				
Distributor	r 247,559	r 146,404	(2)	(2)	(2)	(2)
Consumer r	600,080	329,556	103,402	73,308	194,367	187,183
Total r	847,639	475,960	103,402	73,308	194,367	187,183
1970:						
Mine	(1)	(1)				
Distributor	194,523	118,428			(2)	(2)
Consumer	602,978	332,252	115,266	81,761	211,683	203,363
Total	797,501	450,680	115,266	81,761	211,683	203,363

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 1969. 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) rose in several steps from $160 to $185 in June, where it remained at yearend.[3] Titanium slag (70 percent TiO_2) was steady at $45 per long ton throughout the year.

Manufactured Titanium Dioxide.—Competition sparked by new producers resulted in a 2-cent-per-pound reduction in rutile-grade list prices to a range of 26 to 27 cents per pound. Prices on other pigment grades remained steady throughout the year. Yearend quotations from the Oil, Paint and Drug Reporter of Dec. 28, were as follows:

	Price per pound
Anatase, all grades, bags:	
30-ton carlots, minimum, freight allowed	$0.26
Less than carlots, same basis	.27–$0.275
Rutile, all grades, bags:	
30-ton, carlots, minimum freight allowed	.26– .270
Less than carlots, same basis	.27– .285
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 at yearend follow:

3 Metals Week. Rutile Price Kicked to $185. V. 41, No. 25, June 22, 1970, p. 22.

	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 56 countries, mainly to Canada (39 percent), increased 7 percent to 26,183 tons valued at $7,944,343. The quantity of ores and concentrates exported to 11 countries decreased 23 percent, the lowest level since 1954. Canada was the principal recipient with 74 percent, followed by Japan with 14 percent. Although exports of unwrought metal and alloy and waste and scrap to 19 countries (54 percent to United Kingdom) increased only 3 percent, there was a 29-percent increase in unit value. There was a 2-percent decrease in exports of combined intermediate titanium mill shapes and wrought metal and alloys, but the unit value increased 16 percent. Of the 17 countries to which intermediate mill shapes were exported, West Germany received 61 percent and Canada dropped to second place with only 31 percent. The United Kingdom received 41 percent and Canada received 19 percent of wrought titanium and alloys shipped to 37 countries.

Imports of ilmenite from Australia increased more than threefold, but those of titaniferous concentrates (Sorel slag) from Canada increased only 64 percent. Attention is called to an error that has appeared under ilmenite imports from Canada for the past several years. Since 1966, imports of ilmenite from Canada have included 436,643 tons of ilmenite ore containing about 35 percent TiO_2. This material was imported for its density rather than for its titanium content. It was used in concrete aggregate for oil and gas pipeline coatings.

Although rutile imports from Australia reached a new high, those from Sierra Leone dropped 25 percent below the 1969 level. Imports for consumption of unwrought titanium and waste and scrap from 10 countries increased slightly over the previous year. Japan shipped to the United States about 69 percent (4,507 tons) of these materials, practically all as titanium sponge. The United Kingdom and the U.S.S.R. also supplied the United States with significant quantities of sponge metal. Most of the remaining items under this import category, largely scrap, came from West Germany and Canada. The value per pound of imports was $0.80, compared with $0.82 in 1969 and $0.92 in 1968. Imports for consumption of wrought titanium doubled to 552 tons, principally from Canada and Japan. Imports of titanium dioxide from 16 countries, principally from Japan, France, Finland, and Canada, totaled 60,207 tons, valued at $22,184,870.

The tariff on unwrought titanium and waste and scrap was lowered to 18.5 percent ad valorem on January 1, 1970, but the suspension of duty on waste and scrap was continued throughout the year.

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)
1968	4,238	$276	2,756	$1,748	1,228	$7,575	30,188	$8,227
1969	1,424	183	2,802	1,936	1,773	9,206	24,507	7,510
1970	1,100	297	2,892	2,583	1,740	10,435	26,183	7,944

Table 9.—U.S. imports for consumption of titanium concentrates, by countries

Country	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ilmenite:						
Australia	45,196	$380	28,524	$371	96,123	$976
Canada [1]	r 132,958	r 4,220	r 82,329	r 5,546	134,996	5,455
Total	r 178,154	r 4,600	r 110,853	r 5,917	231,119	6,431
Rutile:						
Australia	171,847	12,508	176,550	14,273	223,407	18,395
Canada	1,171	54	262	22	180	17
Sierra Leone	1,348	91	26,422	1,793	19,682	1,401
Other countries	----	----	1,673	119	----	----
Total	174,366	12,653	204,907	16,207	243,269	19,813

r Revised.
[1] Titanium slag averaging about 70 percent TiO_2. Data does not include ilmenite ore for use as heavy aggregate imported in quantities of 67,955; 288,050; 30,564 short tons in 1968, 1969, and 1970, respectively.

Table 10.—U.S. imports for consumption of unwrought titanium and waste and scrap

Country	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	----	----	----	----	13	$30
Canada	238	$675	214	$138	111	96
France	1	2	----	----	3	4
Germany, West	(1)	3	13	9	142	153
Japan	2,466	4,574	4,591	7,611	4,507	7,436
Netherlands	----	----	23	6	9	6
Sweden	----	----	----	----	25	26
Switzerland	----	----	----	----	3	7
U.S.S.R.	421	550	836	1,317	1,035	1,662
United Kingdom	317	548	655	1,267	695	1,083
Total	3,443	6,352	6,332	10,348	6,543	10,503

[1] Less than ½ unit.

WORLD REVIEW

It has become increasingly evident that world demand for natural rutile will progressively outstrip supply, and although development and investigation of programs aimed at upgrading ilmenite along several separate lines are well advanced both in the United States and overseas, no significant output of artificial titania from this source is expected before 1972–73. Both chlorination and leaching methods have been proposed to eliminate iron from the ilmenite. In the United States, Gulf Chemical and Metallurgical Corp. has produced and delivered limited amounts of synthetic rutile from its hydrochloric-acid leaching plant at Texas City, Tex. The ilmenite treated came from Cable (1956), Ltd., in Western Australia. Benilite Corp. of America has announced plans to construct a plant capable of producing up to 100,000 tons of beneficiated ilmenite annually at Corpus Christi, Tex. The plant will employ a process perfected by Benilite, which involves partial reduction of the iron oxides in the ilmenite feed before leaching with hydrochloric acid. In India, Dhrangadhra Chemical Works, Ltd., is reportedly using a process similar to that of Benilite Corp. to produce about 5,000 tons per year of artificial rutile. In England, British Titan Products Co., Ltd., and Woodall-Duckham, Ltd., have been cooperating to develop a synthetic rutile process and have constructed a pilot plant at Grimsby. In Australia, Western Titanium N.L. continued to operate a semicommercial beneficiation plant at Capel, Western Australia, employing a process developed largely by the Commonwealth Scientific and Industrial Research Organization (CSIRO). Another CSIRO process has been under investigation by Murphyores Holding, Ltd. for use on mineral from its Gladstone deposit. Selective chlorination was being investigated by Rutile and Zircon Mines (Newcastle), Ltd., through its subsidiary, Chlorine Technology, Ltd. This process was to be evaluated in a pilot plant being built at Mt. Morgan. The largest titanium dioxide pigment producer in Japan, Ishihara Sangyo Kaisha, was reportedly building a $5.5 million, 44,000-ton-per-year rutile-substitute plant at Yokkaichi, central Honshu Island. Startup, scheduled for some time in 1971, will follow a flow scheme that the company has developed and piloted since 1969.

Australia.—Exploration and development activity continued at a high level in beach-sand heavy-mineral deposits on both the east and west coasts. The Queensland Government denied mining leases to two Australian mining firms that sought to mine 6,000 acres of rutile-rich coastal land in the Cooloola area, about 100 miles north of Brisbane. The action culminates a 6-year battle to save the area by leading conservationists.

Mineral Deposits, Ltd. (85-percent owned by NL Industries of the United States), commissioned a new 300-ton-per-hour mining plant north of Tuncurry, New South Wales. Concentrate from this plant will be treated at the recently expanded dry-separation plant at Hawk's Nest.

Consolidated Rutile, Ltd., announced plans for a substantial increase in the capacity of their dry mill at Meeandah on the Brisbane River, Queensland. Rutile production was to be increased to 75,000 tons per year by late 1971. The company was granted a contract late in the year to sell 50,000 tons of ilmenite to Japan, the biggest single contract for the sale of ilmenite from the east coast of Australia.

Associated Minerals Consolidated, Limited, completed mining operations on South Stradbroke Island, Queensland, in March 1970, and the dredge-concentrator unit was subsequently transferred to North Stradbroke Island where it is currently in operation. The company's separation plant at Wyong was closed in June.

Table 11.—Titanium concentrates: World production (ilmenite and rutile), by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
Ilmenite:			
Australia [2]	[r] 619,481	[r] 794,308	977,400
Brazil [3]	19,710	[r] 22,358	NA
Canada (titanium slag) [4]	672,867	749,281	844,706
Ceylon	82,238	91,327	90,291
Finland	[r] 153,772	152,339	166,449
India	64,733	[r] 56,708	87,000
Japan (titanium slag)	4,624	5,617	8,683
Malaysia (exports)	138,698	[r] 146,197	212,145
Norway	[r] 443,366	540,945	638,193
Portugal	[r] 666	552	254
South Africa, Republic of	----------	18,194	----------
Spain	43,583	[r] 32,471	48,498
United Arab Republic	----------	225	----------
United States [5]	978,509	931,247	867,955
Total [6]	[r] 3,222,247	[r] 3,541,769	3,941,574
Rutile:			
Australia	[r] 322,131	[r] 399,100	405,735
Brazil	126	[r] 10	NA
Ceylon	1,270	[r] 3,036	[e] 3,000
India	2,961	[r] 2,751	2,756
Sierra Leone	[r] 6,304	[r] 31,379	48,593
South Africa, Republic of	----------	543	----------
United States	W	----------	----------
Total [6]	[r] 332,792	[r] 436,819	460,084

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Titanium concentrates are produced in the U.S.S.R. but no reliable figures are available.
[2] Includes leucoxene.
[3] Production—Comissao Nacional de Energia Nuclear only.
[4] Containing approximately 70–72 percent TiO_2.
[5] Includes a mixed product containing ilmenite, leucoxene, and rutile.
[6] Total is of listed figures only.

Coastal Rutile, Ltd., started dredging and concentrating heavy minerals in the Tewantin area, approximately 100 miles to the north of the port of Brisbane. Final production of rutile concentrate is being carried out at a small, dry separation plant at Brisbane, the heavy mineral concentrate recovered in the wet plant operating at Tewantin being transported down the coast by barge. Dillingham Corp. and Signal Oil and Gas Co. through its subsidiary, Signal Pacific Co., have completed agreements to acquire mining rights and certain plants and equipment from Murphyores. According to the newly signed agreement, Dillingham-Signal will pay $1.2 million plus royalties for an operating dry mill at Cudgen, N.S.W., several coastal primary treatment plants, a large modern warehouse on the Brisbane River, and substantial mineral reserves held by N.S.W. Rutile Mining Co. Pty., a Murphyores subsidiary. Mining rights have been acquired on Moreton Island, as well as options to acquire rights to mine on Fraser Island off Queensland's central coast. These properties are held by another Murphyores subsidiary, Murphyores, Inc., Pty., Ltd.

Table 12.—Australia: Exports of ilmenite and rutile concentrates, by countries

(Short tons)

Destination	1968	1969	1970 p
ILMENITE [1]			
France	134,635	123,895	98,626
Germany, West	2,852	56,741	1
Japan	75,501	127,369	223,801
United Kingdom	173,144	258,665	204,531
United States	33,599	41,091	89,170
Other countries	23,689	26,741	30,931
Total	443,420	634,502	647,060
RUTILE			
Canada	26,649	2,993	11,726
France	9,668	6,061	6,034
Germany, West	7,865	10,995	5,959
Japan	34,287	32,331	33,058
Netherlands	18,325	24,363	36,050
United Kingdom	18,572	34,773	37,437
United States	164,528	168,386	192,746
Other countries	39,300	55,105	45,279
Total	319,194	335,007	368,289

p Preliminary.
[1] Includes leucoxene.

Belgium.—NL Industries has announced plans to increase titanium dioxide production capacity at its plant operated by Derives du Titane, S.A., a wholly owned Belgian subsidiary. The plant, located at Langerbrugge, will be enlarged to produce a minimum of 40,000 tons of pigment produced by the sulfate process. The new facilities are expected to be in operation by late 1971.

NV Bayer, the Belgian subsidiary of Farbenfabriken Bayer AG, commissioned a new 20,000-ton-per-year titanium dioxide pigment plant in Antwerp early in January. The plant will employ the conventional sulfate process and consume Sorel titanium slag as the raw material.

Brazil.—In 1969, a new company was formed, Titanio do Brasil, S.A. (TIBRAS), to produce titanium dioxide from imported ilmenite at a plant at Arambepe on the coast, 58 kilometers north of Salvador, Bahia. The plant will utilize a sulfate process developed by Laporte Industries, Ltd., an English firm, which has licensed TIBRAS to use it. Initial production of pigment is scheduled for 1971 at an annual rate of 22,000 metric tons of TiO_2 per year. By the end of 1970, the plant had essentially been completed, and the sulfuric acid unit had begun producing acid from imported sulfur. TIBRAS also formed a new company, Rutile e Ilmenita do Brasil, S.A. to commence large-scale production of mineral sands in southern Bahia. A 50-percent interest in this company will be owned by Industrial Mining and Investment, Ltd., a private concern linked with Australia's Kathleen Investments Group. The company has rights over five exploration areas and, if sufficient heavy mineral can be proved, dredging and separation operations will start in 1972 or 1973.

Currently only one plant produces titanium dioxide in Brazil, Companhia Química Industrial S.A. CIL, in São Paulo.

What may be a major deposit of titanium at Tapira, located 50 kilometers to the south of Araxá in western Minas Gerais, is being explored. This volcanic chimney has been known for many years as an interesting but not necessarily commercial occurrence of pyrochlore. Reportedly, the TiO_2 is found with the pyrochlore as perovskite or anatase. No active development has taken place although the Government has done considerable drilling in the area.

France.—Tioxide, S.A., a subsidiary of British Titan Products, is to increase production capacity for titanium dioxide from 31,000 long tons per year to 60,000 tons by mid-1972. The new plant will use the sulfate process. This is the second capacity increase of titanium dioxide at Tioxide's Calais plant in the last 2 years. In 1969 the company completed a small expansion of 6,000 tons. It is expected that this latest capacity increase will be the last at Tioxide to use the sulfate method.

Thann et Mulhouse is also planning to increase the titanium dioxide capacity at its Le Havre site, to 110,000 tons per year by 1972. This plant was increased from 52,000 to 61,000 tons per year in 1969 and will shortly be at 78,000 tons per year.

India.—Indian Rare Earths Ltd., announced plans to double capacity of its Chavara dry separation plant by the end of 1972. The plant will be capable of producing 100,000 tons of ilmenite and 6,000 tons of rutile annually.

Italy.—Montecatini-Edison S.p.A. will build a 30,000-ton-per-year chloride-process titanium dioxide plant at Scarlino on the coast of Tuscany where a 55,000-ton-per-year sulfate titanium dioxide plant is nearing completion.

Japan.—Japan's total production of titanium sponge by two producers, Osaka Titanium Co., Ltd., and Toho Titanium Co., Ltd., was 10,174 short tons. Titanium slag production by Hokuetsu Metal Co., the only producer now operating, was 8,683 short tons. Shipments of sponge totaled 9,480 short tons, of which 4,740 was for domestic consumption; exports accounted for an equal amount. A third sponge producer, New Metal Industry Co., began trial operations of its newly installed sponge plant toward the end of the year. The plant has a capacity of about 200 tons per month and employs a one-step sodium-reduction process developed by Nippon Soda.

Japan's largest producer of titanium dioxide pigment, Ishihara Sangyo Kaisha, Ltd., is to build a new 30,000-ton-per-year chloride-process pigment plant. The new plant will employ the process of the American Potash and Chemical Corp. under license. Tohoku Chemical Co., 50 percent controlled by Japan's second ranking producer of titanium dioxide pigment. Sakai Chemical Industry Co., was formed to build and operate a 15,000-ton sulfate-process titanium pigment plant at Akita. The plant is expected to be completed before the end of 1971 and will increase Sakai's titanium dioxide capacity to approximately 40,000 tons per year.

Table 13.—Malaysia: Exports of ilmenite, by countries
(Short tons)

Destination	1968	1969	1970
Japan	138,472	146,187	[1] 187,547
Netherlands	223	-------	NA
Singapore	3	10	NA
Total	138,698	146,197	[2] 212,145

NA Not available.
[1] Japanese imports.
[2] Total as reported.

Korea, Republic of.—A small titanium dioxide pigment plant based on the sulfate process is to be built at Inchon by Hankuk Titanium Co. The plant will be engineered by Meiji Sangyo Co., Ltd., of Japan, and will have an initial capacity of 3,500 tons per year. It is expected to be on stream before the end of 1971.

Norway.—Plans for the expansion of ilmenite mining operations at Tellnes, Norway, by Titania A/S, an affiliate of NL Industries, were announced in the first half of the year. The $6 million expansion will increase production to 1 million tons per year of concentrate within the next 2 years. Capacity was boosted from its initial 300,000-ton rate to 500,000 tons per year in 1969 and was to be at a 650,000-ton level by September of 1970. At the projected 1-million-ton rate, the Tellnes deposit is expected to last for at least 100 years.

Sierra Leone.—A consortium of two German firms, Farbenfabriken Bayer AG, and Preussag A.G., was granted a prospecting license by the Sierra Leone Government over a 3,000-square-mile concession. The concession area is adjacent to the lease held by Sherbro Minerals. Ltd. Despite modifications to its plant, Sherbro Minerals was again unsuccessful in raising production to anything like its rated capacity of 100,000 tons per year. Mining operations again failed to show a profit, and the company reported a loss of about $3 million for the year.

United Kingdom.—Laporte Industries, Ltd., inaugurated and placed in operation Europe's first full-scale plant to produce titanium dioxide pigment by the chloride process. The new plant, which has a capacity of 40,000 tons per year, is located at Stallingborough, Lincolnshire. British Titan Products, was also constructing a chloride-process plant at Greatham. The 30,000-ton-capacity plant is expected on stream early in 1971.

TECHNOLOGY

The increasing demand for rutile in spite of dwindling reserves, has created considerable interest in the upgrading of ilmenite. Development of commercial upgrading processes was initiated in the early 1960's by the ilmenite industry in Western Australia. Though various processes developed around the world have achieved reasonable success, full-scale commercial production of a consistent upgraded ilmenite product is not envisaged before 1972. The major mode of attack entailed in the several processes developed or being developed involves increasing the TiO_2 content to over 90 percent, and the reduction of impurities such as iron, chromium, and vanadium. Bureau of Mines personnel have reviewed the proposed processes for making a rutile substitute.[4]

The Bureau of Mines and industry collaborated in a program to determine the occurrence and recoverability of heavy minerals in the sand and gravel operations in Alabama.[5]

A U.S. patent covering a method of upgrading ilmenite was issued and assigned to National Lead Co.[6] The patent describes a method and apparatus for continuously leaching a metallized titaniferous iron ore to obtain a reduced-iron concentrate suitable for chlorination in the production of titanium tetrachloride. Metallized ore is leached with dilute sulfuric acid in an upright leaching tower divided into a first rough-leaching zone and then a plurality of superimposed finish-leaching zones wherein successive portions of the iron content are leached out.

A method for producing pure titanium by the alkali reduction of its chloride was patented.[7] A reaction vessel is equipped with a three-outlet nozzle for discharging titanium chloride and molten magnesium entrained within an inert gas enveloping stream into a downwardly extending flame from the upper portion of the vessel. The stream of reaction products is then cooled to agglomerate the titanium particles but not the magnesium particles, so that a separation can be made in a collecting chamber at the bottom of the vessel.

A patent was granted for an improved laminar-flow sluice concentrator for concentration of ilmenite and other finely divided ores. The patent was assigned to Carpco Research and Engineering, Inc. A laminar flow of ore solids is converged through a first zone so as to stratify the components. The flow is immediately diverged into a second zone of laminar flow to decrease the depth and velocity of the slurry and to spread the strata evenly. The desired values fraction is then taken immediately from the slurry. Thus, ilmenite and rutile can be separated from zircon, garnet, and other commonly associated minerals.[8]

Reflecting more advanced and sophisticated use of titanium, the producing industry introduced several new products in 1970. TMCA marketed stress-free, completely flat titanium alloy plate; Reactive Metals introduced new 60-inch-wide titanium alloy and commercially pure titanium sheet. Valenite Division of Valeron Corp. unveiled tungsten carbide cutting tools, to which a thin super-hard coating of pure titanium carbide is metallurgically bonded. Gould, Inc., introduced a lightweight porous titanium fiber mat as a potential answer to the growing public concern over noise pollution generated by commercial jet aircraft.[9] The titanium fiber material is strong, corrosion-resistant, accoustically absorbent, and 40 percent lighter than its steel fiber counterpart. The new mat is likely to find primary applications in absorbing sounds from jet engine air intakes, auxiliary engines, and aircraft compartment walls. A special titanium brazing process was developed by Aeronca and used in producing the first full-sized brazed titanium honeycomb panel for the SST. Honeycomb panel is used for lightly loaded areas of the wing and tail assembly, an area of about 17,000 square feet per plane.[10]

A new nonconsumable electrode process for melting and casting titanium and other

[4] Work cited in footnote 2.
[5] Sullivan, G.V., and James S. Browning. Recovery of Heavy Minerals From Alabama Sand and Gravel Operations. BuMines Tech. Prog. Rept. 22, 1970, 14 pp.
[6] Honchar, A.P. Method for Treating a Solid Particulate Material with a Solid. U.S. Patent 3,529,933, Sept. 22, 1970.
[7] Ingersoll, D.Y. Method for Producing Titanium and Other Reactive Metals. U.S. Patent 3,535,109, Oct. 20, 1970, 6 pp.
[8] Tomlinson, W.B. Improved Laminar Flow Sluice Concentrator. U.S. Patent 3,509,997, May 5, 1970, 6 pp.
[9] American Metal Market. V. 77, No. 99, May 25, 1970, p. 15.
[10] American Metal Market. V. 77, No. 232, Dec. 7, 1970, p. 16.

reactive metals was placed on the market. The Schlienger melting process can use 100 percent titanium scrap, sponge, or combinations of sponge and scrap. The system basically consists of a material-feed process, and electrode assembly dipping into a water-cooled melting chamber. The latter includes a water-cooled copper crucible and a unique water-cooled casting mold. The furnace system can be operated from vacuums in the micron range to positive pressures.[11]

The tendency of titanium metal to wear excessively has virtually restricted the use of titanium to nonmoving parts in aircraft and automobiles. In a new process, a tough metallurgical case is imparted to the surface of the metal by a 2-hour immersion in molten salt at 1,500° F. The metal is then cooled and water quenched.[12]

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[11] American Metal Market. V. 77, No. 220, Nov. 18, 1970, pp. 1, 5.
[12] Materials Engineering. V. 71, No. 8, August 1970, p. 41.

Tungsten

By Richard F. Stevens, Jr. [1]

During 1970 domestic production of tungsten concentrate rose 17 percent to 8.1 million pounds of contained tungsten. Imports for consumption fell to a 29-year low of 1.3 million pounds. Exports of concentrate increased threefold to 19.5 million pounds as the United States continued to be a net exporter of tungsten. To meet increased domestic demand, which rose by 28 percent, 15 million pounds of tungsten in concentrate were purchased from U.S. Government stockpiles during the year.

Although the domestic price of tungsten concentrate during 1970 remained stabilized by the General Services Administration (GSA) tungsten disposal program, and averaged about $49 per short ton unit (stu), the European price rose to about $80 per stu in late February and averaged $70 per stu during the year as shipments from China (mainland) were discontinued or significantly reduced. To fill the supply deficit caused by the withdrawal of Chinese exports, substantial amounts of tungsten purchased from GSA by traders were sent to West and East European countries.

As a result of relatively large sales made in 1969 from GSA stocks, there appears to be a significant amount of tungsten that is uncommitted to the final consumer.

[1] Physical scientist (Metallurgy), Division of Ferrous Metals.

Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten and thousand dollars)

	1966	1967	1968	1969	1970
United States:					
Concentrate:					
Production	W	r 7,170	r 7,496	6,904	8,105
Shipments	7,166	6,569	7,866	7,004	7,798
Value	$15,038	$13,562	$19,377	$18,195	$21,890
Consumption	18,058	13,860	11,038	13,053	16,700
Releases from Government stocks	8,273	6,393	3,225	38,314	14,993
Exports [1]	101	974	623	7,151	19,470
Imports, general	4,203	2,004	1,824	1,534	1,299
Imports for consumption	4,298	1,699	1,743	1,503	1,284
Stocks, Dec. 31: Mine and plants	1,940	2,109	1,177	1,569	2,232
Primary products:					
Production	15,111	12,604	10,538	13,334	18,308
Consumption	16,235	13,663	13,108	16,056	15,352
Stocks, Dec. 31:					
Producers	4,660	5,168	4,747	3,392	4,467
Consumers	1,640	2,518	2,364	1,778	2,698
World:					
Ore and concentrate:					
Production	63,085	62,725	68,380	70,749	74,017
Consumption	65,441	62,628	64,410	76,889	83,603

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Estimated tungsten content.

Legislation and Government Programs.—On March 4, 1970, the Office of Emergency Preparedness (OEP) changed the nonnuclear war stockpile objective and subobjectives for tungsten and tungsten-bearing materials as follows:

Material	Old objective	New objective
Tungsten ore, lb. W content	35,785,000	55,655,000
Tungsten carbide powder:		
Pounds [1]	2,410,000	2,289,000
Pounds W content	(2,000,000)	(1,900,000)
Tungsten, ferro:		
Pounds [1]	1,960,000	----------
Pounds W content	(1,800,000)	(----------)
Tungsten, metal powder, hydrogen reduced:		
Pounds [1]	1,880,000	1,410,000
Pounds W content	(1,600,000)	(1,200,000)
Tungsten, metal powder, carbon reduced:		
Pounds [1]	590,000	645,000
Pounds W content	(500,000)	(547,000)
Tungsten, crystalline carbide:		
Pounds [1]	1,375,000	(2)
Pounds W content	(1,100,000)	(2)
Total tungsten, lb	44,000,000	60,000,000

[1] Equivalent amount of tungsten in concentrate needed to produce this form.
[2] Removed from list.

Through January 1970 the GSA continued disposing of tungsten concentrate for domestic consumption only, on a "first-come, first-serve" basis at a "shelf price" of $43 per stu. The price was adjusted for premiums and penalties, and GSA sold 2.3 million pounds of contained tungsten at an average price of $42.99 per stu.

In April about 1.4 million pounds of tungsten contained in concentrate was sold for domestic consumption only, on the basis of sealed bids at adjusted prices, ranging from $47.99 to $52.01 per stu. The average price of the tungsten concentrate sold in April was $49.99 per stu. Over 10.4 million pounds of tungsten in concentrate was awarded, for domestic consumption only, in June, at a second sealed bid sale. Prices ranged from $48.02 to $60.58 per stu and averaged $50.43 per stu.

On July 10, 1970, a new tungsten disposal bill was signed into law (P.L. 91–325) which authorized the disposal of 100 million pounds of tungsten excess to stockpile requirements. However, since OEP increased the basic tungsten objective in March, only about 71 million pounds of tungsten was available for disposal. Late in July a joint Government-industry meeting was held to discuss various methods of releasing the tungsten that would be acceptable to all sectors (producing, consuming, and trading) of the tungsten industry. The announcement of GSA's two-phase disposal policy was made on October 22 and finalized on December 11. Under one phase, excess tungsten concentrate was offered to domestic consumers only, on a "first-come, first-serve," basis at a "shelf price" of $55 per stu adjusted for premiums and penalties. About 325,000 pounds of tungsten in concentrate was sold late in December at an average adjusted price of $53.48 per stu. Under the second phase of this program, tungsten concentrate for export was offered for sale on a sealed bid basis, however, the price of material sold could not be below the adjusted "shelf price" ($55 per stu). No sales under this phase were reported in 1970.

In addition to other stockpile releases during the year, a sale of approximately 561,000 pounds of tungsten was made in April under a U.S. Army contract for shell cores and ordnance projectiles. Because this material, subcontracted to Kennametal, Inc., was for U.S. Government use, the price was reduced by the amount of U.S. duty ($5.55 stu) from $43 to an adjusted average of $37.43 stu.

Table 2.—U.S. Government tungsten stockpile materials inventories and objectives

(Thousand pounds, tungsten content)

Material	Objective	Inventory by program Dec. 31, 1970			Total
		National (strategic) stockpile	DPA inventory	Supplemental stockpile	
Tungsten ore and concentrate:[1]					
Stockpile grade	55,656	73,748	13,049	3,304	90,101
Nonstockpile grade	----------	40,509	1,754	1,052	43,315
Total inventory	----------	114,257	14,803	4,356	133,416
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 266,349 pounds of tungsten concentrate sold but unshipped.

DOMESTIC PRODUCTION

Tungsten mine production in 1970, stimulated by higher prices, rose 17 percent compared with the previous year, and mine shipments increased 11 percent. Although 47 mines in eight States reported production and/or shipments of tungsten concentrate in 1970, only two mines operated continuously throughout the year: the Pine Creek mine and mill of the Mining and Metals Division, Union Carbide Corp., near Bishop, Calif.; and the Climax mine and mill of the Climax Molybdenum Co., a division of American Metal Climax, Inc. (AMAX), at Climax, Colo. Both companies reported increased tungsten production in their 1970 annual reports. At Pine Creek, tungsten was the major mineral value recovered along with minor amounts of molybdenum, copper, silver, and gold. Union Carbide processed scheelite ore on a "straight through" basis and produced ammonium paratungstate (APT), an intermediate processed form of tungsten suitable for ready conversion to tungsten metal powder. At Climax, the major mineral value recovered was molybdenum. Concentrates of tungsten, tin, pyrite, and monazite were recovered as byproducts and were entirely dependent upon the rate of molybdenum production. Partially as a result of adding new equipment to its tungsten recovery plant, production of tungsten at Climax rose about 17 percent. In addition, a third operation, the Tungsten Queen mine and mill (the former Hamme mine) near Townsville, Vance County, N.C. was reopened during the year by its new owner, Ranchers Exploration & Development Corp. By yearend, the mill was operating at about 60 percent of capacity. Early in 1971 the mill is scheduled to be operating at about 90 percent of its initial designed capacity of 600 tons of huebnerite per day. Initial mill production is expected to reach 1.4 to 1.5 million pounds of contained tungsten per year. A provision was made so that annual output can be readily expanded to 2.3 million pounds of contained tungsten. Most of the concentrate recovered is reportedly exported. When in full initial production, this mine will be the third largest domestic tungsten mining operation. If production is expanded, the mine could rank with the second largest U.S. tungsten producer. Minor amounts of lead, silver, copper, and pyrite will also be recovered. The mine is currently estimated to contain proven and probable reserves of about 1 million tons of huebnerite ore averaging from 0.50 to 0.55 percent WO_3 (tungsten trioxide). Through December 1970 all of the production was sold at a producers price of $68.50 per stu.

Additional intermittent tungsten production and/or shipments were also reported from Mohave, and Santa Cruz Counties, Ariz.; Inyo, Madera, San Bernardino, and Tulare Counties, Calif.; Lake County, Colo.; Custer County, Idaho; Churchill, Elko, Humboldt, and Pershing Counties, Nev.; and Tooele County, Utah. The exact source of small quantities of tungsten production in California, Nevada, and Montana was unknown and credited to "Undistributed."

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 (thousand)	Average per unit of WO_3	Average per pound of tungsten
1966 [r]	7,530	451,772	7,166	$15,038	$33.29	$2.10
1967 [r]	6,901	414,119	6,569	13,562	32.75	2.06
1968 [r]	8,264	495,891	7,866	19,377	39.07	2.46
1969 [r]	7,360	441,547	7,004	18,195	41.21	2.60
1970	8,194	491,621	7,798	21,890	44.53	2.81

[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.

National Lead's antimony mill at Lovelock, Nev., was converted into a tungsten mill with the installation of new equipment and the rearrangement of existing mill circuits.

A commercial tungsten discovery by Silver Star-Queens Mines near Wells, Nev., was reportedly sufficient to warrant construction of a new mill. The limited exploration program conducted to date indicates an ore body of at least 30,000 tons, averaging 0.7 to 1.0-percent WO_3. Until additional exploration is conducted to prove the extent of the ore body, no specific size for the mill can be determined. Initially, selective shipments of high-grade ore will be sent to Silver Star's tungsten mill at Gold Hill, Utah. The Gold Hill mill processes about 50 tons per day from Silver Star's nearby Yellow Hammer tungsten-copper mine. The concentrated Yellow Hammer ore was sold to Nevada Scheelite Division of Kennametal, Inc., at Fallon, Nev.

General Electric Co. (GE) awarded a tungsten concentrate purchase contract to Tungsten Properties Ltd., of Imlay, Nev. The contract will enable the Segerstrom family to reopen their property at Tungsten, Nev., which formerly operated as the Nevada-Massachusetts Co. A plant to process tailings was being constructed, and plans were underway for mining and concentrating tungsten ore.

A report issued during the year covered the number of employees, wages, value added in mining, cost of supplies, value of shipments, and capital expenditures in the tungsten ore and ferroalloy industries.[2]

CONSUMPTION AND USES

Tungsten carbides continued to represent the major end use of tungsten, accounting for 46 percent of the total consumption. Consumption of intermediate tungsten products used to make the end use items was: tungsten carbide (38 percent), tungsten metal powder (34 percent), scheelite and scrap (21 percent), and ferrotungsten (7 percent).

Several special reviews of tungsten were published that discussed and evaluated supply-demand patterns and projected these relationships to future years.[3]

[2] Bureau of the Census. 1967 Census of Mineral Industries: Tungsten Ores and Ferroalloy Ores, n.e.c. U.S. Department of Commerce, Prel. Rept. MIC67(P)-10C-3, March 1970, 6 pp.

[3] American Metal Market. International Molybdenum Report, Sec. 2. Aug. 31, 1970, 16 pp.

———. Recycling: Practical Answer to the Problems of Air Pollution, Water Pollution, Solid Waste, Sec. 2. 1970 Secondary Metals Supp., Mar. 6, 1970, 42 pp.

———. Tungsten Section, Sec. 2. Feb. 16, 1970, 24 pp.

Griffith, Robert F. Tungsten. Ch. in Mineral Facts and Problems. BuMines Bulletin 650, 1970, pp. 399–415.

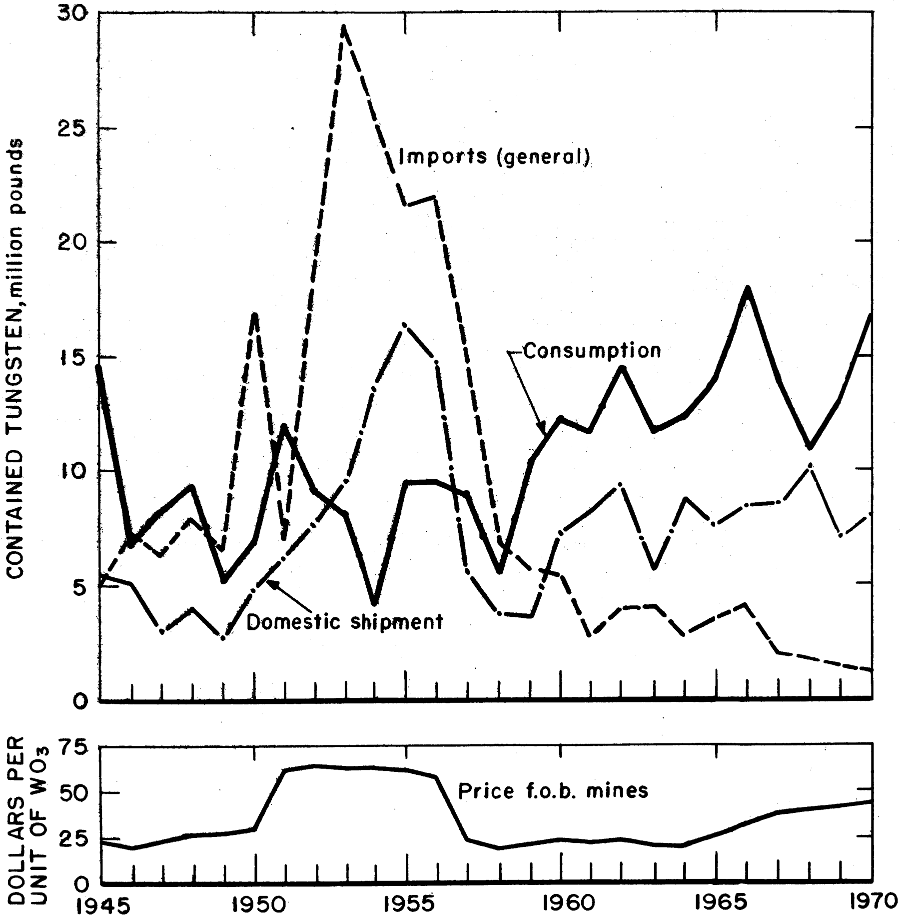

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate.

The Chemical and Metallurgical Division of Sylvania Electric Products, Inc. began construction of a new two-story, 52,000-square-foot plant in Towanda, Pa., to chemically process low-grade tungsten ores. The liquid ion exchange (LIX) facilities will provide a significant increase in the production of APT from scheelite or wolframite. Partial occupancy of the new plant was expected in March 1971 and the new production facility was scheduled to be in full operation by November 1971. Prior to the adaption of this LIX system Sylvania recovered tungsten almost exclusively from wolframite.

During the year the Stellite Division of Union Carbide Corp. in Kokomo, Ind., was purchased by and became an operating unit of the Cabot Co. M&R Refractory Metals Inc., of Springfield, N.J., became a subsidiary of the Whittaker Corp.

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		Chemicals	Other [1]	Total [2]
		Made from metal powder	Crushed and crystalline			
1969						
Gross production during year	9,205	5,531	2,831	11,556	2,599	31,722
Used to make other products listed here	6,517	--------	--------	10,418	1,452	18,387
Net production	2,688	5,531	2,831	1,138	1,147	13,334
Shipments [3]	8,756	5,571	3,414	7,019	2,640	27,400
Producer stocks, December 31	1,369	216	408	1,180	220	3,392
1970						
Gross production during year	9,478	5,031	2,847	16,413	2,354	36,122
Used to make other products listed here	5,939	--------	--------	11,875	--------	17,814
Net production	3,539	5,031	2,847	4,538	2,354	18,308
Shipments [3]	7,840	4,912	2,961	10,632	2,386	28,730
Producer stocks, December 31	1,772	381	701	1,411	202	4,467

[1] Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, pellets, and scrap (1969).
[2] Data may not add to totals shown because of independent rounding.
[3] Includes quantities consumed by producing firms for manufacture of products not listed here.

Table 5.—Consumption, by end uses, and stocks of tungsten products in the United States in 1970

(Thousand pounds, contained tungsten)

	Ferro-tungsten [1]	Tungsten metal powder [2]	Tungsten carbide powder	Other tungsten materials [3]	Total [4]
Steel:					
Carbon steel	--------	--------	--------	W	W
Stainless and heat resisting	121	W	--------	131	252
Alloy (excludes stainless and heat resisting)	185	--------	W	W	185
Tool	601	W	--------	874	1,475
Cast irons	1	--------	--------	W	1
Superalloys	49	W	W	216	265
Alloys (exclude alloy steels and superalloys):					
Cutting and wear resistant materials	W	1,042	5,311	675	7,028
Other alloys [5]	46	397	W	106	549
Mill products made from metal powder	--------	3,306	W	W	3,306
Chemical and ceramic uses	W	W	W	W	W
Miscellaneous and unspecified	39	426	476	1,350	2,291
Total [4]	1,049	5,171	5,787	3,353	15,352
Consumer stocks Dec. 31, 1970	361	643	659	1,035	2,698

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.

A significant contribution to manufacturing productivity was the commercial development of titanium-coated, tungsten carbide cutting tools, which speed production and last two to three times as long as uncoated cutting tools.[4] The thin (0.0002 to 0.0003 inch) titanium carbide coatings are vapor deposited on tungsten carbide tools and significantly reduce the coefficient of friction between the tool and workpieces.

PRICE AND SPECIFICATIONS

Throughout the first 4 months of 1970 the price of imported tungsten ore and concentrate was quoted at $43 (nominal) per short ton unit (stu). From June through early October, the nominal quoted price ranged from $50 to $55 per stu. These prices followed those paid to GSA for purchases of tungsten concentrate from Government stockpiles. Effective in mid-October, the price was quoted at $55 (nominal) per stu and reflected the new "shelf price" set by GSA. As quoted in Metals Week and in Metal Bulletin (London), the world tungsten price, shown in table 6, remained above the nominal GSA price ($43 to $55 per stu) during the year. The world price reached its highest quotation in February when it was reported at 758 shillings per long ton ($81.32 per stu). Because of this price differential, the United States continued to be a net exporter of tungsten concentrate during the year.

The cause of the high European price was reported to be due almost entirely to the continued reduction of tungsten shipments from mainland China. This action forced most of the industrialized countries of East and West Europe, which had previously received all or a significant amount of their supply from mainland China, to seek most of their tungsten requirements from free world sources. The price of APT delivered to contract customers, was increased during the year, and ranged from $56.38 per stu (metallurgical grade) to $58.43 per stu (catalytic grade). A conversion fee of $11 per stu was charged for converting tungsten concentrate to APT.

Table 6.—Monthly price quotations of tungsten concentrate in 1970

Month	Wolfram and scheelite: London market, shillings per long ton unit of WO_3, 60-percent basis:		Equivalent quotations, dollars per short ton unit of WO_3, 60-percent basis		
	Low	High	Low	High	Average[1]
January	652	701	$69.93	$75.15	$72.54
February	730	758	78.24	81.32	79.78
March	694	730	74.38	78.24	76.31
April	641	676	68.73	72.48	70.60
May	656	703	70.61	75.42	73.02
June	681	735	72.98	78.78	75.88
July	677	733	72.62	78.65	75.64
August	648	683	69.46	73.20	71.33
September	620	652	66.45	69.93	68.19
October	533	562	57.12	60.29	58.70
November	543	579	58.19	62.11	60.15
December	568	605	60.96	64.84	62.90

[1] Arithmetic average of weekly quotations. Equivalent 1970 average price $70.42; duty $5.55, equivalent average price, duty paid, $75.97 per short ton unit.

The quoted prices of both carbon- and hydrogen-reduced tungsten metal powder increased during the year, reflecting the higher price of tungsten concentrate. At yearend, carbon-reduced tungsten metal powder (99.8-percent purity in 1,000-pound lots) was quoted by Metals Week at $4.50 per pound of contained tungsten, compared with the 1969 quotation of $3.06 per pound. The quoted price of hydrogen-reduced tungsten metal powder (99.99-percent purity) rose, and ranged from $5.43 to $6.36 per pound of contained tungsten at yearend 1970, compared with $4.91 to $5.75 in 1969.

[4] Wilson, R. A. TiC Coated Inserts Are Levelers. Iron Age, v. 206, No. 22, Nov. 26, 1970, pp. 37–40.

In Metals Week, 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, effective January 1, 1970, increased from $3.65 per pound of tungsten to $3.75 per pound. The price of UCAR, Union Carbide's special high-purity ferrotungsten, was increased from $3.86 to $4.00 per pound of tungsten during the year.

In 1970, the U.S. dealer (export) price of ferrotungsten was quoted at $4.50 per pound of tungsten.

Although not quoted, the price of scheelite concentrate for direct addition to steel melts was believed to be from about $47 to $54 per stu, equivalent to about $2.96 to $3.40 per pound of contained tungsten.

FOREIGN TRADE

Exports.—Exports of tungsten concentrate (table 7), increased almost threefold in 1970. This represented material purchased from the GSA stockpile and shipped by traders primarily to Europe to take advantage of higher prices. Reexports of tungsten concentrate and products are listed in table 8.

In 1970 exports of unwrought tungsten metal and alloys in crude form, waste, and scrap rose 64 percent to 1,463,101 pounds, gross weight, valued at $2,820,923 and were shipped primarily to West Germany (73 percent), the United Kingdom (15 percent), and the Netherlands (7 percent). Tungsten and tungsten alloy powder exports increased more than sixfold during the year to 404,862 pounds, gross weight, valued at $2,139,706. These exports were shipped to the United Kingdom (29 percent), Austria (26 percent), France, Japan, and West Germany (12 percent each), and Canada (6 percent).

In 1970, tungsten and tungsten alloy wire exports, primarily to West Germany (30 percent), Canada (17 percent), and Brazil (10 percent), rose 78 percent to 110,986 pounds, gross weight, valued at $2,651,996. Exports of wrought tungsten and tungsten alloys fell 72 percent to 105,723 pounds, gross weight, valued at $1,205,794. Shipments were primarily to West Germany (45 percent), Canada (22 percent), and Japan (10 percent).

Table 7.—U.S. exports of tungsten ore and concentrates, by countries
(Thousand pounds and thousand dollars)

Country	1969			1970		
	Gross weight	Tungsten content [1]	Value	Gross weight	Tungsten content [1]	Value
Austria	86	44	$104	--------	--------	--------
Belgium-Luxembourg	618	319	824	2,634	1,359	$3,873
Canada	457	236	713	469	242	958
Czechoslovakia	--------	--------	--------	1,837	948	3,382
France	649	335	1,004	452	233	809
Germany:						
East	1,452	749	2,234	1,556	803	2,481
West	3,913	2,019	5,344	11,771	6,074	18,915
India	93	48	144	--------	--------	--------
Italy	26	14	44	--------	--------	--------
Japan	2,156	1,112	2,917	3,723	1,921	6,358
Mexico	(2)	(2)	1	2	1	7
Netherlands	1,175	606	1,690	1,609	830	2,655
Poland	548	283	796	3,004	1,550	4,538
South Africa, Republic of	--------	--------	--------	300	155	565
Sweden	246	127	424	1,708	881	2,595
U.S.S.R	228	118	366	896	462	1,411
United Kingdom	2,212	1,141	3,224	7,773	4,011	12,584
Total	13,859	7,151	19,829	37,734	19,470	61,131

[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).
[2] Less than ½ unit.

Table 8.—U.S. reexports of tungsten materials in 1970, by country and product

(Pounds, gross weight)

Product and country	Quantity	Value
Tungsten ore and concentrate:		
Germany, West	187,647	$341,447
Tungsten wire:		
Netherlands	490	11,173
Tungsten, wrought:		
Germany, West	2,931	61,937
Netherlands	93	3,929
Sweden	795	1,042
Total, wrought	3,819	66,908

Because of the significant interest expressed by industry and Government in the flow of processed tungsten products, effective Jan. 1, 1971, export data on ferrotungsten and ammonium paratungstate (APT), which previously had been in a "basket" category and consequently unavailable will be reported separately.

Imports.—During the year, general imports of tungsten concentrate and imports for consumption both decreased 15 percent.

Imports of tungsten carbide during the year, primarily from West Germany (40 percent) and Canada (34 percent), increased over fivefold and totaled 73,275 pounds of tungsten valued at $518,070. There continued to be no imports of semifabricated tungsten in ingots and shot during the year.

Imports of tungsten waste and scrap containing over 50 percent tungsten, fell 12 percent to 27,763 pounds of tungsten valued at $149,835 in 1970 and were received primarily from West Germany (41 percent), Canada (28 percent), and the Netherlands (27 percent). During the year, imports of unwrought tungsten in lumps, grains, and powder increased elevenfold to 74,659 pounds of tungsten valued at $491,682. These imports came primarily from West Germany (87 percent) and Mexico (12 percent). During 1970, imports of wrought tungsten increased by 40 percent to 6,946 pounds, gross weight, valued at $478,827. This material was imported from Austria (38 percent) and the Netherlands (30 percent).

Table 9.—U.S. imports [1] of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1969			1970		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	235	132	$348			
Canada	1,870	1,046	2,234	2,048	1,234	$2,986
Mexico	2	1	1	45	27	70
Peru	449	256	671	66	38	157
Portugal	168	99	273			
Total	2,724	1,534	3,527	2,159	1,299	3,213

[1] Data are "general imports"; that is, they include tungsten imported for immediate consumption plus material entering warehouses.

Table 10.—U.S. imports for consumption of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1969			1970		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	179	101	$266			
Canada	1,870	1,046	2,234	2,048	1,234	$2,986
Mexico	2	1	1	25	12	33
Peru	449	256	671	66	38	157
Portugal	168	99	273			
Total	2,668	1,503	3,445	2,139	1,284	3,176

Table 11.—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
1968	44	$51	r 29	r $426	r 73	r $477
1969	33	65	r 30	r 552	r 63	r 617
1970	35	173	190	1,560	225	1,733

r Revised.

Table 12.—U.S. import duties on all forms of tungsten

(Tungsten content per pound of contained tungsten)

Tariff classification	Article	Rate of duty [1]	
		Effective Jan. 1, 1970	Effective Jan. 1, 1971
601.54	Tungsten ore	$0.35 per pound	$0.30 per pound.
603.45	Other metal bearing materials in chief value tungsten	$0.294 plus 14 percent ad valorem.	$0.25 plus 12 percent ad valorem.
607.65	Ferrotungsten	$0.294 plus 8.5 percent ad valorem.	$0.25 plus 7.5 percent ad valorem.
629.25	Waste and scrap containing by weight not over 50 percent tungsten	$0.29 plus 8.5 percent ad valorem.	$0.25 plus 7.5 percent ad valorem.
629.26	Waste and scrap containing by weight over 50 percent tungsten	14.5 percent ad valorem	12.5 percent ad valorem.
629.28	Unwrought tungsten, except alloys in lump, grain and powder	$0.29 plus 17.5 percent ad valorem.	$0.25 plus 15 percent ad valorem.
629.29	Unwrought tungsten ingots and shot	14.5 percent ad valorem	12.5 percent ad valorem.
629.30	Unwrought tungsten, n.e.c	17.5 percent ad valorem	15 percent ad valorem.
629.32	Tungsten alloys, unwrought, containing by weight not over 50 percent tungsten	$0.294 plus 8.5 percent ad valorem.	$0.25 plus 7.5 percent ad valorem.
629.33	Tungsten alloys, unwrought, containing by weight over 50 percent tungsten	17.5 percent ad valorem	15 percent ad valorem.
629.35	Wrought tungsten	do	Do.
416.40	Tungstic acid	$0.29 plus 14 percent ad valorem.	$0.25 plus 12 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	$0.294 plus 17 percent ad valorem.	$0.25 plus 15 percent ad valorem.
422.42	Other tungsten compounds, n.e.c	$0.29 plus 14 percent ad valorem.	$0.25 plus 12 percent ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value tungsten	do	Do.

[1] Not applicable to Communist countries.

Imports of calcium tungstate during 1970 decreased 8 percent and totaled 19,064 pounds of tungsten valued at $164,706. This material was received from West Germany (85 percent) and the United Kingdom (15 percent).

There were no imports of material classified as "Other Metal-Bearing Materials in Chief Value Tungsten" during the year. In previous years, this category was believed to primarily cover synthetic scheelite. During 1970 there continued to be no imports of ferrotungsten.

As in the previous 4 years, there were no imports of foreign tungsten concentrate into the Virgin Islands or shipments of processed tungsten products from the Virgin Islands to the continental United States during 1970.

In accordance with the "Kennedy round" of tariff negotiations, the U.S. import duties on all forms of tungsten were further reduced, effective January 1, 1971, as indicated in table 12.

WORLD REVIEW

A meeting of the Working Group of the United Nations Committee on Tungsten was held in November at Geneva, Switzerland. This eight-member body met to prepare a review of the prevailing world tungsten situation. It was composed of Government representatives from Australia, Austria, Bolivia, Portugal, South Korea, Sweden, the United States, and West Germany. Because the Working Group was also interested in the representativeness of tungsten price quotations, an official representative from the United Kingdom was invited to attend as an observer and to comment on the methods of determining tungsten price quotations used in the United Kingdom. Representatives from the Governments of France and the Netherlands also attended the meeting as observers.

Table 13.—Tungsten: World production by countries

(Thousand pounds of contained tungsten) [1]

Country [2]	1968	1969	1970 p
North and Central America:			
Canada	r 2,855	3,223	2,956
Guatemala	26	-------	-------
Mexico	586	635	586
United States	7,496	6,904	8,105
South America:			
Argentina	408	322	e 260
Bolivia	r 3,904	4,059	4,068
Brazil	r 957	2,222	2,557
Peru	r 1,221	1,519	1,823
Europe:			
Austria	r 309	353	e 350
Italy	8	3	e 3
Portugal	3,049	2,934	3,935
Spain	273	443	430
U.S.S.R. e	13,700	14,300	14,800
Africa:			
Congo (Kinshasa)	86	143	-------
Rwanda	708	374	e 400
South Africa, Republic of	51	64	7
South-West Africa, Territory of [3]	240	212	139
Tanzania	33	13	-------
Uganda	97	117	152
Asia:			
Burma	r 430	353	419
China, mainland e	17,600	17,600	17,600
India	44	46	40
Japan	r 1,177	1,343	1,493
Korea, North e	4,720	4,720	4,720
Korea, Republic of	r 4,614	4,345	4,564
Malaysia	143	304	300
Thailand	r 1,096	1,442	1,567
Oceania: Australia	2,549	2,756	2,743
Total	r 68,380	70,749	74,017

e Estimate. p Preliminary. r Revised.

[1] Conversion factors: WO_3 to W, multiply by 0.7931; 60 percent WO_3 concentrate 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, New Zealand, Nigeria, and Southern Rhodesia.

[3] Data are for the South-West Africa Co., Ltd. only, and are for the year ended June 30 of the year stated.

Table 14.—World consumption of tungsten ores and concentrates, by countries [1]

(Thousand pounds, tungsten content)

	1968	1969	1970 p
Actual consumption:			
Australia	e 110	e 110	88
Austria	2,822	3,395	4,387
Canada	1,182	1,049	e 1,100
Czechoslovakia	r 3,770	3,023	e 3,085
India	194	e 200	e 200
Japan	4,993	7,302	8,962
Portugal	525	688	763
Sweden	r 2,573	3,371	3,289
United Kingdom	r 5,348	7,079	8,691
United States	11,038	13,053	16,700
Apparent consumption, including stock variations:			
France	1,964	3,329	3,192
Apparent consumption, excluding stock variations:			
Argentina	119	66	e 77
Belgium-Luxembourg	79	[2] 75	[2] 70
Bulgaria [2]	75	80	80
China, mainland [2]	1,375	1,400	1,450
Germany:			
East [2]	430	800	850
West	r 5,622	9,299	7,112
Hungary [2]	40	50	50
Italy	62	53	152
Korea, North [2]	3,500	3,500	3,500
Netherlands	284	489	496
Poland	r 3,807	3,422	3,924
South Africa, Republic of [2]	620	630	700
Spain	128	26	e 35
U.S.S.R. [2]	13,750	14,400	14,650
Total	r 64,410	76,889	83,603

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: Brazil, Denmark, Finland, Israel, Norway, Romania, Switzerland, Yugoslavia.

[2] Estimated by author of chapter.

Primary Source: United Nations Committee on Tungsten.

Australia.—King Island Scheelite (1947) Ltd., a subsidiary of Peko-Wallsend Ltd., began a $10 million project to rebuild its open pit tungsten mining-processing complex at Grassy, Tasmania. A new concentrator, being constructed 1 mile north of the existing complex on King Island, will have an initial annual capacity of 450,000 tons of ore with provision for subsequent expansion to 600,000 tons per year. As part of the expansion project, a 1,600-foot breakwater was being built on King Island to permit more rapid and efficient loading of ships. Feasibility studies conducted by both the Tasmanian and Commonwealth Governments recommended that a new deepwater port for King Island be located at Currie, rather than at Grassy, as requested by Peko-Wallsend.

Abaleen Minerals N.L. estimated reserves of tungsten minerals at its property near Kempsey, N.S.W., to total 1.3 million short tons. Open pit mining operations were conducted and material was stockpiled at a rate of 500 tons of ore per day until midyear, when a pilot plant with a crushing and treating capacity of 15 tons per hour, together with three separating tables, was put into operation. Abaleen conducted further tungsten exploration work in the locality and plans to install a large volume treatment plant to process the company's expanded wolfram reserves.

Evaluation of old workings at the Spotted Dog tungsten deposit near Mt. Garnet, Queensland, by Overland Mining N.L., indicated the existance of at least 250,000 tons of ore assaying 0.4 percent WO_3, minable by open pit operations. A recovery plant having an initial capacity of 500 tons of ore per week was established on the site. It is anticipated that the ultimate capacity of this unit will be increased to 1,000 tons per week.

Bolivia.—The Chojlla mine of International Mining Co. (50-percent owned by W.R. Grace & Co.) located northeast of La Paz in the Yungas region is the country's largest tungsten producer. Because of diminishing reserves and current unfavorable foreign investment conditions, production was expected to decrease. Current mine ore production averages 0.76 percent combined tin and wolfram content. Ore in place, averages 0.44 percent tin and 0.32 percent wolfram, which indicates that the mill operated at top efficiency. A new mine in the same mountain, but above the Chojlla workings, was being developed in an attempt to extend the known tungsten reserves of the area.

Brazil.—Scheelite concentrate averaging better than 70 percent WO_3 was produced in the Currais Novos and Lajes areas of Rio Grande do Norte. The Brejui mine remained the major operation in the district producing 1.2 million pounds of a 73-percent WO_3 concentrate. Work continued in the area by the joint Departmento Nacional de Produção Mineral—U.S. Geological Survey (DNPM—USGS) tungsten project team toward accumulating ore reserve information, developing improved mining methods, and designing a centralized milling facility for the district.

Burma.—During the year, the Burmese Government installed a new tin-tungsten smelter at Namtu with an improved capacity to provide concentrate for export rather than ore.

Five technicians from the Soviet firm Tyazhpromexport conducted a rehabilitation survey of the Mawchi tin-tungsten mine under a contract with the Burmese Mineral Development Corp. (MDC). By mid-1970, Mawchi's monthly production of mixed tin-tungsten concentrates was less than 50 tons, significantly under the targeted production of 100 tons of ore per month.

West Germany signed an agreement with Burma for the rehabilitation of the Heinda tin-tungsten mines near Tavoy in the Tenasserim Division. German technicians attempted to rationalize the extraction of tin-tungsten mineral ores from existing mines in the Tenasserim area, rather than to develop new ones.

Canada.—Production of high-quality scheelite concentrate by Canada Tungsten Mining Corp. Ltd. (CTMC), the country's major tungsten producer, fell 8 percent in 1970 at the mine and mill at Tungsten (formerly Flat River), Northwest Territories, near the Yukon border. Mine production totaled 186,340 short ton units of WO_3 (almost 3 million pounds of contained tungsten), and the concentrator was operated at 94.68-percent capacity, treating an average of 512 dry tons of ore containing 1.36 percent WO_3 per day.[5] The concentrator operated on schedule for the first half of the year and averaged 80 percent recov-

[5] Canada Tungsten Mining Corp. Ltd., (Canada). Annual Report 1970. Toronto, Canada, April 1971, 9 pp.

ery. As scheduled, a higher ratio of chert to skarn ore was mined at the open pit operation during the 1970 summer mining season. Treatment of this harder ore taxed crushing and grinding circuits beyond their rated capacity, resulting in a lower recovery for the second half of the year. Overall average scheelite recovery of WO_3 in 1970 dropped to 75.95 percent from 78.81 percent in 1969, as the grade of ore milled fell from 1.54 percent WO_3 in 1969 to 1.39 percent WO_3 in 1970. A continuing program was carried out to improve recovery and to determine the most economical and efficient methods of treating a blend of skarn and chert ore.

In addition to the scheelite, 366,224 pounds of byproduct copper was produced during the year, a decrease of 21 percent compared with 1969. This large decrease indicated that the concentration of byproduct copper in the scheelite ore fell significantly.

On December 31, 1970, CTMC estimated its reserves of ore in place at 558,000 tons, averaging 1.56 percent WO_3. In addition 89,000 tons of ore averaging 1.43 percent WO_3 was stockpiled. The stockpiled ore contains about 2 million pounds of tungsten. The stockpile material and estimated reserves are adequate to sustain the current rate of operation for about 4 years. CTMC announced that a study of methods for extending the mine's life indicated that to maintain the current production rate with the available lower grade ores, milling capacity would have to be expanded to about 750 tons of ore per day.[6]

Encouraged by rising tungsten prices, Canadian Exploration Ltd., a subsidiary of Placer Development Ltd., planned to begin production from its Invincible scheelite property near Salmo, British Columbia, in mid-October. The orebody was estimated to contain 480,000 tons averaging 0.65 percent WO_3. Mining and milling was proposed to be conducted at a rate of about 10,000 tons of ore per month. The company will make use of milling equipment previously used in treating its Emerald and Dodger ore bodies in the same area during an earlier operation that was terminated in 1958.

China, mainland.—The marked curtailment of mainland Chinese tungsten exports was believed to be due to increased domestic consumption in steel production and hard metal (carbide) uses and to the probability that China was stockpiling tungsten.

Processing of tungsten concentrate to metal is done chiefly at two plants: one in Shanghai and the second in Peking. In addition to producing tungsten metal, the Shanghai plant produces tungsten light bulb filaments, drawn wire, electronic tube grids and plates, and tungsten carbide tools. The Peking plant also reduces tungsten ore concentrate to metal for use in the manufacture of electronic components. The Nan-ching Electric Tube Plant, although of lesser importance than the Shanghai and Peking plants, also produces tungsten metal.

China produces most of its hard alloys (principally tungsten carbide) for cutting tools, rock drill bits, and precision instruments at the Tung Fang Alloy Plant in Kiangsi Province. The plant produces a wide variety of tools and other shapes from sintered tungsten carbide. Some hard metals and other relatively high tungsten alloys are produced at the Chung-Kiang Nonferrous Metal Plant.

Mongolia.—Tungsten ore was recovered from the Ih Hairham and Burentsogt mines. The tungsten recovered from these mines was converted to concentrates at onsite mills before being shipped to the U.S.S.R. for further processing.

Peru.—The Mitsui Mining and Smelting Co., Ltd., was scheduled to install a 10-ton-per-day capacity processing mill adjacent to the Acopalca mine (in Ancash Province) to mill high quality (4-percent WO_3) tungsten ore. Reportedly, Mitsui plans to produce 120 tons per year of 65-percent WO_3 concentrate for shipment to Japan.

Cerro de Pasco Corp. continued to be the major Peruvian tungsten producer. Output from its San Cristobol mine was concentrated at Cerro's nearby Mahr Tunnel concentration plant. Output was in excess of 70 tons per month.

Poland.—Much or all of the tungsten formerly supplied to Poland by mainland China is now being obtained from Western countries. During the year, a Polish industrial mission announced that it had offered to give Bolivia machinery and equipment to mechanize its mining industry in

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[6] The Northern Miner (Canada). Canada Tungsten May Up Mill To Handle Lower Grade Ore. No. 9, May 21, 1970, Canada, pp. 1, 8.

exchange for 4,000 tons of tin, 80,000 tons of zinc, and 4,000 tons of tungsten.

Portugal.—Beralt Tin and Wolfram Ltd., the country's major tungsten producer, announced that combined production of wolfram and tin concentrates in 1970 was 18 percent higher than in 1969, but fell 66 tons short of the target owing to a labor shortage and low productivity in the long-wall stopes.[7] It was apparent that the tin and copper content of the ore increased with depth. The mill continued to operate efficiently during the year, and the grade of concentrate was maintained at a high level. The selective screening and jigging plant installed at Barroca Grande during the previous year made it possible to increase output of the preconcentration plant and to discard a greater proportion of waste.

Part of a major expansion at Beralts' Panasqueira mine and mill involved making alterations and increasing the capacity of an aerial ropeway, which transports ore from the mine to the beneficiation plant.[8] When completed by yearend 1970, the expanded system will increase capacity by 50 percent to 2,400 tons. Through the use of modernized automated operations, the continuing labor shortage will be offset.

South-West Africa, Territory of.—The Nord Mining Co. of America announced plans to develop a new scheelite mine in the Rehoboth district south of Windhoek. At a projected production rate of 130,000 tons per year, the life of the mine should exceed 10 years. The mine was expected to initiate production late in 1971.

Sweden.—AB Statsgruvor announced plans to reopen the Yxsjöberg scheelite mine in central Sweden late in 1970 or early in 1971. Production capacity was expected to be 500 tons of high-grade scheelite (73 percent WO_3) and about 100 tons of lower-grade scheelite per year. Most of the output will be used to meet the nation's domestic consumption requirements.

United Kingdom.—The open pit Hemerdon tungsten mine, about 6 miles north of Plymouth and which was worked during World War II, was being reevaluated. Exploration of the deposit in which the tungsten content appears to increase with depth, was being conducted to determine the extent and grade of the reserves. Metallurgical tests will be conducted to establish suitable recovery practices that will yield recoveries of 60 to 70 percent. Interest in Hemerdon has grown as tungsten's price and demand increased, and reserves of present suppliers dwindle. With inferred reserves of 5.6 million tons, proposals have been made for a 10,000-ton-per-day, large-scale, low-grade, open pit mining operation.

U.S.S.R.—An extensive new tin-tungsten ore deposit was reported in the Kazakhstan, and a second commercial tungsten ore deposit was located in the maritime territory of the Soviet far east. To process and recover tungsten from this and another deposit in the area, an ore dressing complex was reportedly being built.

TECHNOLOGY

Studies conducted by Bureau of Mines researchers evaluated methods of electrowinning tungsten from wolframite [$(Fe,Mn)WO_4$] concentrates.[9] Direct electrowinning from wolframite dissolved in molten sodium salt mixtures was unsuccessful, yielding impure products. Electrowinning from a halide-tungstate melt, which was obtained by high-temperature, two-phase extraction of tungstic oxide (WO_3) from wolframite, produced tungsten metal of 99.9-percent purity. Tungsten carbide was electrodeposited from the halide-tungstate melt.

Bureau metallurgists evaluated electrowon tungsten metal powder with respect to consolidation, fabrication, and mechanical properties.[10] After being high-energy-rate extruded to 100-percent density, the material was rolled conventionally to sheet. The mechanical properties compared favorably with sheet prepared from commercially produced hydrogen-reduced tungsten powder.

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[7] Beralt Tin and Wolfram Ltd. (London). Annual Report and Accounts 1970. Apr. 20, 1971, 16 pp.

[8] Frenkiel, Zygmunt F. Panasqueira Tungsten Mine Revamps Its 40 Year Old Ropeway From Mine to Mill in Portugal. World Min., v. 6, No. 13, December 1970, pp. 50–53.

[9] Gomes, John M., Kenji Uchida, and M. M. Wong. Electrolytic Preparation of Tungsten Metal and Tungsten Carbide From Wolframite. BuMines Rept. of Inv. 7344, February 1970, 8 pp.

[10] Keith, G. H., J. S. Winston, and H. G. Iverson. Evaluation of Electrowon Tungsten Sheet. BuMines Rept. of Inv. 7385, May 1970, 14 pp.

A report issued during the year evaluated the current status of high-temperature oxidation resistant coatings and indicated that satisfactory coatings do not exist for use on tungsten above 3,300° F.[11] Further work on silicide-base coatings on tungsten was not recommended and a new approach to coating, such as the multilayer technique, must be developed.

A new way to improve the properties of tungsten powder used to make cemented carbide was described. This method utilizes a chloride process in which tungsten chloride are reduced with hydrogen to a predetermined particle size.[12]

A new process for upgrading tungsten concentrates that contain 40 to 75 percent WO_3 was developed by Canada's Department of Energy, Mines and Resources (Canadian patent 836,441). The process is available for license through the Canadian National Research Council (Ottawa).[13] In this process caustic soda converts tungsten acid into sodium tungstate with a recovery rate of 98 percent, compared with 80 percent when ammonium hydroxide is employed.

A new air pollution control unit atop the exit gas stack at Sylvania's tungsten products plant at Exeter, N.H., was reported to be 99.9-percent effective. The stack uses a thermal incinerator to convert toxic nitrogen dioxide to harmless carbon dioxide, nitrogen, and water vapor.

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[11] National Research Council. Summary Report: High Temperature Oxidation Resistant Coatings —A Report by the National Materials Advisory Board. NMAB–263, Nat. Acad. Sci.—Nat. Acad. Eng., Wash., D.C., March 1970, 54 pp.

[12] Ramguist, Lans. A New Tungsten Powder for Producing Carbides. Modern Developments in Powder Metallurgy (Proc. of International Powder Metallurgy Conference, New York, 1970), v. 4, 1971, 6 pp.

Ruth, John P. New Tungsten Process Developed. Am. Metal Market, v. 77, No. 136, July 17, 1970, pp. 1, 20.

[13] Chemical Week. Upping Tungsten Tonnage. V. 106, No. 18, May 6, 1970, pp. 47–48.

Engineering and Mining Journal. A New Way to Tungsten V. 171, No. 7, July 1970, pp. 81–86.

Uranium

By Walter C. Woodmansee [1]

Despite a growing short-term surplus of uranium, the domestic uranium industry was characterized by continued growth in most sectors during 1970. Exploratory and developmental drilling for uranium, entirely by private industry, remained extensive although reduced from the record pace of 1969. New reserves were established as a result of this exploration. Both mine and mill production showed moderate increases, compared with 1969, but milling operations continued substantially below productive capacity. Regardless of this excess capacity, four new mills were under construction.

Private industry continued preparations for anticipated future growth in uranium demand. A number of nuclear fuel processing, reprocessing, and fabricating plants were planned or under construction. Demand was growing for certain uranium compounds, enriched uranium, and plutonium. Research and development studies on advanced nuclear reactors were emphasized by both Government and industry.

There was an upsurge in orders for nuclear powerplants, compared with the slackening during 1969, although nuclear power plant completion and operation continued behind schedule because of environmental problems and construction delays.

On the international scene, important new uranium resources were under development, particularly in Australia and Africa. Discoveries in the Northern Territory of Australia are especially notable, because they appear to be potential new sources of low-cost uranium. As nuclear power reactors continued to proliferate worldwide, several of the industrialized nations (non-Communist) made preparations for establishing uranium enrichment facilities.

Legislation and Government Programs.—In November the U.S. Atomic Energy Commission (AEC) announced the publication of Domestic Uranium Program Circular 8, Revised, in preparation for resumption of leasing certain AEC-controlled properties in uranium-mining areas of the Western United States.[2] The tracts, comprising 40 square miles in Colorado, Utah, and New Mexico, are the remainder of more than 700 square miles withdrawn by the Government during 1948–54 and not returned to the public domain. Certain tracts contain ore deposits discovered by AEC-sponsored exploration.

New environmental legislation had increasing impact on the AEC's regulatory program. The AEC and the nuclear industry continued efforts toward development and implementation of safeguard and environmental programs for nuclear powerplants. Amendments were proposed to licensing regulations for siting of reprocessing plants and disposal of high-level radioactive waste materials.[3] The AEC issued four operating licenses for nuclear powerplants, and 27 were pending. Twenty-two States had joined the AEC in assuming certain regulatory authority governing the use of nuclear materials. The AEC initiated a program of contractual arrangements with individual States for environmental monitoring services at power reactor installations.[4]

Exploration.—Despite the long-term projections of high demand for uranium, starting perhaps in the late 1970's, the near-term soft market has discouraged large-scale investment in exploration and development. However, surface drilling for uranium, wholly by private industry, continued at a fairly fast pace in 1970, although total footage completed was 21 per-

[1] Physical scientist, Division of Nonferrous Metals.
[2] Federal Register. V. 35, No. 219, Nov. 10, 1970, pp. 17271–17272.
[3] U.S. Atomic Energy Commission. The Nuclear Industry 1970. November 1970, pp. 343–355.
[4] U.S. Atomic Energy Commission. Annual Report to Congress for 1970. January 1971, pp. 65–66.

cent below the record high of 1969. (The total of 23.5 million feet drilled in 1970 does not include drilling for mining claim validation or underground longholing and diamond drilling, which totaled about 2 million feet.) Nearly 90 percent of the footage drilled was confined to three States —Wyoming, 41.7 percent; Texas, 25.8 percent; and New Mexico, 22 percent. Operating companies reported a number of discoveries in the Western United States.

An AEC survey of company drilling plans at mid year indicated that 52 companies planned 78 million feet of drilling during 1970–73 at an estimated cost of $120 million.

Table 1.—Salient uranium concentrate (U_3O_8) statistics

(Short tons U_3O_8 unless otherwise specified)

	1966	1967	1968	1969	1970
Production:					
Domestic:					
Mine:[1]					
Ore thousand tons	4,329	5,272	6,448	5,904	6,324
Content of ore	9,906	10,657	12,570	12,281	12,768
Average grade of ore percent U_3O_8	0.229	0.202	0.195	0.208	0.202
Recoverable [e] [2]	9,520	10,330	12,070	11,870	12,340
Value [e] [3] thousands	$152,281	$165,239	$182,698	$142,161	$149,464
Mill, concentrate [4]	10,590	11,250	12,340	11,610	12,900
World [e] [5]	19,520	19,098	23,005	23,056	23,707
Purchases of concentrate:					
Atomic Energy Commission (AEC):					
Quantity	9,488	8,425	7,337	6,184	2,510
Value thousands	$151,773	$134,785	$117,026	$72,336	$28,078
Price per pound	$8.00	$8.00	$7.98	$5.85	$5.59
Private industry [e]	100	700	5,000	[r] 6,200	9,300
Imports, concentrate	2,123	1,309	470	1,504	665
Reserves [6] thousand tons	141	148	161	204	246
Employment [7] number of persons	[e] 7,000	6,751	8,355	9,059	8,165

[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.
[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.—Surface drilling for uranium

	1969	1970
Type of drilling:		
Exploration million feet	20,470	17,981
Development do	9,385	5,547
Total	29,855	23,528
Number of holes:		
Exploration	47,850	43,980
Development	28,012	14,874
Total	75,862	58,854
Average depth per hole:		
Exploration	428	409
Development	335	373

Source: U.S. Atomic Energy Commission.

DOMESTIC PRODUCTION

Mine.—Mine shipments to mills totaled 13,037 tons of U_3O_8 in ore, compared with 12,595 tons shipped in 1969. Shipments of contained U_3O_8 by State were as follows: New Mexico, 6,056 tons; Wyoming, 3,415 tons; Colorado, 1,549 tons; Utah, 874 tons; and other States (mainly Texas), 1,197 tons. Output was from 263 producing sources, including 216 underground mines, 27 open pits, and 20 others (leaching, mine water, and raffinate). Of total mine output, 52.9 percent was from underground mines, 44.8 percent from open pits, and the remaining 2.3 percent from the other sources, mainly leaching operations.

There were a number of significant mine developments during 1970. On February 1, American Metal Climax, Inc. closed its 10 mines in the Uravan mineral belt of western Colorado and eastern Utah, owing to the weak prospective short-term market for uranium. Rio Algom Corp., the U.S. subsidiary of Rio Algom Mines Ltd., a major Canadian uranium-mining company, continued development of its large new ore body in the Big Indian district, near Moab, Utah. A ventilation shaft, 16 feet in diameter, was completed to a depth of 2,686 feet in November, and a similar production shaft had reached 2,500 feet. Productive operations were scheduled for 1972.[5] Development work continued on Humble Oil & Refining Co.'s 2,000-ton-per-day open-pit operation in the Powder River Basin, near Douglas, Wyo., where initial production was planned for 1972 and full-scale operations for 1973. In the Ambrosia Lake district, New Mexico, Kerr-McGee Corp. completed a shaft, 784 feet deep and 16½ feet in diameter, by rotary drilling techniques, the largest and deepest in the country by this method.

The Cotter Corp. Schwartzwalder Mine, Jefferson County, near Denver, Colo., the premier vein-type uranium deposit in the United States, continued to produce a relatively high-grade ore (0.60 percent U_3O_8) at a rate of 300 tons per day.[6] For several years, shipments from this mine averaged 1 percent U_3O_8.

Late in the year, Dawn Mining Co., a subsidiary of Newmont Exploration Ltd., was working a mine at Kendricks Bay in Alaska.[7]

[5] Mining Record. V. 82, No. 48, Dec. 2, 1970, p. 1.
[6] Skillings, D.N. Schwartzwalder Uranium Mine. Skillings Mining Review, v. 59, No. 5, Dec. 12, 1970, pp. 1, 8–9.
[7] Skillings Mining Review. V. 59, No. 50, Dec. 12, 1970, p. 4.

Table 3.—U.S. uranium milling statistics in 1970

(Short tons U_3O_8 unless otherwise specified)

Operating mills ---- number	17
Average daily milling rate ---- tons of ore	18,100
Mill receipts, content of ore	12,768
Mill feed:	
Content of ore	13,328
Other [1]	305
Total	13,633
Recovery rate ---- percent	94.7
Production	12,900
Shipments	13,037
Stocks:	
Content of ore, Jan. 1, 1970	942
Content of ore, Dec. 31, 1970	350
Concentrate, Jan. 1, 1970	3,529
Concentrate, Dec. 31, 1970	3,396
In process:	
Concentrate, Jan. 1, 1970	407
Concentrate, Dec. 31, 1970	430

[1] Concentrate from leaching operations, mine waters, and refinery residues.

Source: U.S. Atomic Energy Commission.

Table 4.—U.S. uranium milling companies and plants in 1970 [1]

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	[2] 1,750
Cotter Corp	Canon City, Colo	450
Dawn Mining Co	Ford, Wash	500
Federal–American Partners	Gas Hills, Wyo	950
Humble Oil and Refining Co	Powder River Basin, Wyo	[2] 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	Moab, Utah	[2] 500
Susquehanna Corp	Falls City, Tex	1,000
Do	Ray Point, Tex	1,000
Union Carbide Corp	Uravan, Colo. / Rifle, Colo.	2,000
Do	Gas Hills, Wyo	1,000
Do	Grants, N. Mex	3,500
United Nuclear-Homestake Partners	Gas Hills, Wyo	1,200
Utah Construction and Mining Co	Shirley Basin, Wyo	[3] 1,200
Do	Jeffrey City, Wyo	1,200
Western Nuclear, Inc		
Total		31,900

[1] Does not include mill of American Metal Climax, Inc., at Grand Junction, Colo., which was closed early in the year.
[2] Under construction; planned completion in 1972.
[3] Under construction; planned completion in 1971.

Source: U.S. Atomic Energy Commission.

Table 5.—Principal companies with capacity for processing and fabricating nuclear fuel materials in 1970

Company	Location	UF_6	UO_2	UO_2 pellets	Fuels					Depleted uranium		Scrap		Spent fuel reprocessing	Enriched U to UF_6
					UO_2	Carbide	Metal	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.	----	----	[1] X	X	X	X	----	X	X	----	----	[1] X	----	----
The Babcock & 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 Co.	Morris, Ill.	----	----	----	----	----	----	----	----	----	----	----	----	[1] X	[1] X
Do.	San Jose and Vallecitos, Calif.	----	X	X	X	----	----	----	X	----	----	X	[1] X	----	----
Do.	Wilmington, N.C.	----	X	X	X	----	----	----	----	----	----	X	----	----	----
Gulf Energy and Environmental Systems, Inc.	San Diego, Calif.	----	[1] X	[1] X	[1] X	X	X	[1] X	[1] X	----	----	[1] X	----	----	----
Jersey Nuclear Co.	Richland, Wash.	----	[1] X	[1] X	[1] X	----	----	----	[1] X	----	----	[1] X	[1] X	----	----
Kerr-McGee Corp.	Cimarron, Okla.	----	X	X	X	X	X	----	X	X	X	X	X	----	----
Do.	Sequoyah, Okla.	X	----	----	----	----	----	----	----	----	----	----	----	----	----
National Lead Co.	Albany, N.Y.	----	----	----	----	----	X	----	----	X	----	----	----	----	----
Nuclear Chemicals and Metals Corp.	Huntsville, Tenn.	----	[1] X	[1] X	----	X	----	----	----	----	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.	Apollo, Pa.	----	X	X	X	X	X	----	----	----	X	X	----	----	X
Do.	Leechburg, Pa.	----	X	X	X	X	X	X	X	X	----	----	X	----	----
Do.	Leeds, S.C.	----	----	----	----	----	----	----	----	----	----	----	----	[1] X	[1] X
Nuclear Metals Div., Whittaker Corp.	West Concord, Mass.	----	----	----	----	----	X	----	----	----	----	----	----	----	----
Tennessee Nuclear Specialties, Inc.	Jonesboro, Tenn.	----	X	----	----	----	----	----	----	X	----	----	----	----	----
Texas Instruments, Inc.	Attleboro, Mass.	----	----	----	----	----	X	----	----	----	----	----	----	----	----
United Nuclear Corp.	Elmsford and Pawling, N.Y.	----	----	----	----	X	----	----	X	----	----	----	[1] X	----	----
Do.	Hematite, Mo.	----	X	X	----	X	----	----	----	----	X	----	----	----	----
Do.	New Haven, Conn.	----	----	----	X	----	X	----	----	X	----	----	----	----	----
Do.	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.

Source: U.S. Atomic Energy Commission.

Mill.—Production of U_3O_8 in concentrate at 17 operating mills in the United States increased 11 percent in 1970. Capacity was enlarged at the Petrotomics Co. mill in the Shirley Basin, Wyo., and the Dawn Mining Co.'s mill at Ford, Wash., was reopened during the year. The new mill of Susquehanna Corp. at Ray Point, Tex., went on stream in 1970. Early in the year, American Metal Climax, Inc. closed its mill at Grand Junction, Colo., as well as its mines in the Uravan mineral belt.

Four new mills were under construction during the year. Their completion will increase total annual mill capacity to about 19,000 tons U_3O_8. Kerr-McGee Corp., United Nuclear Corp., and Western Nuclear, Inc. planned additional mills, but no firm construction schedules were announced.

Special Nuclear Materials.—*Uranium Hexafluoride.*—Sufficient commercial capacity apparently exists or is planned for processing normal uranium to UF_6 at rates that will meet the demand for enriched uranium. Kerr-McGee Corp. completed its $25 million Sequoyah plant for UF_6 production in eastern Oklahoma. In July the first shipment was made—38,000 pounds, valued at $250,000 or $6.58 per pound.[8] The company planned to double capacity in the near future. Allied Chemical Corp. completed expansion of its Metropolis, Ill., UF_6 plant to 14,000 Separative Work Units (SWU) per year. The company reported that its processing period was reduced from 6 to 3 months.

The AEC maintained capacity for UF_6 production from normal uranium only at its Paducah, Ky., plant.

Private capacity does not exist for conversion of slightly enriched uranium in nonirradiated scrap and irradiated fuel elements to UF_6, but Allied Gulf Nuclear Services, Inc. (Barnwell, S.C. plant), Nuclear Materials and Equipment Corp. (NUMEC) (Leeds, S.C. plant), and Nuclear Fuel Services, Inc. (West Valley, N.Y. plant) planned this capacity in connection with their fuels-reprocessing programs. In addition, General Electric Co.'s fuel recovery plant, near Morris, Ill., is designed to annually reprocess 330 tons of slightly enriched fuels, starting in 1972. NUMEC's plant at Apollo, Pa., has capacity for conversion of highly enriched uranium, recovered from spent fuels, to UF_6.

Enriched Uranium.—The AEC's gaseous diffusion plants at Oak Ridge, Tenn., Portsmouth, Ohio, and Paducah, Ky., were operated at only partial capacity because of a power reduction program. Owing to electric power shortages, a portion of the scheduled power was transferred to municipal needs for a limited period during the summer months. The level was increased to 2,500 megawatts in October, the beginning of a series of increases that were scheduled to raise total power capacity to 6,000 megawatts by 1978. The AEC reported that during fiscal year 1970 production of enriched uranium required to meet domestic commercial and foreign demand was 47 percent higher than in 1969.

Table 6.—Planned U.S. production of enriched uranium

(Metric tons of separative work units)[1]

Fiscal year	Production	
	Annual	Cumulative[2]
1970	6,900	20,200
1975	16,400	81,800
1980	25,700	196,600

[1] Measure of work expended in separating a quantity of uranium at a given assay into two parts—one enriched in U-235 to a specified grade, and the other deficient in U-235 to a specified tailings grade.
[2] Includes inventory of 13,300 tons.

Source: United States Atomic Energy Commission.

Domestic and foreign orders for toll enrichment services increased rapidly during the year. AEC revenues were $60.8 million during 1969, the first year of the toll enrichment program, $104 million ($70 million domestic, $34 million foreign) in 1970, and were expected to reach an annual rate of $850 million by 1980. Early in the year, the AEC announced that orders had reached $1.18 billion in 11 domestic and 24 foreign contracts covering 30 years.[9] As of September, long-term contracts totaling $437 million were concluded with five domestic companies, and orders with 17 domestic and 29 foreign customers totaled $1.7 billion.[10] By yearend, orders had increased to $2.3 billion in 53 agreements.[11]

Plutonium.—Studies continued on plutonium fuels for use in the breeder reac-

[8] Mining Record. V. 81, No. 28, July 15, 1970, p. 3.
[9] Mining Congress Journal. V. 56, No. 7, July 1970, p. 24.
[10] Wall Street Journal. V. 176, No. 63, Sept. 28, 1970, p. 11.
[11] Chemical & Engineering News. V. 48, No. 51, Dec. 7, 1970, p. 21.

tor. The AEC phased out its work on plutonium recycle. Research and development have been taken over by industry, where plutonium, produced in reactors, was expected to be recycled in reload cores. Demonstration fuel elements, containing plutonium and uranium oxide in fuel rods, were placed in light water reactors (LWR) for irradiation under Edison Electric Institute, United Nuclear Corp., and Commonwealth Edison programs. During 1970, the first large-scale commercial contact for replacement fuel with recycled plutonium was awarded to Westinghouse Electric Corp. in connection with its sale of two nuclear units to the Tennessee Valley Authority (TVA). Private interest remained high in plutonium recovery, recycling, and storage. The AEC estimated that recovery (in nitrate form) would be about 1,000 pounds in 1971, 14,000 pounds in 1975, and 40,000 pounds in 1980.

Fuel Fabrication.—Industry has developed the capability to produce essentially all types of nuclear fuel elements. However, this capability was considered limited for highly specialized types of fuels. A number of nuclear-fuel processing and fabricating plants were under construction or expansion as fuel orders from utility companies, reactor manufacturers, and foreign customers multiplied. NUMEC and United Nuclear Corp. completed major expansion programs. Allied Gulf Nuclear Services, Inc. planned additional fabricating facilities. In February, Babcock & Wilcox Co. concluded an agreement with Nuclear-Chemie und Metallurgie G.m.b.H. (NUKEM), West Germany, on licensing a NUKEM UO_2 pellet process. Nuclear Fuel Services, Inc., owned by Getty Oil Co. and Skelly Oil Co., continued construction at West Valley, N.Y. Jersey Nuclear Co., an affiliate of Standard Oil Co. of New Jersey, also has new facilities under development, at Richland, Wash.

Radioisotopes.—The market for radioisotopes continued to expand at a rate of about 10 percent annually. Private industrial capacity for production, processing, and distribution was growing, but the AEC continued to play a major role. Production of the actinide isotopes, particularly californium-252, progressed significantly during the year. The AEC produces research quantities at its high-flux isotope reactor at Oak Ridge National Laboratory (ORNL) and is developing capacity for large-scale continuous separation of californium-252 and other radioisotopes at Savannah River. The AEC expects that by 1972 kilogram quantities of certain radioisotopes and more than 15 grams of californium-252 will be available annually. Ultimately, 100 grams or more of californium-252 per year may become available.

The AEC announced production of the largest quantity of californium-252 in one batch—110 milligrams recovered and purified at ORNL from a Savannah River production run. The AEC planned to supply the bulk material to industry, which is encouraged to develop other services, including encapsulation and secondary recovery. The market evaluation program and applications development for californium-252 were further advanced during the year.[12]

CONSUMPTION AND USES

After a sharp drop in 1969, demand for uranium followed renewed expansion in nuclear reactor orders in 1970, despite rising costs, construction problems, and environmental delays. An AEC survey of the nuclear industry fuel supply situation revealed that uranium-milling companies delivered about 10,000 tons U_3O_8 to electric utility companies and reactor manufacturers during 1966-69 and 9,300 tons in 1970. These committed deliveries are scheduled to peak in 1973 and are contracted for as late as 1988. The total domestic uranium commitment through 1988 was 108,600 tons, 28 percent higher than that indicated by a similar survey a year earlier. In addition, of 6,300 tons U_3O_8 committed to foreign buyers, 4,400 tons had been delivered by yearend, including 2,100 tons in 1970. Scheduled domestic deliveries were well in excess of estimated requirements through 1975. AEC purchases in 1970, the final year of the AEC uranium-procurement program, were 2,510 tons U_3O_8.

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[12] U.S. Atomic Energy Commission. Californium-252. Progress Rept. No. 6, January 1971, 53 pp.

Table 7.—Projected U.S. commercial uranium delivery commitments

(Short tons U_3O_8)

Year	Commitments [1]	
	Annual	Cumulative
1966–69	--------	10,000
1970	9,200	19,200
1971	12,800	32,000
1972	11,300	43,300
1973	13,000	56,300
1974	11,800	68,100
1975	12,000	80,100
1976	5,600	85,700
1977	5,200	90,900
1978	4,400	93,300
1979	3,900	99,200
1980	2,500	101,700

[1] In the post-1980 period, through 1988, an additional 6,900 tons have been committed. In addition, 6,300 tons have been committed to foreign buyers, of which 1,900 tons were scheduled for delivery after 1970.

Source: U.S. Atomic Energy Commission.

Table 8.—Projected U.S. commercial uranium requirements

(Short tons U_3O_8)

Year	Estimated requirements	
	Annual	Cumulative
1971	6,900	6,900
1972	10,200	17,100
1973	14,000	31,100
1974	16,700	47,800
1975	18,400	66,200
1976	21,100	87,300
1977	24,400	111,700
1978	28,600	140,300
1979	31,700	172,000
1980	34,200	[1] 206,200

[1] Projected to 1985, annual demand is 59,300 tons in that year, and cumulative demand is 452,100 tons. Estimates are based on fueling characteristics supplied by reactor manufacturers, 0.2 percent U^{235} enrichment tailings assay, and plutonium recycle starting in 1974 and resulting in demand reduced by 2 percent in 1974 and 12 percent in 1980.

Source: U.S. Atomic Energy Commission.

The survey also indicated that 86 percent of the uranium required had been ordered for initial fuel loadings in reactors operating, under construction, or scheduled, and that more than half the uranium needs had been met for the first three refuelings (estimated at yearly intervals).

The AEC also reported that orders for UF_6 by utility and reactor companies were the equivalent of about 10,000 tons uranium in 1970, including some 2,000 tons for foreign reactors. This does not include UF_6 derived from the reprocessing of scrap and irradiated fuels. There was little demand for this service, although industry planned these facilities for future UF_6 recovery.

U.S. annual demand for enriched uranium services was estimated to be at a $100 million rate in 1970, and other non-Communist world annual demand was estimated at $30 million. By 1980, the U.S. market was expected to reach a $600 million annual rate, and the entire non-Communist world market may reach $1 billion yearly.[13] More than 2 million pounds of enriched uranium in the form of UF_6 was supplied to domestic industry during the fiscal year that ended June 30, 1970.

The AEC also estimated the 1970 domestic commercial nuclear fuel market at $59 million for first cores and $14 million for replacement fuel, based on fuel costs of $90 per kilogram of contained uranium. The annual market in 1980 was expected to be $189 million for the initial fueling and $352 million for the fuel reloads. In fiscal 1970, the AEC shipped 2,035,000 pounds of enriched uranium in the form of UF_6 to domestic processors and fuel fabricators for use in commercial reactors, Government-sponsored reactors (exclusive of plutonium-production types), and fuels processed and fabricated in the United States for foreign reactors. The foreign market was 355,136 pounds in the form of

[13] Page 58 of work cited in footnote 3.

Table 9.—Uranium fuel supply arrangements for domestic nuclear reactors [1]

(Percent of total generating capacity)

Source of supply	First core	Reloads [2]													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Lease from AEC	1	2	2	1	1	1	1	1	1	--	--	--	--	--	--
Primary producers	48	41	34	31	23	19	12	5	5	4	3	2	2	2	1
Reactor manufacturers	37	30	31	29	20	14	10	5	4	3	3	--	--	--	--
Total	86	73	67	61	44	34	23	11	10	7	6	2	2	2	1

[1] Includes reactors operating, under construction, and scheduled, totaling 85,200 megawatts.
[2] Refueling estimated on annual basis.

Source: U.S. Atomic Energy Commission.

UF_6 in fiscal 1970, compared with 202,355 pounds during the preceding fiscal year. In addition, domestic processors and fabricators supplied 477,867 pounds of enriched uranium in processed or fabricated fuels to foreign customers during fiscal 1970 (334,600 pounds in fiscal 1969).

For its own programs, the AEC placed orders of $79.2 million with industry for fabricated nuclear fuels for naval reactors and other purposes during fiscal 1970, substantially less than the $147.8 million during fiscal 1969. Both foreign and domestic demand for enriched uranium is expected to escalate steadily in the future.

Table 10.—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

[1] Fiscal year ending June 30.
Source: U.S. Atomic Energy Commission.

During the next several years, the AEC, domestic industry, and foreign programs will require increasing quantities of plutonium for research and development, including experimental and demonstration reactors. The AEC estimated the market at 1,100 pounds of plutonium in 1970 and 4,400 pounds in 1975.

In addition to its industrial uses as counterweights, ballasts, catalysts, alloys, ceramics, and refractories, depleted uranium is being employed increasingly as a shielding agent. Late in the year, the AEC issued a license, the first of its type, for the manufacture of two uranium casks by National Lead Co. These casks will be used for shielding during transportation of radioactive spent fuels from the gas-cooled reactor under construction at Fort St. Vrain, Colo.[14]

The AEC continued its programs, requiring continuing supplies of uranium, for national defense, reactor development, space nuclear systems (nuclear rockets and space power and heat systems), isotopic systems development, and peaceful nuclear explosives (Plowshare).[15] By far the greatest future consumption of uranium will be in nuclear fuels for commercial nuclear power reactors. A total of 14 reactors with designed capacity of 14,336 megawatts were ordered in 1970, compared with only seven reactors with capacity of 7,200-megawatts in 1969. Five new plants began operations in 1970, adding 3,203 megawatts to total operating nuclear generating capacity. Overall, 20 plants (7,498-megawatts capacity) were operable, 53 were under construction, and 36 (including one in Puerto Rico) were planned, totaling 109 reactors with designed capacity of 86,894 megawatts. According to the Federal Power Commission, nuclear generating capacity comprised only 1.8 percent of the national energy total in 1970 but was expected to reach 25 percent by 1980.

STOCKS

According to the AEC, its stockpile of uranium in excess of projected needs was equivalent to 50,000 tons U_3O_8. Studies were underway regarding disposal of these stocks. In addition, the milling companies reported a total U_3O_8 inventory of 3,396 tons at yearend, 133 tons U_3O_8 less than at the first of the year, and utility companies and reactor manufacturers reported a total of 7,400 tons U_3O_8 in inventory (including all materials in concentrate form, title to which was held, regardless of location).

PRICES AND SPECIFICATIONS

During fiscal year 1970 (ended June 30, 1970), the AEC purchased 4,010 tons U_3O_8, valued at $45,954,000, at an average price of $5.73 per pound. For the remaining half of the calendar year, the AEC purchased an additional 1,295 tons U_3O_8, valued at $14,416,000, at an average price of $5.57 per pound.[16] These purchases marked the termination of the AEC's uranium-procurement program, which ended on December 31, 1970. Since inception of the program in 1948, the AEC purchased 173,665 tons U_3O_8 at an average price of

[14] Chemical Week. V. 108, No. 1, Jan. 6, 1971, p. 46.
[15] Pages 131–213 of work cited in footnote 4.
[16] U.S. Atomic Energy Commission. Statistical Data of the Uranium Industry. Grand Junction, Colo., Jan. 1, 1971, p. 8.

$8.52, for a total value of nearly $3 billion. AEC purchase prices during 1970 were based on the following formula: $1.60 per pound, plus 85 percent of allowable production costs per pound during the 6-year period from 1963 through 1968, with a maximum price of $6.70 per pound.

According to the Nuclear Exchange Corp., private prices for 1970 delivery ranged from $6.00 to $6.20 per pound U_3O_8, but a new level at about $6.30 per pound seemed to be emerging.[17] For purchases 3 to 5 years ahead, quotations are listed at gradually increasing prices until the $8-per-pound rate is reached, near 1976.

For conversion services from U_3O_8 to UF_6, the Kerr-McGee Corp. base charge was $1.13 per pound U at the first of the year and was escalated to $1.24 per pound U, effective March 31, 1970. The Allied Chemical Corp. base rate of $1.04 per pound U was raised to $1.197 on the same date. Since the Kerr-McGee rate usually includes charges for sampling, transportation, and UF_6 production, the rates of the two companies were believed to be similar. Both are based on a 99.5-percent yield and penalties for unusual impurities above specified limits.[18]

The AEC announced price increases for enrichment services, based on revised Uranium Enrichment Services Criteria, published in the Federal Register of August 25, 1970. The prevailing rate of $26 per SWU would be raised to $28.70 per SWU, effective February 22, 1971, and, as of June 1970, the escalated ceiling was raised to $32.91 per SWU. On December 23, 1970, the AEC submitted proposed new enrichment services criteria to the Joint Committee on Atomic Energy, which included a proposed price increase to $32 per SWU.

The AEC also proposed a revised base charge for plutonium containing 80 percent Pu-238, and establishment of a base charge for plutonium containing 90 percent Pu-238. The price for the former would be $0.70 per milligram, and for higher concentrations (containing not more than 0.30 part per million Pu-236) the price is $1.25 per milligram.[19]

Early in the year, the AEC announced a 5-year extension (to December 31, 1975) of the guaranteed price of $13 per gram for uranium-233, which is produced in thorium-fueled reactors. This price is subject to deductions for the presence of other uranium isotopes and to adjustment if charges for uranium enrichment are revised.

FOREIGN TRADE

Exports of the various uranium and nuclear materials attained record highs in 1970. Shipments of uranium ores and concentrates, containing some 20 tons U_3O_8 valued at $7 per pound, were the first sizable exports of these raw materials in several years. Increases were especially pronounced in exports of uranium compounds, stable isotopes, and various radioisotopes and other radioactive materials. Data on exports of AEC-produced nuclear materials, including enriched uranium, uranium-233, plutonium, and heavy water, were provided by the AEC's Division of International Affairs. These data, although available only for fiscal year 1970 (ending June 30, 1970), indicate a continued rise in exports of fuel materials for U.S. reactors in foreign countries.

Pursuant to subsection 161V of the Atomic Energy Act of 1954, as amended, foreign uranium cannot be enriched in the United States for domestic consumption. The AEC considers this regulation temporary and that it will be withdrawn when it is no longer needed to maintain a viable domestic uranium mining and milling industry. Some 665 tons of U_3O_8 from Canada, France, and the Republic of South Africa were imported for enrichment and then reexport of the enriched product.

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[17] Engineering and Mining Journal. V. 171, No. 4, April 1970, pp. 74–75.
[18] Page 51 of work cited in footnote 3.
[19] Federal Register. V. 35, No. 103, May 27, 1970, p. 8300.

Table 11.—Foreign trade in uranium, uranium-bearing materials, and other nuclear materials, by principal countries

Product	1969 Quantity	1969 Value	1970 Quantity	1970 Value	Principal sources and destinations, 1970
EXPORTS					
Uranium:					
Ores and concentrate, U_3O_8 content.......pounds..	84	$641	40,828	$286,711	Canada 39,831; Italy 997.
Compounds [1]......do....	105,620	316,561	4,045,549	24,579,293	United Kingdom 2,007,967; Switzerland 1,066,924; Canada 555,954.
Metal including alloys [1] do....	788	26,182	5,503	86,021	Japan 4,885; Canada 335.
Isotopes (stable) and their compounds..................	NA	9,263,939	NA	34,689,780	Canada $33,506,417; Japan $394,471.
Radioactive materials: Radioisotopes, elements, and compounds [2]...thousand curies..	5,669,844	5,394,937	8,105,520	4,847,247	West Germany 1,905,384; Japan 1,799,590; Canada 1,360,035; Australia 1,133,377; Nigeria 683,105.
Special nuclear materials [3]......	NA	87,766,071	NA	79,920,628	West Germany $36,694,736; Japan $22,041,736; Spain $10,824,165; France $4,453,642; United Kingdom $3,504,324.
IMPORTS					
Uranium:					
Oxide (U_3O_8)....pounds..	3,008,361	14,600,618	1,329,367	7,789,367	Canada 830,441; France 276,736; Republic of South Africa 221,000.
Other compounds..do....	1,277,952	8,349,515	2,681,301	20,459,856	United Kingdom 1,266,759; Canada 805,199; France 506,155.
Isotopes (stable) and their compounds..................	NA	350,272	NA	428,375	Canada $211,240; Israel $77,844; Norway $37,966; United Kingdom $35,285.
Radioactive materials: Radioisotopes, elements, and compounds [2]...thousand curies..	45,297,376	4,696,930	7,769,906	3,471,441	Canada 5,346,118; West Germany 1,007,217; Italy 1,001,875.

NA Not available.
[1] Includes thorium.
[2] Includes carbon-14 and cobalt-60.
[3] Includes plutonium, uranium-233, uranium-235, and enriched uranium.

Table 12.—U.S. exports of AEC-produced nuclear materials, by countries, in fiscal year 1970 [1]

(Pounds)

Country [2]	Enriched uranium: Less than 20 percent U-235 [3]	Enriched uranium: Greater than 20 percent U-235 [4]	Uranium-233	Plutonium (Pu)	Heavy water (D_2O)
Australia	---------	24	---------	(5)	4,000
Canada	76	99	---------	(5)	2,064,000
Denmark	24	12	---------	(5)	---------
Euratom [6]	17,078	2,628	8	81.3	(5)
Greece	---------	12	---------	---------	---------
International Atomic Energy Agency (IAEA)	36	9	---------	---------	---------
Japan	1,895	125	---------	2.2	(5)
Norway	35	(5)	---------	---------	---------
South Africa, Republic of	---------	2	---------	---------	12,000
Spain	388	---------	---------	---------	---------
Sweden	340	57	---------	---------	---------
Switzerland	6,146	---------	---------	---------	(5)
United Kingdom	172	198	---------	.5	---------
Total	26,190	3,166	8	84.0	2.080.000

[1] Fiscal year ends June 30, 1970.
[2] Initial destination; may not be country of final destination.
[3] Mainly for use as power reactor fuel.
[4] Mainly for use as fuel in research and test reactors and other research applications.
[5] Less than ½ unit.
[6] Belgium, France, West Germany, Italy, and the Netherlands.

Source: Division of International Affairs, U.S. Atomic Energy Commission.

WORLD REVIEW

The International Atomic Energy Agency and the United Nations Economic Commission for Europe held a symposium on the economic integration of nuclear power stations in electric power systems. The meetings, at which a number of papers were presented by representatives from many countries, were held in Vienna during October 5 – 9, 1970. It was pointed out that nuclear power is expected to comprise 10 to 15 percent of total world electric generating capacity in 1980, and an increasingly larger share thereafter. Because the technical and economic considerations in nuclear power development differ from those in conventional powerplants, the symposium was considered beneficial to countries planning nuclear development.

A recent publication of the European Economic Community (EEC) provides data on Community uranium requirements and nuclear reactor development plans.[20] A total of 48 reactors with total capacity of nearly 18,000 megawatts were in operation (3,090 megawatts), under construction, or projected early in the year. The cumulative uranium requirements of the EEC at the end of the century were estimated at 360,000 to 580,000 tons.

Angola.—Junta de Energia Nuclear of Portugal and Urangesellschaft m.b.H., West Germany, concluded a joint venture agreement for uranium exploration in the Dondo and Malange areas, east of Luanda, Angola. Mozambique also is included in the agreement.

Table 13.—Estimated world demand for uranium [1]

(Thousand short tons U_3O_8)

Year	Demand	
	Annual	Cumulative
1970	12	12
1975	37	141
1980	73	430

[1] Non-Communist world only.

Source: European Nuclear Energy Agency and International Atomic Energy Agency.

Table 14.—Estimated world demand for enriched uranium [1]

(Thousand metric tons of separative work units)

Year	Demand	
	Annual	Cumulative
1970	4	4
1975	19	65
1980	42	226

[1] Non-Communist world only. Does not include estimates for uranium derived from plutonium recycling.

Source: International Atomic Energy Agency and European Nuclear Energy Agency.

Argentina.—The Comission Nacional de Energia Atomica (CNEA) announced the discovery of a sizable uranium deposit, known as Sierra Pintada, in Southern Mendoza Province. The exploration program included more than 3,000 drill holes.[21]

[20] Metal Bulletin Monthly. No. 1, January 1971, pp. 40–43.
[21] Engineering and Mining Journal. V. 171, No. 9, September 1970, p. 201.

Table 15.—Uranium oxide (U_3O_8): Free world production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
Argentina	47	54	[e] 55
Australia [e]	330	330	330
Canada	3,700	3,855	4,011
France	[2] 1,626	[2] 1,690	[3] 1,627
Gabon [e] [2]	585	595	463
Niger	------	------	59
Malagasy Republic [e] [4]	[r] 23	------	------
Portugal [e]	105	105	105
South Africa, Republic of	[r] 3,882	3,979	4,119
Spain [e]	[r] 60	[r] 90	90
Sweden [e]	77	77	80
United States [3]	12,570	12,281	12,768
Total	[r] 23,005	[r] 23,056	23,707

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, mainland China, Czechoslovakia, United Kingdom, East Germany, West Germany, Hungary, India, Japan, Mozambique, 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.
[3] Content of chemical concentrates produced from domestically mined ores.
[4] Content of uranothorianite exported.

Early in the year, the CNEA announced plans for the country's first nuclear powerplant, a 319-megawatt, heavy-water, natural-uranium reactor to be built some 40 miles north of Buenos Aires. The project is a joint venture with the Siemens group, West Germany. Completion was originally scheduled for mid-1972, but late in the year the project was far behind schedule.

The Government projected a nuclear generating capacity of 6,000 megawatts in the year 2000, about 20 percent of total electrical generating capacity.[22]

Australia.—Major uranium discoveries were announced by two companies in the Northern Territory. In addition, new reserves were announced in Queensland and South Australia. Exploration, often involving foreign participation, continued at a fast pace throughout the year. At yearend, 31 companies were searching specifically for uranium, and others included uranium in their exploration programs.[23]

Because of the important new uranium resources, the Government acted to limit foreign participation in uranium properties to protect the national interest. Revision of export controls was expected also. Formerly, exports were limited to achieve self-sufficiency in uranium. Increased reserves will permit the release of larger quantities to the export market.

In July, Queensland Mines Ltd. announced discovery of a uranium deposit at Nabarlek in the Northern Territory, 170 miles east of Darwin. The deposit consists of lenticular ore bodies over a north-south strike length of 3,600 feet in Precambrian metasediments. The mineralized surface area is up to 300 feet wide. The deposit dips east-northeast at 50°.[24] One ore lens reportedly assayed at an average of 27 percent U_3O_8. The company initially planned a small open-pit operation if sales contracts could be made.

Queensland Mines Ltd. also reported sizable uranium reserves at Westmoreland, Queensland, near the Northern Territory border, and at Valhalla, 28 miles north of Mount Isa.

The second major discovery was announced by Peko Mines N.L., a subsidiary of Peko-Wallsend Ltd. and Electrolytic Zinc Corp. of Australia, Ltd. The deposit, called the Ranger 1, is located 40 miles southwest of the Nabarlek deposit. The anomalous area extends intermittently 4 miles in a north-south direction and is 600 to 3,000 feet wide. Average grade appears to be 0.20–0.30 percent U_3O_8. Late in the year, the chairman of the company announced potential at 70,000 tons U_3O_8.[25]

The Mary Kathleen mine, Queensland, which was closed in 1963 following completion of a Government program, was expected to reopen. Mary Kathleen Uranium Ltd. has two new contracts for 2,700 tons U_3O_8 to be delivered during 1974–79. Customers are a U.S. utility company and Rio Tinto Zinc Mineral Services Ltd.[26] Exploration in the mining area has established 7 million tons of ore at 0.12 percent U_3O_8 and 2 million tons possible at 0.10 percent U_3O_8. An estimated 480,000 tons of ore averaging 0.06 percent U_3O_8 were in stockpile.[27]

The Australian Government announced plans to close the uranium processing plant at Rum Jungle, Northern Territory, by April 1971. A large stockpile of uranium oxide has been accumulated at nearby Lucas Heights. The Government planned to open up the reserved area to private prospecting.

A group including Exoil N.L. and Transoil N.L. has announced low-grade ore reserves of 2.5 million tons in the Mount Painter area, South Australia.[28] The group also reported a discovery near Lake Frome, also in South Australia, at a depth of 400 feet.

Australia's first nuclear power reactor, a 500-megawatt plant, was proposed for siting at Jervis Bay, New South Wales. It will be owned by the Government and operated by the Electricity Commission of New South Wales. Reactor type was not firmly established, although the heavy-water type, operating on natural uranium mined and fabricated in Australia, reportedly was favored.

Westinghouse Electric Corp. was interested in purchasing Australian uranium under a long-term agreement and in asso-

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[22] U.S. Embassy, Buenos Aires, Argentina. State Department Airgram A-601, Dec. 24, 1970, p. 6.
[23] Mining Engineering. V. 22, No. 12, December 1970, p. 8.
[24] Northern Miner. No. 28, Oct. 1, 1970, pp. 1, and 11.
[25] American Metal Market. V. 77, No. 210, Nov. 2, 1970, p. 17.
[26] Metal Bulletin. No. 5524, Aug. 14, 1970, p. 21.
[27] World Mining. V. 6, No. 1, January 1970, p. 43.
[28] Mining Journal. V. 274, No. 7036, June 26, 1970, p. 597.

ciating with Australian interests in uranium exploration, development, and processing.[29]

According to the Australian Atomic Energy Commission, Australian nuclear power capacity will be 11,500 megawatts in 1990 and 36,000 megawatts by the end of the century.

Brazil.—Reserves at the Agostinho deposit, near Poços de Caldas, Minas Gerais, exceed 1,000 tons U_3O_8, according to the Comissão Nacional de Energia Nuclear (CNEN). About 500 tons of ore averaging 0.22 percent U_3O_8 has been stockpiled for processing study.

Early in the year, a final decision was made to construct Brazil's first nuclear powerplant, a 500-megawatt installation, in the Angora dos Reis area, State of Rio de Janeiro. Later in the year, invitations to bid on the reactor program were announced.

Canada.—Uranium production was at a rate similar to that for 1969. Uranium oxide shipments totaled 4,010 tons, valued at $50.2 million or $6.26 per pound.[30] Four companies were in active production during the year—Denison Mines Ltd., Rio Algom Mines, Ltd., and Stanrock Uranium Mines Ltd., all at Elliot Lake, Ontario, and Eldorado Nuclear Ltd. at Uranium City, Saskatchewan. Stanrock suspended its leaching operation during the year; the others operated at partial capacity. Exploration activity was well below the 1969 level. A few private U_3O_8 sales contracts were announced.

Gulf Minerals Co. continued development of its $50 million, 2,000-ton-per-day operation at Rabbit Lake, west of Wollaston Lake, northern Saskatchewan. Uranerzbergbau G.m.b.H., West Germany, acquired a 49-percent interest and agreed to provide a market for 4 million pounds U_3O_8 per year. This was considered the largest private uranium sale made to date.[31] This ownership arrangement was approved by the Canadian Government,[32] which earlier in the year had acted to limit foreign participation in uranium operations.[33]

Following completion of the second uranium stockpiling program, the Government prepared to offer further assistance to keep the mines open at mimimum levels of efficient production. The Canadian stockpile contained 9,500 tons U_3O_8. Late in the year, an "emergency joint venture stockpiling program" between the Government (75 percent) and Denison Mines Ltd. (25 percent) was announced.[34] It involved the stockpiling of 6,467,000 pounds U_3O_8 during 1971–74.

The Port Hope, Ontario, uranium hexafluoride (UF_6) plant of Eldorado Nuclear Ltd. was in continuous production at an annual rate of 2,500 tons in midyear. The company planned to double production by 1974. Delivery of UF_6 to customers, mainly in Japan, Sweden, and West Germany, began in September.

There was a continuing shortage of heavy water for Canadian Deuterium Uranium (CANDU) nuclear reactors under construction or on order in Canada. Atomic Energy of Canada Ltd. reportedly needs 2,000 tons of heavy water by 1972. Three heavy water plants, each of 400 tons' annual capacity, were under construction. Because of the shortage, Canada purchased 55 tons of heavy water from the U.S.S.R. This apparently was the first U.S.S.R. sale of nuclear materials to a major Western country. Further deliveries from the U.S.S.R. were expected.[35]

Finland.—Finnish authorities ordered a 440-megawatt, pressurized-water reactor, the first in the country, and two turbogenerators from the U.S.S.R. The estimated cost is $120 million, of which Finland will provide 55 percent and the U.S.S.R. the remainder through 20-year credits. The plant will be situated in the town of Lovisa. The U.S.S.R. will supervise construction and will supply fuel elements for 20 years.

The Committee for Energy Supply proposed two nuclear power reactors (600 and 720 megawatts) for the Helsinki area.

In December Finnish authorities notified the International Atomic Energy Agency that Finland proposed purchasing fuel elements from Gulf Energy and Environmental Systems, Inc., San Diego, Calif.

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[29] Mining Journal. V. 276, No. 7065, Jan. 15, 1971, p. 49.
[30] Williams, R. M. Uranium. Canadian Min. J., v. 92, No. 2, February 1971, pp. 114–120.
[31] Mining Record. V. 81, No. 33, Aug. 19, 1970, p. 5.
[32] Mining Record. V. 81, No. 38, Sept. 23, 1970, p. 3.
[33] Bureau of Mines. Mineral Trade Notes. V. 67, No. 8, August 1970, pp. 32–34.
[34] American Metal Market. V. 77, No. 246, Dec. 28, 1970, p. 12.
[35] Wall Street Journal. V. 176, No. 105, Nov. 25, 1970, p. 11.

Table 16.—Estimated world growth of nuclear generating capacity, by countries [1]

(Megawatts)

Country	1970	1975	1980
Argentina	-------	300	1,300
Australia	-------	500	1,000
Austria	-------	600	1,800
Belgium	100	1,300	3,600
Brazil	-------	-------	1,500
Canada	200	2,500	8,000
Denmark	-------	-------	600
Finland	-------	400	800
France	1,500	2,600	9,200
Germany, West	800	11,100	25,000
Greece	-------	400	1,200
India	600	2,300	6,400
Israel	-------	-------	600
Italy	600	1,400	8,000
Japan	1,300	8,400	23,500
Korea, South	-------	600	2,700
Mexico	-------	600	2,000
Netherlands	100	500	2,000
New Zealand	-------	-------	800
Norway	-------	-------	500
Pakistan	-------	500	1,000
Philippines	-------	-------	1,200
Portugal	-------	-------	500
South Africa, Republic of	-------	500	2,000
Spain	600	2,500	7,000
Sweden	400	3,800	7,500
Switzerland	400	1,800	3,500
Taiwan	-------	600	2,000
Thailand	-------	-------	400
Turkey	-------	-------	800
United Kingdom	5,300	11,700	26,200
United States	6,100	62,000	150,000
Total	18,000	116,900	302,600

[1] Non-Communist world only; data as of April 1970.

Source: European Nuclear Energy Agency and International Atomic Energy Agency.

France.—France's first nuclear powerplant using enriched uranium fuel will be built at Fessenheim in the northeastern part of the country. Planned capacity is 900 megawatts, the largest nuclear plant in France. Selection of a reactor type using enriched uranium was the result of a reorganization of the nuclear energy program. It was decided to discontinue the gas graphite reactor, which uses natural uranium fuel.[36]

Germany, West.—A tripartite agreement for production of enriched uranium by the gas centrifuge process was signed with the United Kingdom and the Netherlands. Design and engineering work will be centered in West Germany; the two other partners will each have an enrichment facility with an annual capacity of about 50 tons enriched uranium.

Since completion of the first commercial nuclear reactor, 12 have been ordered or were under construction. The first fast breeder reactor was planned for construction at Weisweiler, near Aachen. Nuclear power capacity was 900 megawatts in 1970 and is expected to be 4,000 megawatts in 1975, according to the West German Ministry of Science,[37] and 25 percent of total energy output is expected to be nuclear by 1980. However, environmental problems were posed. The Reactor Safety Commission may insist that a 1,200-megawatt plant, planned for Ludwigshaven, be an underground installation.

Greece.—The test reactor at the Democritus Nuclear Research Center supplied about three-fourths of Greek demand for radioisotopes and was under expansion to provide essentially all these requirements by 1973.

The first stage of a $1 million, 3-year exploration program was scheduled to start at favorable uranium areas in Macedonia, near the Bulgarian and Yugoslav borders. The project is sponsored by the United Nations Development Program ($850,000) and the Greek Government ($150,000).

[36] Chemical & Engineering News. V. 48, No. 7, Feb. 16, 1970, p. 25.

[37] Mining Journal. V. 275, No. 7052, Oct. 16, 1970, p. 340.

India.—The uranium concentrating plant of the Government-owned Uranium Corp. of India, Ltd. at Jaduguda, Bihar, operated at nearly full rated capacity of 1,000 tons of ore per day. Ore reserves at the nearby mine were reported to be on the order of 1 million tons. Lower grade deposits at Umra and Udaisagar, near Udaipur, Rajasthan, were being tested by heap-leaching methods.

A 10-year program, 1970–80, in nuclear and space research was proposed by the Indian Department of Atomic Energy.[38] The program includes nuclear powerplant capacity of 2,700 megawatts by 1980, including three new plants; development of a gas centrifuge for uranium enrichment; and a 500-megawatt prototype fast-breeder reactor.

Construction continued on India's third nuclear power station, at Kalpakkam, on the east coast, 35 miles south of Madras. Twin Candu-type plants, each of 200-megawatt capacity, were planned.

Italy.—AGIP Nucleare, part of Ente Nazionale Idrocarburi, the state-owned oil and chemical firm, and Montecatini Edison will build a UF_6 prototype plant to study production technology of this compound, which is used in uranium enrichment. The plant will initially produce 20 tons UF_6 annually.

Japan.—A Tokyo Institute of Technology report described a uranium enrichment process in which a uranium compound is passed through a small tube with a cation-exchange resin.[39]

By 1984, Japan was expected to have total nuclear capacity of 36,000 megawatts in 45 plants.[40] The Japan Atomic Industry Conference forecast cumulative uranium demand of 190,000 tons to 230,000 tons by 1990. Existing long term contracts total only about 30,000 tons.

The Japanese Government in conjunction with a number of trading and electric utility companies formed Overseas Uranium Resources Development Corp. to seek out and develop foreign uranium deposits. The Government-financed Power Reactor and Nuclear Fuel Development Corp. conducted research on UF_6 and centrifuges for uranium enrichment.

Korea, Republic of.—Ground was broken for a $175 million, 595-megawatt, pressurized-water, nuclear powerplant at Kori, on the Republic of Korea's east coast. Westinghouse Electric International Co. is assisting the state-owned Korea Electric Co. in the project. The plant, scheduled for operation in November 1975, will be the country's largest power producer.

Mexico.—The Comisión Nacional de Energía Nuclear (CNEN) continued exploratory work on two areas in the State of San Luis Potosí and was authorized to prepare proposals for exploitation of deposits in Durango. According to the President's annual report, proven ore reserves were increased to 4.4 million tons, containing 2,800 tons of U_3O_8 (0.064 percent U_3O_8, or 1.28 pounds of U_3O_8 per ton).

Early in the year, the Comisión Federal de Electricidad (CFE) asked for bids on a 600-megawatt, $120 million, nuclear plant, probably to be built on the coast north of Veracruz. The CFE reported that seven bids were received for a 600-megawatt plant to serve Mexico City. CFE decisions were to be based on comparative advantages of nuclear or fossil-fueled plants and, if a nuclear plant is decided upon, whether natural uranium or enriched uranium fuel is more desirable.[41]

Netherlands.—A centrifuge manufacturing plant was built, and a small-capacity experimental enrichment plant was under construction as part of the cooperative agreement with West Germany and the United Kingdom for uranium enrichment. Both installations will be located at Almelo, Overijssel Province, the Netherlands. West Germany also will build an enrichment facility in the same area. Electric power producers expected that at least four nuclear power reactors, having a total capacity of 1,500 to 2,000 megawatts, will be completed in the Netherlands by 1980. However, the availability of large quantities of natural gas at relatively low cost was expected to delay commercial nuclear power development. Gas-Unie, the domestic gas distributor, contracted with Ebasco Services, Inc., the U.S. engineering consultant firm, for a study of the competitive position of nuclear power.[42]

Niger.—Open-pit mine development continued at the Arlit deposit, operated by

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[38] Department of Atomic Energy. Nuclear India. V. 8, No. 10, June 1970, pp. 1,3, and 7.
[39] Chemical Week. V. 106, No. 16, Apr. 22, 1970, p. 56.
[40] Harris, S. G. Japan's Nuclear Plans Important to Canada. Foreign Trade, v. 134, No. 6, Oct. 24, 1970, pp. 7–9.
[41] Bureau of Mines. Mineral Trade Notes. V. 67, No. 6, June 1970, pp. 30–31.
[42] U.S. Embassy, The Hague, Amsterdam. State Department Airgram A–508, Dec. 4, 1970, 2 pp.

Société des Mines de l'Air (SOMAIR). Production started late in the year and totaled 59 tons of concentrate. The first stage called for a 825-short-ton-per-year mill, with expansion to 1,650 tons U_3O_8 per year by 1974. The concentrate will be hauled by rail to port in Dahomey, pending completion of a new haulage road to join the existing southbound road to railhead in Dahomey.[43] About 24 French technical personnel and more than 500 Nigerians are employed in the project. The Niger Government holds a 16-percent interest in SOMAIR.

The Niger Government, the French Commissariat de l'Energie Atomique (CEA), and the Japanese Overseas Uranium Resources Development Co. (representing 20 companies in Japan) concluded an agreement for development of a uranium deposit at Akokan, 12 miles south of Arlit.[44] Exploration was scheduled to start in July. The CEA will finance 70 percent, and the Japanese consortium 30 percent, of the first stage. Developmental costs of the second stage will be financed as follows: Japanese, 25 percent; Niger Government, 30 to 40 percent; and the CEA, the remainder. The CEA and the Japanese will take equal shares of the production.[45]

A third uranium deposit was reported at Imouraren, 30 miles south of Arlit, where a mineralized zone was intersected by drilling at depths of 450 to 1,200 feet.

Pakistan.—The United Nations Development Program has allocated $400,000 for uranium exploration in the Dera Ghazi Khan area. Survey work was scheduled for October, following the monsoon and summer season.

A 200-megawatt, pressurized-water reactor was planned for East Pakistan, Ateliers de Construction Électriques de Charleroi, a Westinghouse subsidiary, was selected as main contractor by the Pakistan Atomic Energy Commission. The Commission had engaged Motor-Columbus A.G., the Swiss consulting firm, as its technical and economic advisor.[46]

Somali Republic.—Nucleare Somala, a subsidiary of Ente Nazionale Idrocarburi, Italy, continued exploration for uranium. A West German consortium relinquished its concession, and Western Nuclear, Inc., United States, suspended operations about midyear pending evaluation of completed exploratory work.

The $1.8 million second stage of the 10-year United Nations Development Program was underway. Areas of anomalous radioactivity were discovered during the first stage, from 1964 to 1968. Further radiometric surveying, geochemical work, mapping, and drilling were planned for the second stage.[47]

South Africa, Republic of.—In July the Government announced that the Atomic Energy Board had developed a new and unique process for uranium enrichment, reportedly not an adaptation of either the gaseous diffusion or the centrifuge method. Plans were made to develop the process on a pilot-plant stage. A new company Uranium Enrichment Corp. of South Africa Ltd., was to be formed to conduct further research on uranium enrichment.[48]

Palabora Mining Co., the major copper producer, was building a $4.2 million plant at its Phalaborwa mine for recovery of byproduct uranium oxide from a heavy mineral concentrate containing uranothorianite. The South African Atomic Energy Board, in conjunction with the National Institute of Metallurgy, has developed a process for recovery of uranium and byproduct thorium sulfate.[49]

Uranium in excess of contract requirements was stockpiled. The original uranium mills have been modernized, most by incorporation of the solvent extraction process, which reduced operating costs and produced a higher purity uranium oxide. Solvent extraction has also been adopted at all new uranium recovery plants.

The Nuclear Fuels Corp. of South Africa Pty. Ltd. (NUFCOR) sponsored research on treating old slimes and tailings dumps from gold-mining operations. These materials total millions of tons and contain low-grade uranium values. One process is based on bacterial oxidation of pyrite in the slimes.[50]

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[43] Engineering and Mining Journal. V. 171, No. 6, June 1970, p. 257.
[44] Mining and Minerals Engineering. V. 6, No. 11, November 1970, p. 49.
[45] American Metal Market, V. 77, No. 64, Apr. 6, 1970, p. 16.
[46] Foreign Trade. V. 135, No. 3, January 1971, p. 36.
[47] American Metal Market. V. 76, No. 83, May 1, 1970, p. 15.
[48] South African Mining and Engineering Journal. V. 81, No. 4043, pt. 2, July 31, 1970, p. 471.
[49] Mining Journal. V. 276, No. 7063, Jan. 1, 1971, p. 10.
[50] Engineering and Mining Journal. V. 171, No. 10, October 1970, p. 89.

The Atomic Energy Board established a Division of Site and Installation Licensing. At midyear, South Africa's first nuclear power reactor had reached the advanced planning stage. The site is Duynefontein, Cape Province, where completion was scheduled for 1977–78. A total of 20,000 megawatts of nuclear power was projected for the year 2000.[51]

South-West Africa.—An extensive drilling program at Rössing has resulted in the discovery of a large, low-grade ore deposit. Bulk sampling and pilot-plant testing were underway. The mineralized area is 5 miles long, up to 1 mile wide, and of undetermined depth. The deposit will be mined by open-pit methods. Average grade was reported to be 0.03 percent U_3O_8, or 0.8 pound per ton.[52] General Mining and Finance Corp. and Rio Tinto Africa (Pty.) Ltd. were cooperating in mine development. The United Kingdom Atomic Energy Authority contracted to purchase 7,500 tons of U_3O_8 during 1976–82.[53]

Spain.—Further progress was made on nuclear power facilities. Plants were under construction at Vandellos and Santa María de Garoña. In April the first part of an 80-ton enriched-uranium-fuel core arrived in Madrid.

Twin-unit nuclear power projects were planned at Almarez and Lemoniz. Two electric utility companies have joined forces to contract on a combined basis. Thirteen bids were received from six suppliers in four countries. The reactors were expected to be in the 500-to 900-megawatt range.

Another two-unit nuclear installation was planned by Fuerzas Eléctricas de Cataluña, S.A., of Barcelona. A tentative site has been selected, where one plant would be completed in 1976, and the other in 1981. Light-water, enriched-uranium types, in the 800-megawatt range, were considered.[54]

Sweden.—In January Swedish and U.S.S.R. officials signed a 30-year agreement to cooperate on peaceful uses of atomic energy. The agreement includes exchange of unclassified information, delivery of nuclear equipment and materials on a commercial basis, and toll enrichment of Swedish uranium in the U.S.S.R.

Necessary design modifications continued to delay operations at the 140-megawatt, heavy-water reactor at Marviken. Later in 1970, conversion of the installation to an oil-fueled plant was considered.[55]

Four commercial reactors, with a total capacity of 2,500 megawatts, were under construction. Sweden's first commercial power reactor, the 440-megawatt Oskarshamn I, went critical in December. Construction work started on the 580-megawatt Oskarshamn II, which was scheduled for completion in 1974. By 1980, plans call for 12 nuclear power installations and more than 7,000 megawatts of total nuclear capacity.

Switzerland.—The first nuclear reactor in Switzerland using enriched uranium fuel will be built at Kaiseraugst on the Rhine River. The 840-megawatt plant is a joint effort of Swiss, French, and West German interests. General Electric Co. and Sogerca, a subsidiary of France's Générale d'Électricité, will build the nuclear facilities.[56]

Bernische Kraftwerke A.G. (BKW), Berne, continued construction of a 306-megawatt plant at Muehleberg, near Berne, scheduled to start producing electricity late in 1971. BKW was also seeking Government approval for a two-unit installation, each of 540 megawatts, at Graben, 30 miles north of Berne.[57]

United Kingdom.—A geologic reconnaissance project for uranium in northern Scotland, conducted by the Institute for Geological Sciences for the United Kingdom Atomic Energy Authority (UKAEA), was essentially completed. Uranium indications were fairly widespread in Sutherland and Caithness Counties, and further study appeared justified.[58]

Delays continued at the 1,200-megawatt, advanced gas-cooled Dungeness B reactor. This installation was originally intended to be the first commercial application of this concept. Completion, originally scheduled for September 1971, has been delayed,

[51] Canadian Mining Journal. V. 91, No. 9, September 1970, pp. 28–29.
[52] U.S. Consulate, Johannesburg. South Africa. State Department Airgram A–33, Mar. 5, 1970, 1 p.
[53] Mining and Minerals Engineering, V. 6, No. 10, October 1970, p. 44.
[54] Bureau of Mines. Mineral Trade Notes. V. 67, No. 11, November 1970, pp. 38–40.
[55] Chemical Week. V. 107, No. 10, Sept. 2, 1970, p. 89.
[56] Chemical & Engineering News. V. 48, No. 53, Dec. 21, 1970, p. 31.
[57] Foreign Trade. V. 135, No. 2, Jan. 16, 1971, pp. 31–32.
[58] Chemicals and Industry. No. 37, Sept. 12, 1970, p. 1185.

Table 17.—Status of development of the liquid-metal fast-breeder reactor in 1970

Status and country	Power (megawatts)		Initial operation
	Thermal	Electrical	
Operating:			
United States	200	66	1963
Do	62.5	20	1964
Do	20	----------	1969
France	40	----------	1967
United Kingdom	60	15	1959
U.S.S.R	5	----------	1959
Do	60	12	1970
Under construction:			
United States	400	----------	1974
France	600	250	1973
United Kingdom	600	250	1972
U.S.S.R	1,000	150	1971
Do	1,500	600	1973–75
Planned:			
United States	750–1,250	300–500	1976
Italy	140	----------	1975
Japan	100	----------	1973
Do	750	300	1976
West Germany	58	20	1972
Do	730	300	1975

Source: U.S. Atomic Energy Commission.

probably until the end of 1973. The main problems were in design and corrosion.[59]

The UKAEA concluded a 3-year agreement with Combustion Engineering, Inc., United States, for conversion of 3 million pounds of U_3O_8 to UF_6 at its Springfields, Lancashire, fuel plant. The UF_6 product will be returned to the United States for enrichment.[60]

The Production Group, UKAEA, represents British participation in the tripartite uranium-enrichment agreement, also involving the Netherlands and West Germany. According to the UKAEA Annual Report for 1969–70, a gas centrifuge plant will be commissioned at Capenhurst in 1972. Eventual capacity will be 40 to 50 tons separative work units. The UKAEA will transfer its functions in the project to a proposed new company, British Nuclear Fuels Ltd.

U.S.S.R.—Russia reportedly has received orders for equipping more than 20 nuclear power units in Bulgaria, Hungary, East Germany, Romania, Czechoslovakia, and Finland.

A fast-breeder reactor (FBR) program is underway. A 350-megawatt FBR has been completed at Melekess, a similar plant is under construction at Shevchenko, and a 600-megawatt unit is under construction in the Ural Mountains.[61] A number of power reactors of various types were planned for service during 1971–75.

Late in the year, the U.S.S.R. negotiated with representatives of nuclear companies in Finland, France, West Germany, and Sweden to provide toll enrichment services.

WORLD RESERVES

The current edition of a report on world (non-Communist) uranium resources, prepared for the Organization for Economic Cooperation and Development (OECD), lists total established reserves of nearly 840,000 tons U_3O_8 (at less than $10 per pound) and 880,000 tons U_3O_8 as estimated additional reserves (same price).[62] Reserves are subject to revision upward, because of increases mainly in the United States and Australia. According to the AEC, U.S. reserves at yearend were 246,000 tons U_3O_8 at $8 per pound and 300,000 tons U_3O_8 at $10 per pound. The former is based on nearly 118 million tons of ore averaging 0.21 percent U_3O_8 and represents a 55,000-ton increase from the first of the year. Domestic potential reserves ($8 per pound) increased by more

[59] Economist. V. 236, No. 6624, Aug. 8, 1970, p. 70.

[60] Mining Magazine. V. 123, No. 4, October 1970, p. 345.

[61] Foreign Trade. V. 135, No. 5, Feb. 27, 1971, p. 17.

[62] Organization for Economic Cooperation and Development. Uranium Resources, Production, and Demand. A Joint Report by the European Nuclear Energy Agency and the International Atomic Energy Agency. Paris. September 1970, 54 pp.

than 100,000 tons to 490,000 tons U_3O_8. These increases resulted from the large-scale private exploratory drilling programs, which peaked in 1969 but remained substantial in 1970.

Preliminary estimates for two major discoveries in the Northern Territory of Australia indicate a substantial reserve increase. In addition, new reserves were reported in other parts of the country.

Table 18.—World uranium reserves and production capacity, by countries [1]

(Short tons)

Country	Reserves [2]	Annual capacity	
		Planned 1973–74	Attainable 1975
Argentina	10,000	88	88
Australia	[3] 21,700	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	200,000	6,000	6,000
Spain	11,000	550	550
Turkey	2,300	----------	----------
United States	[4] 250,000	19,000	23,000
Yugoslavia	1,300	----------	----------
Total	839,300	38,138	50,598

[1] Non-Communist world only.
[2] U_3O_8 at less than $10 per pound; data as of April 1970.
[3] Subject to major revision upward, based on recent major discoveries.
[4] Does not include 90,000 tons of byproduct U_3O_8.

Source: European Nuclear Energy Agency and International Atomic Energy Agency.

TECHNOLOGY

The AEC continued its sponsorship of large-scale research and development in all phases of nuclear technology. About three-fourths of the overall basic research program is conducted at AEC-owned laboratories and at AEC-owned contractor-operated research and development facilities. The remainder is contracted research and development.[63] Because of the significance of the environmental issue in connection with nuclear development, the AEC reported its sponsoring of 1,072 projects on environmental matters in 1970.

A report compared roll-type uranium ore deposits in Wyoming and peneconcordant tabular deposits of the Colorado Plateau, the principal sources of uranium in the United States, and discusses their genetic implications.[64] The Wyoming ore rolls are considered dynamic, having been pushed downward by downward-moving oxygen-bearing ground water, whereas the Plateau deposits seemingly formed as static bodies.

The geologically unique Orphan mine structure, Grand Canyon, Ariz., where uranium ore occurred in a nearly circular, vertical pipe structure, 150 to 500 feet in diameter, is considered to have probably formed by solution collapse.[65] The pipe structure and uranium mineralogy suggest a hydrothermal origin for the ore deposit, but the authors suggest the importance of ground-water activity.

A new concept for uranium ore deposition is postulated for the Athabasca sandstone of northern Saskatchewan, Canada.[66]

[63] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1970. January 1971, 210 pp.
[64] Fischer, R. P. Similarities, Differences, and Some Genetic Problems of the Wyoming and Colorado Plateau Types of Uranium Deposits in Sandstone. Econ. Geol., v. 65, No. 7, November 1970, pp. 778–784.
[65] Gornitz, V., and P. F. Kerr. Uranium Mineralization and Alteration, Orphan Mine, Grand Canyon, Ariz. Econ. Geol., v. 65, No. 7, November 1970, pp. 751–767.
[66] Johns, R. W. Athabasca Sandstone and Uranium Deposits. Western Miner, v. 43, No. 10, October 1970, pp. 42–52.

The paper is pertinent because the recently discovered Wollaston Lake deposit of Gulf Oil Corp. is believed to lie near the eastern margin of the widespread and thick Athabasca sandstone. This discovery started a wave of land acquisition, resulting in the entire region underlain by this sandstone being covered by mineral permits. As a result of his work on the origin and geologic environment of this sandstone, the author considers that much of the previous exploration drilling did not penetrate to deep favorable zones in a regolith at the base of the sandstone and that future exploration should attempt to develop data on this zone.

A Bureau of Mines reserve study comprised not only current economic uranium reserves but also low-grade, potential resources, such as copper leach solutions, wetprocess phosphoric acid, Florida phosphates, and the Chattanooga shale.[67]

Kermac Nuclear Corp. completed a major shaft-sinking project, the largest of its type in the country, at an Ambrosia Lake property, New Mexico. The shaft is 784 feet deep, 16-½ feet in external diameter, and steel-lined with external reinforcing members to full depth. Rotary-rig drilling was employed, using a 16½-foot hard-rock bit, weighing nearly 40 tons, and a newly engineered 150-foot twin mast.[68]

Bacterial leaching tests were applied on a commercial scale in experimental stopes at a mine in the Elliot Lake district, Ontario.[69] Bacteria are considered to play two roles: Direct oxidation of U+4 to U+6 or replenishing the supply of ferric iron, which also oxidizes uranium. The latter is considered more significant.

In situ leaching has been underway at the Pitch mine in the Gunnison National Forest, southern Colorado, since 1968. This operation followed 3 years of conventional top slicing in a highly fractured fault zone. Success of the leaching reportedly has been variable. The leach solutions were introduced into the stopes by a system of pumps, pipelines, and 40 injection wells. Originally, natural water was the leaching agent; later, the pH was adjusted with sodium bicarbonate.[70]

Work continued on improvement of uranium-processing techniques. Despite increasing costs of labor, equipment, supplies, and services, costs have decreased in several milling operations. Development work was underway on two modifications to the well-established solvent exchange process; namely, cyclone separators to replace mixer-settlers and solvent exchange from acid leach slurries.[71] Anticipated demand for nuclear fuels has caused a resurgence of ore-processing research, particularly in bacterial leaching and in the reduction of the uranyl ion and precipitation of UO_2.[72]

Two types of countercurrent ion exchange columns, developed by the Bureau of Mines, were tested for uranium recovery from mine waters in the Ambrosia Lake district.[73] For 1 year, mine waters containing 10 parts per million U_3O_8 were processed through a compartmented, upflow-type ion exchange column of 1-square-foot area at flow rates up to 25 gallons per minute. Recovery reportedly appeared better than that attained with existing ion exchange equipment and commercial techniques used in the district. This work is part of the Bureau's continuing Uranium Recovery Project, started in fiscal year 1969, and includes research to improve uranium-recovery techniques from ores, waters, wet-process phosphoric acid (WPPA), and other resources, and also to improve metallurgical techniques for the processing of commercial ores. Regarding WPPA, which contains 0.15 to 0.25 gram U_3O_8 per liter, 2,000 tons U_3O_8 are potentially recoverable annually. Commercial solvent exchange techniques, used to recover several hundred tons U_3O_8, were not economic because of excessive solvent losses and high chemical costs. Research continued on improved extractants and chemical techniques.

Research and development on uranium enrichment for nuclear fuels continued in many of the industrialized nations. The

[67] Bieniewski, C. L., F. H. Persse, and E. F. Brauch. Availability of Uranium at Various Prices From Resources in the United States. BuMines Inf. Circ. 8501, 1971, 92 pp.

[68] Engineering and Mining Journal. V. 171, No. 6, June 1970, p. 140.

[69] Duncan, D. W., and A. Bruynesteyn. Microbiological Leaching of Uranium. British Columbia Research, Vancouver, B.C. Presented at Uranium Symposium, Socorro, N. Mex., May 1970, 9 pp.

[70] Marrs, L. F. Underground Leaching of Uranium at the Pitch Mine. Min. Cong. J., v. 56, No. 11, November 1970, pp. 35–43.

[71] Ross, A. H. Uranium Mills Hit High Rate of Efficiency. Northern Miner, No. 5, Apr. 23, 1970, p. 21.

[72] Rickard, R. S. Mill Men See Growing Applications for Chemical Processing. Min. Eng. v. 22, No. 2, February 1970, pp. 106–107.

[73] George, D. R., and J. R. Ross. Recovery of Uranium From Mine Waters by Countercurrent Ion Exchange. J. Metals, v. 22, No. 12, December 1970, pp. 25A–26A.

Tokyo Institute of Technology reported a new method, successful in enrichment by a factor of 1.017 on a laboratory scale, and planned a larger test device.The process involves isotopic separation in a long, narrow tube filled with positive ion exchange resin. It is considered suitable for low enrichment concentrations, such as for peaceful uses. Advantages are relatively low-cost equipment and ease of handling. The gas centrifuge process, probably the most widely accepted in research and developmental work, was reported to have a number of advantages over the gaseous diffusion process—the need for perhaps 10 percent as much electric power, lower capital investment, optimum competitive cost efficiency at much lower capacity, and ease of expansion by adding cascades.[74]

Advances were made in nuclear fuel technology as a result of both AEC-sponsored and private industrial efforts. Researches sought fuel cladding with a minimum of swelling and interaction with fuel. A design problem is the swelling of stainless steel under fast neutron irradiation, caused by voids in the steel, formed by the fast neutron bombardment. Emphasis was placed on the ceramic fuels, which are probably among the fastest growing sectors of the nuclear industry. A recent report describes the sintering process in the preparation of ceramic fuels into pellets.[75] Firing requires precise temperatures, timing, and atmospheric conditions. The pellets must withstand extremely high temperatures and changes in composition and structure owing to nuclear radiation, which often induces radial cracks and circumferential parting.

In fuels reprocessing, an improvement in plutonium recovery during plutonium-uranium separation was developed by E.I. Du Pont de Nemours, operator of the AEC's Savannah River plant, Aiken, S.C. Hydroxylamine nitrate, a reducing agent substituted for the sulfate, resulted in less waste products and reduced corrosion, in addition to better plutonium recovery.[76] Westinghouse Electric Corp. and Edison Electric Institute jointly conducted a project designed to test the economic viability of the plutonium fuel assembly in the pressurized-water reactor. Westinghouse fabricated 720 plutonium fuel rods at its Cheswick, Pa., plant to be used in refueling the San Clemente, Calif., nuclear generating station in August.[77] Also, an AEC plutonium reactor carries an inventory of 3,000 kilograms of plutonium for a full-scale mockup of plutonium fuel arrangements in future commercial reactors.

According to the AEC, the high-priority liquid-metal fast-breeder reactor (LMFBR) program was directed toward fuel and material development, construction and operation of experimental and test facilities, and planning a first demonstration plant, jointly with industry. The objective is a burnup rate of 100,000 megawatt-days per ton of fuel. The AEC considers that, potentially, the LMFBR is economically comparable with the LWR and complements the LWR in that it uses plutonium produced in the LWR. It also represents a highly efficient use of energy resources, and, being a high-temperature system, its high thermal efficiency permits designs that will add less waste heat to the environment per unit of power. Experimental Breeder Reactor II at the National Reactor Testing Station, Idaho, continued testing of fuels and irradiated materials for the LMFBR. The Fast Flux Test Facility, to be constructed at Richland, Wash., will test radiation effects on future commercial reactors.[78] The AEC's Bettis Atomic Power Laboratory, Pittsburgh, Pa., continued development of reactor core potential for breeding in the LWR system, based on the advanced seedblanket technique used at the Shippingport (Pa.) Atomic Power Station. The Molten Salt Breeder Reactor, under development at the Oak Ridge (Tenn.) National Laboratory, has potential for reduced fuel costs, high thermal efficiency, and improved fuel doubling time (time required to produce a surplus quantity of fuel equal to that required to fuel the reactor), when combined with an onsite reprocessing plant. A request was made for a 1,000-megawatt design study to be made by an industrial contractor.

Future underground nuclear reactor installations were considered for southern California and parts of Europe,[79] and the

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[74] Brooks, K. Centrifuges. Chem. Week, v. 107, No. 12, Sept. 16, 1970, pp. 33–48.

[75] Goldsmith, F. J. Nuclear Fuel Sintering Concepts. Ceram. Age, v. 86, No. 12, December 1970, pp. 13–15.

[76] Chemical Engineering News. V. 48, No. 52, Dec. 14, 1970, pp. 56–59.

[77] Industry Week. V. 166, No. 5, Feb. 2, 1970, pp. 18–19.

[78] Seaborg, G. T., and J. L. Bloom. Fast Breeder Reactors. Sci. Am, v. 223, No. 5, November 1970, pp. 13–21.

[79] Chemical & Engineering News. V. 48, No. 35, Aug. 24, 1970, p. 29.

U.S. Interior Department granted an award to General Dynamics Corp. for a feasibility study on offshore siting.[80]

The radioisotope californium-252 assumed greater significance in industrial and other applications. Because of certain advantages, mainly as a prodigious neutron emitter, it has replaced other isotopes in a number of uses.[81] A recent paper describes U.S. Geological Survey activities in nuclear geophysical exploration, including the use of californium-252.[82] The basis of this technique is neutron activation of stable elements, which then become artificially radioactive. The elements are identified by measurement of energy from their gamma-ray emissions. The U.S. Geological Survey has extended laboratory techniques to vehicle-mounted equipment for use in the field. Scientists from Battelle Pacific Northwest Laboratories of Richland, Wash., demonstrated this technique in a nuclear probe for exploration on and mapping of the ocean floor.[83] Rapid analysis of some 20–30 elements can be made in their natural environment.

There were no experimental detonations in the AEC's Plowshare program in 1970; efforts were directed toward interpreting results of earlier experiments in natural gasfields. New explosive designs were under study, including special requirements for hydrocarbon applications. Studies also included oil shale, mineral recovery, underground storage, waste management, ground water management, and geothermal energy applications. A feasibility study was underway on development of geothermal power from underground nuclear detonations. A number of engineering problems need to be solved.[84]

Radioactive waste management received increasing attention from both the AEC and industry. It was estimated that some 17,000 gallons of highly radioactive waste materials were generated in 1970, and the rate may reach 1 million gallons in 1980. The AEC announced the Third Annual Symposium on Packaging and Transportation of Radioactive Materials to be held in Richland, Wash., in August 1971. The AEC also established a Division of Waste and Scrap Management to centralize responsibility for control over the processing, transport, storage, and disposal of wastes and the reprocessing of scrap materials containing special nuclear materials. At the AEC's Hanford and Savannah River plants, liquid wastes are evaporated to concentrated salt solutions, which solidify to moist salt cakes. At the reactor testing station in Idaho, the high-temperature fluidized-bed process is used. Wastes are converted to a granular calcined product with about one-ninth the volume of the original solution.

Ion exchange is used for removal of troublesome cesium-137, which has a long half-life and poses heat buildup problems in stored nuclear residues. The ion-exchange medium is an inorganic zeolite, which has affinity for cesium and withstands the radioactive environment.[85]

Several processes have been developed for converting liquid wastes to inert solid ceramic forms.[86] A phosphate or borosilicate is used as the primary flux. The ceramic form occupies one-tenth the volume of the original liquid form. The final product ranges from a true glass to a rock-like ceramic, which has advantages in durability, low dispersion potential, noncorrosion to storage containers, resistance to high temperatures, and minimal surveillance requirements.

In midyear the AEC announced tentative selection of a salt mine site, near Lyons, Kans., for demonstration of long-term storage of high-level, long-lived wastes in the solid state. Storage would be in sealed vessels in a thick salt bed, 1,000 feet underground. Geological and engineering test studies were underway at the site.

Health and safety in uranium mines received increasing attention in 1970. A recent report describes the variable factors affecting the rate of radon gas emanations from rock surfaces and accumulations in mine openings.[87] The author concludes that new mine development and mining methods should be planned so that conditions in

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[80] Chemical Week. V. 107, No. 4, July 22, 1970, p. 34.
[81] Pages 11 to 40 of work cited in footnote 12.
[82] Senftle, F. E. Mineral Exploration by Nuclear Techniques. Min. Cong. J., v. 56, No. 1, January 1970, pp. 21–28.
[83] Engineering and Mining Journal. V. 171, No. 9, September 1970, p. 182.
[84] Industrial Research. V. 12, No. 7, July 1970, pp. 22–23.
[85] Godfrey, W. L., and D. J. Larkin. Ion Exchange Tames Radioactive Waste Solutions. Chem. Eng., v. 77, No. 15, July 13, 1970, pp. 56–58.
[86] Mendel, J. E. Ceramics Make Nuclear Wastes Safe. Ceram. Age, v. 86, No. 12, December 1970, pp. 35–38.
[87] Thompkins, R. W. Radiation in Uranium Mines. Canadian Min. J., v. 91, No. 10, October 1970, pp. 103–105.

the mine are within the proposed working level of radiation.

The Bureau of Mines published a handbook on radiation control in uranium mines, the first of a two-volume study.[88] The Bureau's Mining Research Center, Pittsburgh, Pa., commenced work to develop new techniques needed to meet current and future health standards in uranium mines.

Union Carbide Corp., the AEC's contractor at the Oak Ridge enrichment plant, announced development of a process for removal of essentially all radioactive exhaust gases from nuclear powerplants. These gases–krypton and xenon–are removed with fluorocarbon solvents by selective absorption stripping.[89]

[88] Rock R. L., and D. K. Walker. Controlling Employee Exposure to Alpha Radiation in Underground Uranium Mines. BuMines Handbook, v. 1 of two volumes, 1970, 72 pp.

[89] Chemical & Engineering News. V. 48, No. 39, Sept. 14, 1970, p. 47.

Vanadium

By Harold A. Taylor, Jr.[1]

Domestic demand for vanadium was strong in the first half of the year, but it slacked off in the second half. Domestic production was at a slightly lower level than in the previous year. The huge volume of exports of vanadium ore, oxides, and ferrovanadium, was a reflection of strong demand for vanadium overseas. The Government sold surplus vanadium pentoxide during the early part of the year.

Legislation and Government Programs.—The Office of Emergency Preparedness decreased the conventional war stockpile objective for vanadium from 2,100 to 540 short tons of contained vanadium on March 4. The entire 540 tons is in the form of vanadium pentoxide; there is no longer a ferrovanadium objective.

The General Services Administration (GSA) sold 402,000 pounds of vanadium contained in vanadium pentoxide in February and 399,199 pounds in March on an off-the-shelf basis at $1.55 per pound of contained V_2O_5. They sold 799,300 pounds in April, 803,057 pounds in May, and 801,250 pounds in June, all off-the-shelf at $1.64 per pound of contained V_2O_5. GSA continued making monthly off-the-shelf offerings through October at $1.94, but made no sales. In November, an offering was made on a sealed-bid basis but none of the bids received were accepted. The bids received ranged from $1.10 to $1.68 per pound. All the sales were under strict export controls which forbade either exporting the materials, reselling and then exporting it, or converting it to ferrovanadium and then exporting it.

As of December 31, 1970, the Government had an inventory of 3,345 short tons of vanadium, all in the national stockpile. Of this total, 1,200 tons was in the form of ferrovanadium and 2,145 tons was in the form of vanadium pentoxide.

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[1] Physical scientist, Division of Ferrous Metals.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1966	1967	1968	1969	1970
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium [1]	5,166	4,963	6,483	5,577	5,319
Value thousands	$22,210	$21,331	$23,143	$26,334	$34,923
Vanadium pentoxide recovered	6,496	5,921	6,149	5,906	5,594
Consumption	5,481	5,245	5,495	6,154	5,134
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	482	351	278	644	2,155
Vanadium ores, concentrates, oxides, and vanadates	886	788	463	258	973
Imports (general):					
Ferrovanadium (gross weight)	8	14	626	449	21
Ores and concentrates	72	42	31	---	---
World production	10,029	10,266	13,331	14,830	16,448

[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

While the uranium-vanadium ores of the Colorado Plateau continued to be the principal domestic source of vanadium, the quantity recovered from Arkansas vanadium ore increased. The amount of vanadium recovered from ferrophosphorus continued to be significant. Other vanadiferous materials used as feed at various mills included vanadium residues, spent catalysts, and imported vanadiferous slag. The recovered vanadium pentoxide figures in tables 1 and 4 for 1970 are on the same basis as 1969 and do not include vanadium recovered from imported vanadiferous slag.

The mill of Union Carbide Corp. at Rifle, Colo., is now the only mill recovering significant quantities of vanadium from domestic uranium-vanadium ores. American Metal Climax, Inc., closed its mill at Grand Junction, Colo., early in 1970 because of the present and prospective weak market for uranium. The Soda Springs, Idaho, plant of Kerr-McGee Corp. continued to recover vanadium from byproduct ferrophosphorus obtained when elemental phosphorus is made from Idaho phosphate rock. The feed at some other mills also included ferrophosphorus.

Table 2.—Recoverable vanadium of domestic origin produced in the United States, by States

(Short tons of contained vanadium)

State	1966	1967	1968	1969	1970
Colorado	3,697	3,317	3,492	W	W
Utah	353	471	563	W	257
Other States [1]	1,116	1,175	2,428	W	W
Total	5,166	4,963	6,483	5,577	5,319

W Withheld to avoid disclosing of individual company confidential data; included in total.
[1] Includes Arizona 1966–69, Arkansas 1968–70, Idaho 1966–70, New Mexico 1966–70, South Dakota 1966–67, and 1970, Wyoming 1966–67.

Table 3.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons)

Year	Mine production [1]	Recoverable vanadium [2]
1966	5,685	5,166
1967	5,088	4,963
1968	7,105	6,483
1969	5,737	5,577
1970	5,793	5,319

[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
1966	11,955	11,595
1967	10,915	10,569
1968	12,105	10,976
1969	12,120	10,542
1970	11,035	9,986

[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 and other forms declined in 1970. The decline occurred in all end-use categories except stainless and heat-resisting steels.

One producer removed vanadium-aluminum master alloys containing 40 percent vanadium and 85 percent vanadium from general sale. A new grade of ferrovanadium containing 55 to 60 percent vanadium made its debut. Foote Mineral Co.'s expansion of its Cambridge, Ohio, ferroalloy plant was delayed by almost half a year by a construction workers' strike.

Table 5.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1969		1970	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium [1]	5,193	1,272	4,325	903
Oxide	113	20	138	19
Ammonium metavanadate	110	11	44	11
Other [2]	739	203	627	91
Total	[3] 6,154	[3] 1,507	5,134	1,024

[1] Includes other vanadium-iron-carbon alloys.
[2] Consists principally of vanadium-aluminum alloys, plus relatively small quantities of other vanadium alloys and vanadium metal.
[3] Data may not add to totals shown because of independent rounding.

Table 6.—Consumption of vanadium in the United States, by end uses

(Short tons of contained vanadium)

End use	1970
Steel:	
Carbon	1,050
Stainless and heat resisting	48
Alloy (excluding stainless and tool)	2,420
Tool	473
Cast irons	51
Superalloys	41
Alloys (excluding alloy steels and superalloys):	
Cutting and wear-resistant materials	W
Welding and alloy hard-facing rods and materials	11
Nonferrous alloys	485
Other alloys [1]	17
Chemical and ceramic uses:	
Catalysts	125
Other [2]	11
Miscellaneous and unspecified	402
Total	5,134

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1] Includes magnetic alloys.
[2] Includes pigments.

PRICES

Prices quoted by Metals Week for export of merchant, technical-grade vanadium pentoxide continued the rise begun in 1969 until June, after which month they leveled and then declined moderately. The price quoted at the beginning of the year was $1.75 per pound of contained V_2O_5, free alongside ship (f.a.s.) U.S. shipping port. The quote rose to $2 on January 26 and ranged between $2 to $2.20 from February 2 to March 16. Prices continued to rise and from March 23 to April 27 ranged between $2.40 to $2.50, continued at $2.50 through June 15, and topped off for the year in the $2.50 to $2.60 range from June 22 to September 28. From October 5 to November 30 prices held in the $2.10 to $2.30 range, and ended the year at $2.

The domestic producer prices for 98 percent fused vanadium pentoxide and technical-grade air-dried vanadium pentoxide also rose. They ended 1969 at $1.51 per pound of contained V_2O_5 for fused and $1.54 per pound of contained V_2O_5 for air dried. From January 1 to June 30, the prices were $1.64 for fused and $1.66 for air dried, f.o.b. plant. From July 1 to December 30, the prices were $1.94 for fused and $2.02 for air dried, f.o.b. plant.

GSA sold its vanadium pentoxide at a shelf price of $1.55 per pound of contained V_2O_5 in its February and March sales. In its April, May, and June sales, the vanadium pentoxide went for $1.64. After raising the price to $1.94 in July, GSA made no additional sales.

The domestic price for standard ferrovanadium began the year at $3.12 per pound of contained vanadium, f.o.b. plant, rose to $3.47 on January 2, and reached the yearend level of $4.12 on July 1. The prices for Carvan and Solvan began the year at $2.96 and rose to their yearend levels of $3.48 f.o.b. plant on July 1. The quote for ferrovanadium exported by dealers began the year at $4, reached $4.40 in early February, hit the $4.75 to $5 range from late February to mid-June, peaked at $4.90 to $5.25 from mid-June to early October, and settled back to end the year at $4.50.

FOREIGN TRADE

Exports of both ferrovanadium and vanadium ores, concentrates, and oxides were much higher in 1970 than in 1969, although the last 2 months of 1970 saw a decline in the exports of both categories. The average declared value for exports of ore, concentrates, and technical-grade oxides was $1.67 per pound of contained vanadium pentoxide in 1970. This compares with $1.41 for 1969 and $1.19 in 1968. The average declared value for exports of ferrovanadium was $2.81 per pound of alloy, compared with $2.20 in 1969 and $1.90 in 1968.

No imports classified as ores and concentrates arrived in 1970. Imports of vanadiferous slag, classified as metal-bearing residues, came from Chile, the Republic of South Africa, and the U.S.S.R.

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 ores, concentrates, pentoxide, vanadic acid, vanadium oxides, and vanadates (except chemically pure grade) (vanadium content)			
	1969		1970		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	---	---	44	$139	---	---	5	$12
Australia	---	---	20	70	---	---	(1)	(1)
Austria	---	---	---	---	---	---	91	298
Belgium-Luxembourg	---	---	132	358	1	$1	14	41
Brazil	1	$3	28	85	4	10	---	---
Canada	245	521	912	2,161	35	81	22	62
Chile	---	---	---	---	1	1	1	3
Colombia	---	---	(1)	2	(1)	(1)	---	---
Czechoslovakia	---	---	---	---	---	---	123	328
France	79	214	125	372	28	109	172	456
Germany:								
East	---	---	275	812	---	---	---	---
West	373	769	402	1,269	172	447	662	2,130
Hong Kong	(1)	1	---	---	---	---	---	---
Hungary	---	---	32	51	---	---	---	---
India	---	---	156	418	---	---	15	48
Iran	---	---	---	---	---	---	35	64
Italy	---	---	72	220	19	37	45	151
Japan	107	200	1,102	3,044	107	248	307	828
Libya	---	---	---	---	2	4	---	---
Mexico	110	205	254	726	7	20	8	31
Netherlands	94	228	335	1,036	106	221	165	430
New Zealand	---	---	---	---	---	---	1	2
Poland	---	---	---	---	---	---	2	6
South Africa, Republic of	---	---	---	---	---	---	(1)	1
Spain	37	85	108	363	---	---	---	---
Sweden	173	495	220	739	23	95	187	663
Trinidad and Tobago	---	---	---	---	1	3	---	---
United Kingdom	---	---	71	191	10	23	87	248
Venezuela	69	113	---	---	---	---	---	---
Yugoslavia	---	---	21	71	---	---	---	---
Zambia	---	---	---	---	---	---	4	6
Total	1,288	2,834	4,309	12,127	516	1,300	1,946	5,808

[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			
	1969		1970		1969		1970	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Australia	31	$53	---	---	31	$53	---	---
Austria	262	384	---	---	255	373	---	---
Belgium-Luxembourg	159	268	---	---	153	258	---	---
France	26	43	---	---	---	---	---	---
Germany, West	128	223	31	$86	111	189	47	$114
Italy	42	51	---	---	r 42	51	---	---
Sweden	94	167	11	29	94	167	---	---
United Kingdom	155	183	---	---	77	94	---	---
Total	897	1,372	42	115	763	1,185	47	114

WORLD REVIEW

In addition to the countries listed in table 9, the U.S.S.R. and Chile produced vanadiferous slag from iron ores, and some other countries had relatively small vanadium production from secondary sources, wastes, or as a byproduct recovered along with other metals. In Canada, an oil refinery of Petrofina Canada, Ltd., has a byproduct plant with a capacity of about 100 short tons of contained vanadium per year which recovers vanadium pentoxide from fly ash produced by burning petroleum coke. The Japanese recover byproduct vanadium from several different sources. West Germany probably recovered vanadium from South-West African lead vanadate concentrates (credited to South-West Africa in table 9), from vanadiferous slags, and possibly from other sources.

The great international demand for vanadium reached its height around mid-1970 and then slacked off. Prices and U.S. exports acted similarly.

Australia.—An Australian-French-American group is considering development of a vanadiferous oil shale deposit at Julia Creek, Queensland, on the Townsville-Mount Isa Railway. The attractions of the deposit include nearness to transportation, proximity to the surface (450 feet), and the availability of low-cost power from burning the spent shale. Technical reasons dictate that the deposit must come on stream at a rate of about 5,600 tons of contained vanadium per year. Accordingly, a study of the prospective market in Europe is underway.[2]

South Africa, Republic of.—Highveld Steel and Vanadium Corp., Ltd., produced about 27,500 tons of vanadium-bearing slag

[2] Metal Bulletin (London). No. 5512, July 3, 1970, p. 19.

Table 9.—Vanadium: World production from ores and concentrates, by countries [1]
(Short tons)

Country	1968	1969	1970 p
Finland [2]	1,321	1,484	1,450
France e [3]	100	100	100
Norway e	940	1,010	1,080
South Africa, Republic of:			
Content of pentoxide and vanadate products	r 2,257	r 2,859	2,665
Content of vanadiferous slag product e	r 1,600	r 3,300	5,434
Total e	r 3,857	r 6,159	8,099
South-West Africa, Territory of (in lead-vanadate concentrate) e	630	500	400
United States (recoverable vanadium)	6,483	5,577	5,319
Total	13,331	14,830	16,448

e Estimate. p Preliminary. r Revised.
[1] The U.S.S.R. and Chile are known to produce vanadium in slags from iron ores, but data are insufficient for estimation.
[2] Vanadium in vanadium pentoxide product.
[3] Byproduct from bauxite.

for export in the fiscal year which ended June 30, 1970. They continued to make progress towards reaching capacity, although not as much progress as anticipated; the iron plant producing the slag had reached about 90 percent of capacity by the end of the fiscal year. A fifth prereduction kiln which is coming into production early in 1972 will increase plant capacity.

The company's Vantra Division received a third small kiln, which will enable it to keep production at the present level when an anticipated drop in ore grade occurs. An additional large kiln has been ordered which will increase plant output by 40 percent. The large kiln will be commissioned around mid-1971, as will a new mine in the Rustenburg district which will supply the needed additional ore.

South-West Africa.—Ore bodies in the deeper section of the Berg Aukas mine, now made accessible by a new shaft, came into production and markedly improved the output of lead vanadate.

U.S.S.R.—A pellet plant inaugurated at the Kachkanar iron mine in the Urals is expected to greatly increase blast furnace efficiency and hence increase the output of vanadiferous slag. The ore is a low-grade titanomagnetite, having an iron content of approximately 17 percent but a high vanadium content. A beneficiation plant uses magnetic separation to give a 63-percent concentrate. Formerly this fine concentrate went directly into the blast furnace.

TECHNOLOGY

The Bureau of Mines continued its research on vanadium-base alloys by studying the properties of molybdenum-titanium additions. The alloy with the highest strength contained 20 percent molybdenum, 10 percent titanium, 0.1 percent carbon, 0.5 percent silicon, and 0.5 percent yttrium. It maintained high strength up to 1,200°C. This alloy had a 10,000-meter strength/density at 800°C, which was appreciably greater than that of a variety of commercial high-temperature alloys such as Udimet-M 252, Mar-M 302, Inconel X-750, and AlSl 670.[3]

The Bureau also studied the phase relations of the vanadium-oxygen system in the vanadium-rich region below 1,200°C to determine the solubility of oxygen in vanadium and the interrelationship of the three phases existing in this region.[4]

Oxygen impurities in sodium strongly affect the mechanical and corrosion properties of vanadium alloys which otherwise might be usable as fuel cladding materials in sodium-cooled fast-breeder reactors. A mathematical internal oxidation model explains the hardened zone which forms when vanadium-titanium and vanadium-aluminum alloys react with the oxygen impurities. The oxygen reacts with the titanium and aluminum to give the TiO_2 or Al_2O_3 precipitate which forms the hardened zone.[5] In addition to the mathematical model, some experimental research was conducted on this problem. Corrosion tests on vanadium-base alloys in four forced-convection sodium loops indicate that vanadium-base alloys are sensitive to the activity of oxygen, carbon, and/or nitrogen in sodium. Alloys containing over 10 percent titanium are not stable in the sodium reactor coolant. The most stable alloy tested was V–5Ti–15Cr.[6]

The discovery of new ways of making vanadium-base alloys and the investigation of additional vanadium alloy systems may also lead to the use of vanadium in fast-breeder reactors. Aluminothermic reduction of vanadium pentoxide followed by electron beam melting without an intermediate vacuum sintering step can yield high-purity vanadium. Purity was over 99.9 percent. A high-purity vanadium ingot yields the V–15Cr–5Ti alloy via arc melting. The low cost of using the processes should attract the metals industry.[7] A

[3] Keith, G. H., and J. S. Winston. Development of High-Temperature Vanadium-Base Alloy. BuMines Rept. of Inv. 7393, 1970, 13 pp.

[4] Henry, J. L., S. A. O'Hare, R. A. McCune, and M. P. Krug. The Vanadium-Oxygen System: Phase Relations in the Vanadium-Rich Region Below 1,200°C. J. Less-Common Metals, v. 21, No. 2, June 1970, pp. 115–135.

[5] Klueh, R. L., and J. H. Devan. Effect of Oxygen in Sodium on Vanadium and Vanadium Alloys. J. Less-Common Metals, v. 22, No. 4, December 1970, pp. 380–398.

[6] Litton, F. B., J. H. Bender, and L. A. Geoffrion. Evaluation of Vanadium and Vanadium-Base Alloys in Hot-Trapped Sodium. Metallurgical Trans., v. 1, No. 2, February 1970, pp. 441–445.

[7] Wang, C. T., E. F. Baroch, S. A. Worcester, and Y. S. Shen. Preparation and Properties of High-Purity Vanadium and V–15Cr–5Ti. Metallurgical Trans., v. 1, No. 6, June 1970, pp. 1683–1689.

phase diagram developed for the vanadium-rich portion (0 to 37 percent nickel) of the vanadium-nickel system shows that adding nickel can lower the melting point of vanadium from 1,900° to 1,280°C. The solid solubility of nickel in vanadium increases from 6.8 atomic percent nickel at 800°C to 24.0 atomic percent nickel at 1,280°C.[8]

New processes devised to separate vanadium from such materials as iron ore pellets, granite, crude titanium tetrachloride, and ore leach solutions could increase the U.S. supply of vanadium. One process involves mixing the iron ore with 2 to 5 percent sodium carbonate, pelletizing the mixture, heating it to sinter the pellets and form sodium vanadate, and leaching the roasted material with water to dissolve the vanadate.[9] Extracting vanadium and other metals from granite by chelating the ground rock with a solution of oxalic acid and citric acid and decanting the metal-containing solution gives a liquid suited to treatment by conventional methods.[10] Vanadium is recoverable from crude titanium tetrachloride by precipitating vanadium compounds with hydrogen sulfide, drying the precipitate, and oxidizing the precipitate to remove vanadium oxychloride.[11] Another proposed process removes vanadium and other metals from acidic ore solutions (no higher than a pH of 3.5) by adding iron powder and maintaining the solution at 115°–150°C until most of the metals precipitate as oxides or hydroxides.[12]

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[8] Stevens, E. R., and O. N. Carlson. V–Ni System. Metallurgical Trans., v. 1, No. 5, May 1970, pp. 1267–1271.

[9] Michal, E. J. (assigned to National Lead Co.). Process for Removing Vanadium From Iron Ores. U.S. Pat. 3,486,842, Dec. 30, 1969.

[10] Goni, J. C. (assigned to Bureau de Recherches Geologiques et Minieres). Processes for Extracting Metals From Rocks or Ores. U.S. Pat. 3,511,645 Mar. 11, 1970.

[11] Ferrero, F., G. Sironi, and A. Garberi (assigned to Montecatini Edison S.p.A.). Recovery of Vanadium. British Pat. 1,200,577, July 29, 1970.

[12] Fitzhugh, Jr., E. F. and D. C. Seidel (assigned to Republic Steel Corp.). Recovery of Molybdenum, Vanadium and Uranium From Solutions of Corresponding Salts. U.S. Pat. 3,510,273, May 5, 1970.

Vermiculite

By Frank B. Fulkerson [1]

In 1970 production of crude vermiculite in the United States decreased 8 percent in quantity and 4 percent in value. Quantity and value of exfoliated vermiculite sold or used declined 12 percent and 6 percent, respectively. The average unit value of crude vermiculite increased 4 percent to $22.78 per ton, and the average unit value of exfoliated vermiculite rose 7 percent to $85.11 per ton.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output decreased 8 percent from that of 1969 to 285,000 tons and a value of $6.5 million. Only three mines produced crude vermiculite in 1970 compared with eight in 1969. W. R. Grace & Co., Zonolite Division, supplied the principal production from its mines in Lincoln County, Mont., and Laurens County, S.C. The Patterson Vermiculite Co. mine in Laurens County, S.C., also was active. W. R. Grace & Co. announced plans to increase capacity principally in the smaller particle sizes, at its Libby, Mont., processing plant.

Exfoliated Vermiculite.—Twenty-five companies in 31 States produced 221,000 tons of exfoliated vermiculite. The following six States, listed in order of output supplied 43 percent of the exfoliated vermiculite production: California, Florida, Texas, New Jersey, South Carolina, and Illinois. W. R. Grace & Co., Zonolite Division, the largest producer, operated 23 plants in 20 states.

Table 1.—Salient vermiculite statistics

	1966	1967	1968	1969	1970
United States:					
Sold and used by producers:					
Crude thousand short tons	262	255	290	310	285
Value thousand dollars	$4,955	$4,974	$5,684	$6,805	$6,501
Average value per ton	$18.91	$19.51	$19.60	$21.95	$22.78
Exfoliated thousand short tons	193	180	213	250	221
Value thousand dollars	$15,130	$14,278	$16,845	$19,916	$18,809
Average value per ton	$78.39	$79.32	$79.08	$79.66	$85.11
World: Production, crude thousand short tons	382	371	421	466	432

CONSUMPTION AND USES

The end-uses for exfoliated vermiculite in 1970 were as follows: aggregates (concrete, plaster, cement) and insulation (largely as loose fill), each 40 percent; agriculture (horticulture, soil conditioning, fertilizer carrier, litter), 14 percent; and miscellaneous uses, 6 percent.

PRICES

The Engineering and Mining Journal quoted nominal yearend prices for crude vermiculite, beneficiated at the mine, as follows: Per short ton, f.o.b. mines, Montana and South Carolina, $18 to $35; and South Africa, c.i.f. Atlantic ports, $29.55 to $40.15. The average mine value of all domestic crude vermiculite sold or used was $22.78 per ton, compared with $21.95 per ton in 1969. The average unit value of all exfoliated vermiculite, f.o.b. processing plants, was $85.11 per ton, compared with $79.66 per ton in 1969.

[1] Industry economist, Division of Nonmetallic Minerals.

FOREIGN TRADE

Crude vermiculite was imported duty-free into the United States. The Republic of South Africa continued to be the only important source of vermiculite imports.

WORLD REVIEW

A review of vermiculite uses and world markets was published.[2]

Canada.—Six companies exfoliated vermiculite at 10 locations in 1969. The plants were located in Vancouver, British Columbia (two plants); Calgary and Edmonton, Alberta; Regina, Saskatchewan; Winnipeg and St. Boniface, Manitoba; St. Thomas, Ontario; and Lachine and Montreal, Quebec. The following end-use percentages were reported by exfoliated vermiculite producers in 1969: Loose fill insulation, 71 percent; plaster aggregate, 11 percent; insulating concrete, 7 percent; and miscellaneous uses, 11 percent. All crude vermiculite exfoliated in Canada was imported from the United States and the Republic of South Africa.[3]

India.—The problem of separating vermiculite from biotite was studied by the Ore Dressing Section, Metallurgy Division, Bhabha Atomic Research Centre, Trombay, Bombay. Vermiculite ore from Kasipatanam mines, Andhra Pradesh, was used in the tests. A method of preferential grinding and separation of vermiculite was developed. The separated mineral was further enriched by two processes: magnetic separation and exfoliation. The tests showed that for export purposes, vermiculite could be separated from biotite by magnetic separation and for local consumption it could be exfoliated, which would give better grade and recovery.[4]

South Africa, Republic of.—Vermiculite production decreased 5 percent compared with 1969. The only major supplier of vermiculite outside North America, Palabora Mining Co., decided to expand and modify its existing plant instead of building an entirely new mill. Production was to be increased from 140,000 tons to 175,000 tons per year while at the same time permitting processing of lower grade ores. About 1 year would be required to complete the modifications, but no disruption of production was expected. The company uses a dry milling process. It was originally planned to adopt wet processing, which would increase recovery of vermiculite from serpentinite and pyroxenite ores, but costs proved to be too high.[5]

Uganda.—The Minister of Mineral and Water Resources reported that vermiculite deposits in the Namekara and Bukusu areas were tested and found to be high grade.[6]

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[2] Industrial Minerals. Vermiculite: A Market in Transition. No. 38, November 1970, pp. 9–16.
[3] Wilson, H. S. Lightweight Aggregates, 1969. Dept. of Energy, Mines, and Resources, Ottawa, June 1970, 4 pp.
[4] Ganzu, G. L., and K. K. Majumdar. Studies on the Beneficiation of Vermiculite. Indian J. Mines, Metals & Fuels. V. 18, No. 8, August 1970, pp. 299–300.
[5] Industrial Minerals. Palabora to Modify Vermiculite Plant. No. 35, August 1970, p. 31.
[6] Mining Magazine. Minerals in Uganda. V. 123, No. 4, October 1970, p. 341.

Table 2.—Vermiculite: Free world production by countries

(Short tons)

Country	1968	1969	1970 p
Argentina	r 4,766	5,023	e 5,100
Brazil	2,724	e 4,240	e 4,240
India	2,588	4,388	801
Kenya	308	855	1,839
South Africa, Republic of	121,453	142,184	134,367
Tanzania	33	136	165
United States (sold or used by producers)	289,504	309,467	285,331
Total	r 421,376	466,293	431,843

e Estimate. p Preliminary. r Revised.

Table 3.—Republic of South Africa: Exports of vermiculite by countries

(Short tons)

Country	1968	1969	1970
Australia	3,988	3,666	
Belgium	851	1,449	
Canada	3,850	4,892	
Finland	(1)	977	
France	9,899	9,381	
Germany, West	13,058	14,947	
Italy	20,164	27,021	
Japan	4,647	7,343	NA
Netherlands	1,283	1,348	
Spain	3,902	4,096	
Sweden	1,584	2,521	
Switzerland	(1)	716	
United Kingdom	27,745	27,335	
United States	10,576	6,497	
Undisclosed	4,505	3,395	
Total	106,052	115,584	127,612
Total value [2]	$2,119,344	$2,409,697	$3,150,288
Average value per ton [2]	$19.98	$20.85	$24.69

NA Not available.
[1] Not reported individually; may be included with undisclosed.
[2] Converted to U.S. currency at the rate of 1 rand equals US$1.40.

TECHNOLOGY

In a method for flameproofing paper or fabrics, finely divided vermiculite ore was soaked in a sodium chloride brine, washed with water, steeped in a lithium chloride brine, again washed, and water-exfoliated. The resulting sludge was applied to the paper or fabric, and the coated paper or fabric dried.[7]

An improved, direct-fired, sloping furnace was devised for expanding sized vermiculite ore or perlite and tank-annealing the expanded material.[8]

The surface hardness of fresh concrete was improved by covering it with a blanketing layer of minus 8-, plus 40-mesh exfoliated vermiculite. The layer was up to 6 inches in thickness.[9]

A thermal-insulated, water-repellent board was prepared from a mixture consisting of asphalt-coated, exfoliated vermiculite, asphalt, and a cellulosic fiber.[10]

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[7] Land, E. W., and C. W. Orgell (assigned to W. R. Grace & Co.). Process for Flameproofing Combustible Materials. U.S. Pat. 3,540,892, Nov. 11, 1970.

[8] Johnson, C. W. Apparatus for the Heat Treatment of Comminuted Material. U.S. Pat. 3,522,610, Oct. 13, 1970.

[9] Jackson, W. R. (assigned to W. R. Grace & Co.). Case Hardening of Concrete With Fine Vermiculite. U.S. Pat. 3,499,070, Mar. 3, 1970.

[10] Kawam, A., and M. V. Ernest (assigned to W. R. Grace & Co.). Method of Forming Water-Laid Vermiculite Roof Insulating Board. U.S. Pat. 3,533,907, Oct. 13, 1970.

Table 4.—Vermiculite exfoliating plants in the United States in 1970

Company	State	County
Arizonolite Co	Arizona	Maricopa.
California Zonolite Co	California	Alameda, Los Angeles.
Carolina Wholesale Florist Co	North Carolina	Lee.
Cleveland Gypsum Co., Division of Cleveland Builders Supply Co.	Ohio	Cuyahoga.
Coralux Perlite Corp. of New Jersey	New Jersey	Middlesex.
Filter Media Co., Inc	Louisiana	St. John the Baptist.
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.
Solomon's Mines, Inc	Arizona	Maricopa.
Southwest Vermiculite Co	New Mexico	Bernalillo.
Supreme Perlite Co	Oregon	Multnomah.
Texas Vermiculite Co	Oklahoma	Oklahoma.
	Texas	Bexar, Dallas.
Verlite Co. (Schmelzer Sales Assoc., Inc.)	Florida	Hillsborough.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu.
Vermiculite Industrial Corp	New Jersey	Essex.
Vermiculite-Intermountain	Utah	Salt Lake.
Vermiculite-Northwest, Inc	Oregon	Multnomah.
	Washington	Spokane.
Vermiculite Products, Inc	Texas	Harris.
Zonolite Division, W. R. Grace & Co	Arkansas	Pulaski.
	Colorado	Denver.
	Florida	Dade, Duval, Hillsborough, Palm Beach.
	Georgia	Fulton.
	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.
	Pennsylvania	Lawrence.
	South Carolina	Greenville.
	Tennessee	Davidson.
	Wisconsin	Milwaukee.

Zinc

By Albert D. McMahon [1]

Most all segments of the domestic zinc industry suffered setbacks in 1970 after the strong growth of the preceding 2 years. All elements of zinc supply and consumption declined following the general downward trend in industrial activity. The lower demand and increasing inventories at primary producers' plants resulted in production curtailments of 10 to 15 percent at most smelters and refineries early in the year; additional cutbacks were made later to control another buildup of smelter stocks. Demand for zinc declined progressively and was substantially reduced in the last 2 months of 1970 because of the General Motors Corp. strike. Imports of zinc in ore and concentrates and imports of slab zinc were much lower than those of 1969. The price of zinc resisted the pressure for a reduction through most of the weakening market situation but was lowered 0.5 cent, to 15 cents per pound on August 24, 1970; this quotation continued through the end of the year.

In 1970, U.S. mines produced 534,000 tons, approximately 3.5 percent less than in 1969. Smelter production of slab zinc dropped 14 percent, and imports of zinc in ore and metal declined 13 percent and 17 percent, respectively. Consumption was down 14 percent as producers' stocks rose almost 50 percent and consumers' inventories fell 12 percent.

The free world zinc mine production increased 3 percent; smelter output was down approximately 2 percent. Consumption fell in most countries except Japan, where the smallest increase in years was reported.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient zinc statistics

	1966	1967	1968	1969	1970
United States:					
Production:					
Domestic ores, recoverable content short tons	572,558	549,413	529,446	553,124	534,136
Value thousands	$166,044	$151,562	$142,950	$161,512	$163,650
Slab zinc:					
From domestic ores short tons	523,580	438,553	499,491	458,754	403,953
From foreign ores do	501,486	500,277	521,400	581,843	473,858
From scrap do	83,263	73,505	79,865	70,553	77,156
Total do	1,108,329	1,012,335	1,100,756	1,111,150	954,967
Secondary zinc [1] do	277,967	247,254	276,092	307,714	264,074
Exports of slab zinc do	1,406	16,809	33,011	9,298	288
Imports (general):					
Ores (zinc content) do	521,320	534,092	543,366	602,120	525,759
Slab zinc do	278,175	222,112	304,576	324,776	270,413
Stocks, December 31:					
At producer plants do	64,798	81,916	65,379	65,788	98,314
At consumer plants do	129,593	102,535	101,818	102,007	89,551
Consumption:					
Slab zinc do	1,423,666	1,250,673	1,350,656	1,385,380	1,186,951
All classes do	1,820,012	1,605,862	1,745,357	1,814,167	1,571,596
Price, prime western, East St. Louis cents per pound	14.50	13.85	13.50	14.65	15.32
World:					
Production:					
Mine short tons	4,942,013	5,330,400	5,483,540	5,891,661	6,060,604
Smelter do	4,498,252	4,547,754	5,100,953	5,472,473	5,407,129
Price: Prime western grade, London cents per pound	12.75	12.37	11.89	12.96	13.42

[1] Excludes redistilled slab zinc.

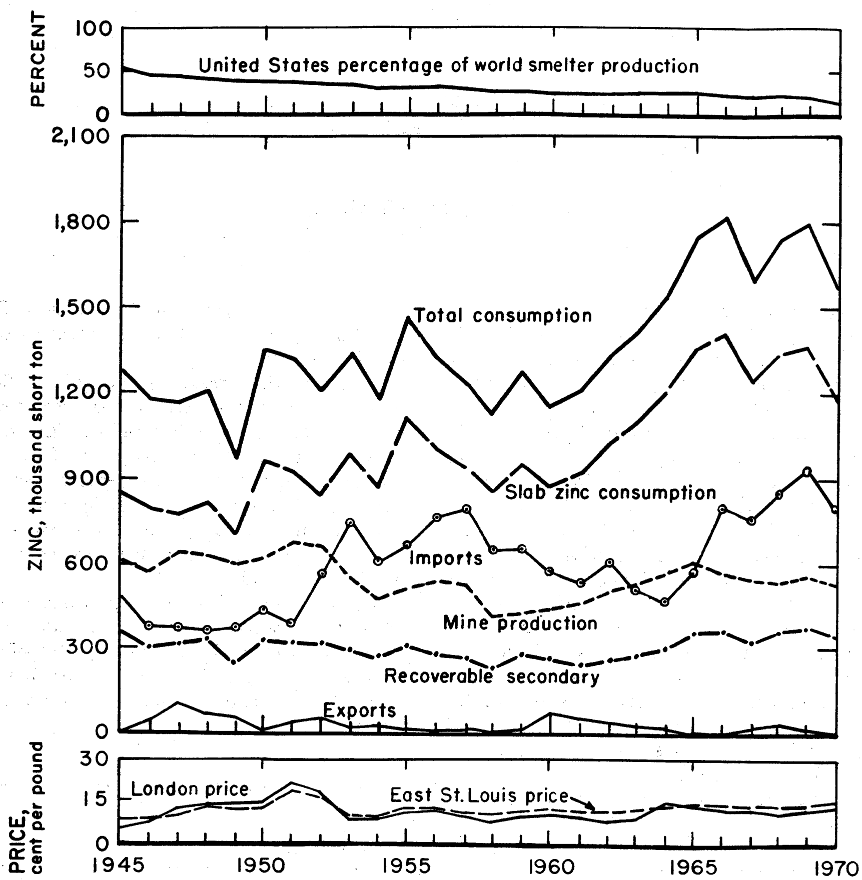

Figure 1.—Trends in the zinc industry in the United States.

Legislation and Government Programs.—General Services Administration sales of zinc continued during the year on an off-the-shelf basis. Sales through the end of December for commercial consumption amounted to only 25 tons, and 22,583 tons remain in the existing disposal authorization. No zinc was sold to the Agency for International Development in 1970. Sales to other government agencies amounted to 20,049 tons, and 22,187 tons remain of the 50,000 tons authorized in 1965 for government use. The stockpile inventory at the end of 1970 was 1,141,490 tons of zinc, including government commitments not delivered.

The International Lead and Zinc Study Group held its 14th session in Geneva on November 16–20 to review past events and to determine outlook for these metals. Representatives from 27 of the 30 member countries attended. The Study Group investigating zinc consumption in 1970 concluded that efforts to curb inflation in the United States and other countries brought varying degrees of industrial stagnation. Because of the general economic situation during 1970, zinc production forecasts made for certain countries by the Group had not been fulfilled, and, even with the curtailment of mine and smelter output, producers' inventories rose to unexpected higher levels. For 1971, the Study Group predicted that a modest upturn in the level of economic activity would support a near balance in estimated world production and consumption. Zinc uses in galvanizing and zinc-base alloys were forecast to rise with industrial activity. Many delegations urged repeal of tariff and other trade barriers on lead and zinc and that no restrictive initiatives be adopted by member governments. Reference was made to the General Agreement on Tariff and Trade (GATT) as the appropriate forum for negotiations of tariff and nontariff barriers on trade.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mine production of recoverable zinc in the United States was 534,136 tons in 1970, a decline of 3.5 percent from that of the previous year. Decreases were recorded for 13 States and increases, for nine. Tennessee, producing about 6,000 tons, or 5 percent less than in 1969, continued to rank first with approximately twice the production of second-place New York. Colorado's production increased 3,000 tons to replace Idaho for third place, only 2,000 tons behind New York; Idaho dropped to fifth place. Missouri moved into fourth place with the largest growth of any State in 1970; in 4 years zinc mine production from the new Missouri Lead Belt has grown from 4,000 to 50,700 tons. Large reductions in Idaho, New Mexico, and Montana with small declines in other States west of the Mississippi, allowed the eastern States to gain 1 percentage point, providing 57 percent of U.S. production.

The sources of zinc production in 1970 are shown in table 4 according to the principal metal or combination of metals extracted. The percentage distribution is as follows: 50 percent from zinc ores; 29 percent from lead-zinc ores; 10 percent from lead ores; 8 percent from copper-lead-zinc ores; and 3 percent from all other sources. The average zinc content of the 7.3 million tons of zinc ore mined in 1970 was 3.67 percent, compared with 8.9 million tons of ore averaging 3.93 percent in 1969.

The 25 leading mines listed in table 5 accounted for 78 percent of domestic recoverable mine production. The five leading mines produced 29 percent, and the first 10 contributed 46 percent.

With 22 percent of the national total, Tennessee was the leading producing State in 1970, a position it has held since 1958. American Zinc Co. mined 2,838,000 tons of ore and produced 125,000 tons of zinc concentrates in Tennessee. A production goal of 2,000 tons per day was attained at the Immel mine early in the year, and forecasts for tonnage and grade have since been exceeded. Improvements in haulage equipment at the New Market joint venture and ventilation at the Coy mine were completed for expansion of mine capacity. American Zinc's east Tennessee ore reserves were increased nearly 3 million tons in 1970 by surface and underground drilling, which resulted in the addition of a year's supply of ore.[2] 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. New Jersey Zinc continued exploration development in the new middle-Tennessee area, principally through a pilot shaft at Elmwood, which was completed in September 1970. The work continued to delineate the zinc mineralization more precisely, which indicated the development of a low-cost mine operation.[3] Production of zinc concentrates at Copperhill by Cities Service Co. increased by a small amount in 1970. Work continued on a large construction program, which is expected to increase current output of iron, zinc, copper, and sulfuric acid by approximately 40 percent when completed in 1972. Included is expansion and modernization of sulfuric acid producing facilities to one of the world's largest oprations converting metallurgical gases to acid.[4]

Mine production in New York, the second ranking State, was just 150 tons below that of 1969 and entirely from the Balmat and Edwards mines of the St. Joe Minerals Corp. (Corporate named changed from St. Joseph Lead Co. May 1970). The mines worked continuously on a 6-day per week basis throughout the year, and the labor-contract was renewed for a 3-year period. The new No. 4 shaft and large-production underground equipment were placed in service for enlarging mine capacity. Prog-

[2] American Zinc Co. Annual Report. 1970, p. 5.
[3] Gulf & Western Industries, Inc. Annual Report. 1970, p. 20.
[4] Cities Service Co. Annual Report. 1970, p. 23.

ress continued with the construction of a new concentrator, which will have twice the capacity of the present mill at 4,300 tons per day.[5]

Production in New Jersey, Pennsylvania, and Virginia by New Jersey Zinc was approximately 500 tons lower than that of 1969. Large expenditures were made and planned for the Friedensville, mine.[6] Mine output in Kentucky declined to 4,200 tons, a 16-percent drop below that of 1969.

In Wisconsin American Zinc closed three small mines and Ivey Construction Co. closed its mine and mill. State production decreased 10 percent from that of 1969. Mine output in Illinois rose 22 percent to 16,800 tons.

Colorado moved up to third place in 1970 with a 5.5 percent increase in production to 56,700 tons, a record high for the State. New Jersey Zinc's Eagle mine produced the largest tonnage of zinc. Newmont Mining Corp.'s Idarado mine was second, and the Sunnyside mine of Standard Metals Corp. ranked third. Production of ore at the Idarado mine was down 13 percent because of a shortage of skilled and semiskilled workers. Sublevel stoping in the wide mineralized areas was introduced late in the year using multidrill jumbos and rubber-tired loading and hauling equipment to improve productivity. Ore reserves were lowered by adjusting the ore grade and increasing the minimum mining width because of increasing costs of production. Resurrection Mining Co., owned by Newmont Mining and the American Smelting and Refining Co., (ASARCO) continued to develop their joint venture at the Leadville Unit. The Black Cloud shaft was complete at 1,650 feet in February 1970, and construction of the 700-ton-per-day concentrator was begun and scheduled for completion early in 1971. Ore reserves remained at 2,401,000 tons averaging 9.5 percent zinc, 5.13 percent lead, 2.64 ounces of silver, and 0.084 ounce of gold per ton.[7]

The recoverable zinc mined in Maine during 1970, entirely from the Penoboscot mine of the Callahan Mining Corp., was 19-percent greater than in 1969. However, in 1970, the best production year, ore reserves were reduced because of a lower copper price. Under the prevailing conditions the deposit will be exhausted in 1972.[8]

Missouri became the fourth-ranking State in 1970 with a 23-percent increase in production over that of 1969. The Buick mine and mill operated by the Missouri Lead Operating Co. produced 32,000 tons of zinc concentrates of its first full year of operation.[9] The Ozark Lead Co.'s zinc production from the Ozark mine was somewhat greater than that of 1969. Mining operations were reduced to a 5-day week during the fourth quarter.[10] The Magmont mine at Bixby, Mo., operated by Cominco-American Inc. mined 859,000 tons of ore having a combined average lead-zinc grade of 11.9 percent.[11] Mine output in Kansas dropped 38 percent from that of 1969 principally because of the closing of Eagle-Picher Industries, Inc.'s Swalley mine. Oklahoma production in 1970 was 3 percent less than that of 1969.

In Idaho production fell 27 percent to 41,000 tons due to the closure of the Page mine in 1969 and the diversion of zinc in lead smelter slag. Production increased at Bunker Hill Co.'s (subsidiary of Gulf Resources & Chemical Corp.) own mines. A new mining method was introduced using small trackless equipment and inclined ramps instead of drifts, shafts, and raises. The new techniques have increased efficiencies and lowered mining costs in the areas where used.[12] The Star-Morning unit operated by Bunker Hill and Hecla Mining Co. produced 215,500 tons of ore averaging 6.77 percent zinc, 5.24 percent lead, and 2.45 ounces of silver. Ore reserves were increased principally from development work on the 7,500-foot level. Mining the Star-Morning veins on the 7,300-foot level and sinking the shaft to the 7,500-foot level were started during the year.[13] Mine output of zinc in Utah was only 214 tons less than in 1969. The United States Smelting Refining and Mining Co. processes ore from the U.S. and Lark mine in Lark,

[5] St. Joe Minerals Corp. Annual Report. 1970, p. 8.
[6] Gulf & Western Industries, Inc. Annual Report. 1970, p. 20.
[7] Newmont Mining Corp. Annual Report, 1970, pp. 7–9.
[8] Callahan Mining Corp. Annual Report. 1970, p. 12.
[9] American Metal Climax, Inc. (AMAX) Annual Report. 1970, p. 7.
[10] Kennecott Copper Corp. Annual Report. 1970, p. 13.
[11] Cominco Ltd. Annual Report. 1970, p. 2.
[12] Gulf Resources & Chemical Corp. Annual Report. 1970, p. 12.
[13] Hecla Mining Co. Annual Report. 1970, p. 8.

Utah, at its flotation mill in Midvale, Utah. The concentrates produced are treated on toll by other companies, and the refined zinc is returned to the company.[14] Production by the Tintic Division of Kennecott Copper Corp. increased almost 100 percent over that of 1969. All ore came from the Burgin mine; a small quantity of development ore was mined at the Trixie mine and an area between the Burgin and Ball Park mineralized areas. The ground water table at the Burgin was being gradually lowered after an increase in pumping capacity.[15]

In 1970, the Mayflower mine, owned by New Park Mining Co. and operated by Hecla, produced 115,672 tons of ore, which assayed 2.85 percent zinc. Ore reserves were reduced from 257,000 to 240,000 tons. Downward projecting veins cut on the 2,600 and 2,800 levels were disappointing when compared with the 2,400 and development work was curtailed.[16] The Anaconda Company, in a joint venture with ASARCO conducted geological and mine development work to delineate new lead-zinc-silver reserves for United Park City Mines Co.[17]

The United States Smelting Refining and Mining acquired the mining properties, claims, and mill facilities of New Jersey Zinc in Bayard, N. Mex. The Hanover mine, included in the purchase, was closed in August 1970 and has not been reopened.[18] Production at ASARCO's Ground Hog mine was considerably higher than that of 1969, and 122,417 tons of ore was mined and milled. The zinc concentrates produced contained 14,179 tons of zinc.[19]

Cyprus Mines Corp.'s Bruce mine near Bagdad, Ariz., operated close to capacity, producing 7,600 tons of zinc. Deepening the shaft for development of two new levels was approved. Known reserves are estimated to maintain operations for 6 years, and the two new levels are expected to add another year of operation.[20] In December 1970, ASARCO closed its Van Stone mine at Northport, Wash., because reserves had been exhausted.[21] Pend Oreille Mines and Metals Co. mined 223,729 tons of ore in 1970 and produced 4,698 tons of zinc in concentrates. Approximately 30 percent of the year's production was from the 900 level where a major development program was also conducted. Although more ore was extracted than in 1969, increasing costs, lower metal prices, and declining ore grades combined for a disappointing year of operations.[22]

SMELTER AND REFINERY PRODUCTION

Slab zinc production at smelters and electrolytic refineries in the United States decreased 14 percent from that of 1969, to approximately 955,000 tons; this reflected the cutbacks initiated earlier in the year to minimize the growing buildup of producers' stocks. Reviewing monthly data published by the Zinc Institute the lowering of refined zinc production and shipments that began in November 1969 fluctuated through the first quarter 1970, and in February production was the lowest since the strike curtailed output of March 1968. Production rebounded in March but then declined progressively to new lows in August and November. Monthly shipments ranged from 83,250 tons down to 66,653 tons, for an average of 76,012 tons per month compared with an average of 95,774 tons in 1969.

Most all zinc smelters and refineries operated at reduced levels in 1970. Notices of cutbacks in production began late in March when the National Zinc Co. announced a 25 percent reduction effective March 29, 1970. St. Joe Minerals said it would cut production 13 percent in April and thereafter would consider the problem on a month-to-month basis. Mattheissen & Hegeler Zinc Co. had been operating at 75 percent capacity since the end of January, taking advantage of the lower demand period for repairs and maintenance. American Zinc followed with a 10 to 12 percent reduction. The Bunker Hill and New Jersey Zinc initiated cutbacks in April and Blackwell Zinc trimmed its production 9 percent at Blackwell, Okla., in May. On

[14] United States Smelting Refining and Mining Co. Annual Report. 1970. p. 4.
[15] Kennecott Copper Corp. Annual Report. 1970, p. 13.
[16] Hecla Mining Co. Annual Report. 1970, pp. 8–9.
[17] The Anaconda Company. Annual Report. 1970, p. 8.
[18] United States Smelting Refining and Mining Co. Annual Report. 1970, p. 3.
[19] American Smelting and Refining Co. (ASARCO) Annual Report. 1970, p. 7.
[20] Cyprus Mines Corp. Annual Report. 1970, pp. 9–10.
[21] American Smelting and Refining Co. Annual Report. 1970, p. 7.
[22] Pend Orielle Mines and Metals Co. Annual Report. 1970, p. 5.

September 21, 1970, 1 week after the start of the General Motors strike, American Zinc closed its electrolytic plant at East St. Louis, Ill., and indicated that the auto strike was the precipitating factor.

Refined zinc production by primary smelters and electrolytic refineries was derived from the following: domestic ores, 42 percent; foreign ores, 50 percent; and scrap, 8 percent. In 1970 the quantities of slab zinc produced from domestic and foreign ores were 12 percent and 19 percent, respectively, lower than those of 1969, and there was an increase of 9 percent in production from scrap. Primary zinc refined by electrolytic plants was down 13 percent from that of 1969 and accounted for 41 percent of total slab zinc produced; smelter production of primary zinc was 18 percent lower than that of 1969 and made up of 51 percent of the total. Redistilled secondary slab zinc produced from scrap by primary smelters increased 9 percent over that of 1969 and contributed 7 percent of the total; the increase from secondary smelters was 14 percent for only 1 percent of the total. Production of all grades of zinc were lower than that of 1969, however, the percentage distribution was about the same with special high grade at 42 percent; prime western, 34 percent; high grade, 11 percent; brass special, 8 percent; and intermediate, 5 percent.

St. Joe Minerals produced 192,000 tons of refined zinc at their electrothermic zinc smelter at Monaca, Pa., a decrease of 11 percent from that of 1969. Production of zinc oxide was 35,000 tons, approximately the same as that of 1969. Zinc oxide capacity will be increased to over 50,000 tons per year with plans to double French-process oxide production. Additional facilities are planned for recycling greater quantities of zinc-base industrial wastes and residues. Improvements of environmental aspects at St. Joe's two smelters were scheduled for 1971 at a cost of $4.5 million.[23] ASARCO's electrolytic zinc refinery at Corpus Christi, Tex., was damaged in August by Hurricane Celia; the damage cost approximately $500,000 and nearly 15 days' production. Construction of fluid-bed roasting facilities was begun and scheduled for completion in 1972. Two old flash roasters will be replaced which will result in lower operating costs and increased capacity. This plant has no air-quality problems; however, water-quality control regulations will require equipment costing $2 million to purify plant effluents. The horizontal-retort zinc smelter at Amarillo, Tex., produced less zinc in 1970 owing to a shortage of labor. Continued operation under the State Air Control Board's regulations is questionable. The plant is working under an extension of a variance granted earlier pending results of feasibility studies to control emissions.[24] American Zinc increased slab zinc production 3 percent, to 130,000 tons, in fiscal 1970. The electrolytic refinery at Sauget, Ill., operated at 95 percent of rated capacity and the horizontal retort smelter at Dumas, Tex., had a good year until April 1970 when production was reduced to control the rising inventory of slab zinc. In October 1970, the electrolytic refinery was shut down because of a large inventory, unsettled market conditions, and principally, the General Motors strike.[25] Blackwell Zinc Co., Inc. (subsidiary of AMAX) horizontal-retort zinc smelter at Blackwell, Okla., produced 81,000 tons of slab zinc in 1970, a 9-percent decrease from that of 1969 because of the weakened market demand.[26] In 1970, The Anaconda Company produced 152,000 tons of zinc, compared with 180,300 tons in 1969. Approximately all production was refined at the Great Falls, Mont., electrolytic zinc plant; 55 percent of the total was treated on toll for other companies. Adverse general economic conditions and the automobile strikes late in 1970 reduced demand, which caused cutbacks in production.[27] Bunker Hill curtailed zinc production at its Kellogg, Idaho, electrolytic plant early in April 1970 due to the lessening of demand. Zinc metal production was reduced to 96,000 tons, from 106,000 tons in 1969.[28] In September 1970, New Jersey Zinc moved its corporate headquarters from New York City to Bethlehem, Pa., to be closer to key operations located at Palmerton, Pa. The lack of demand for zinc metal because of reduced automobile production, growing substitution of plastics for zinc diecastings, increased competition from zinc imports, and lower demand by the steel industry en-

[23] St. Joe Minerals Corp. Annual Report. 1970, pp. 8, 12.

[24] American Smelting and Refining Co. Annual Report. 1970, p. 11.

[25] American Zinc Co. Annual Report. 1970, p. 6.

[26] AMAX Annual Report. 1970, p. 8.

[27] The Anaconda Company. Annual Report. 1970, p. 6.

[28] Gulf Resources & Chemical Corp. Annual Report. 1970, p. 12.

couraged widespread discounting and increased pressures to reduce the price of zinc. A change of 0.5 cent in the price of zinc can affect pretax profits by approximately $1 million per year.[29]

Slag-Fuming Plants.—For many years five slag-fuming plants have treated hot and cold lead blast-furnace slags containing from 7 to 15 percent zinc to produce a zinc oxide fume. The zinc oxide is subsequently delivered to zinc smelters or electrolytic refineries for recovery of the contained zinc and to other consumers of zinc oxide. The following five plants were operating in 1970:

Company	Plant Location
American Smelting and Refining Co. (ASARCO)	Selby, Calif.
American Smelting and Refining Co. (ASARCO)	El Pasco, 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 698,700 tons of new hot slags, 75,000 tons of cold old slags, and 10,700 tons of residues. The yield of zinc oxide fume was 126,400 tons containing 87,560 tons of recoverable zinc, compared with 144,900 tons of fume and 94,700 tons of zinc in 1969.

Secondary Zinc Smelters.—Zinc recovered from processing secondary materials amounted to 339,500 tons, compared with 376,400 tons in 1969. New scrap consisting of the recycling of semimanufactured alloys, primarily zinc-base and copper-base alloys, accounted for 79 percent of the total new and old scrap processed. The largest decreases from 1969 were for new and old copper-base scrap, which made up almost all the total decline. 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, 9 percent; and chemical products, 12 percent.

Byproduct Sulfuric Acid.—In 1970 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 refineries for the recovery of zinc or for sale to other consumers of zinc oxide; three of these had sulfuric acid plants. Six plants; one electrolytic refinery, three horizontal retort smelters, one vertical retort smelter, and one roasting plant, did not have sulfuric acid producing facilities. In 1970 production of byproduct sulfuric acid from the zinc plants and three lead smelters was 1,086,207 tons, compared with 1,086,938 tons in 1969.

Zinc Dust.—Production of zinc dust was 51,136 tons in 1970, or 7 percent lower than that of 1969. Of this total, approximately 29,200 tons was produced from metal distilled from scrap.

CONSUMPTION AND USES

Zinc consumed in the United States as refined metal in slab or other forms totaled 1,186,951 tons (1,385,380 tons in 1969); the zinc content of ore and concentrate consumed to make pigments and salts and used directly in galvanizing was 124,781 tons (126,712 tons); and the zinc content of scrap to make alloys, zinc dust, and salts totaled 264,074 tons (302,075 tons); the overall total was 1,575,806 tons, a drop of 12 percent compared with 1969.

Slab zinc consumption of 1,186,951 tons, as reported by approximately 700 plants, was 13.3 percent less than that recorded for 1969 and the lowest annual total since 1963. Galvanizing accounted for 40 percent of the total slab zinc consumed; brass products, 11 percent; diecasting alloys, 38 percent; dies, rod alloy, and slush- and sand-casting alloys, 1 percent; rolled zinc, 3 percent; zinc oxide, 4 percent; and other uses 3 percent. For the first time since 1961 galvanizing used more zinc than diecasting alloys, which reflected the 1970 slump in the automotive industry. Decreases in most all categories followed the general downturn in the economy. In comparison with 1969, the use of slab zinc declined 4 percent for galvanizing, 29 percent for brass products, 20 percent for zinc-base alloys, 16 percent for rolled zinc, and 21 percent for other products. The amount of zinc oxide made from slab zinc increased 6 percent because of the continuing rise for photoconductive use.

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[29] Gulf & Western Industries, Inc. Annual Report. 1970, p. 20.

The distribution by grade of slab zinc consumed in 1970 is as follows: Special high grade, 47 percent; high grade, 9 percent; intermediate, 1 percent; brass special, 10 percent; prime western, 33 percent; and remelt, less than one-fourth of 1 percent. Relative to 1969, consumption of special-high-grade zinc dropped 19 percent, but for prime western zinc the decline was only 1 percent, which confirmed the lower quantity for diecastings in the automotive industry.

The slab zinc consumed by rolling mills in 1970 at 41,000 tons was 16 percent lower than that of 1969; the production of rolled zinc products fell from 46,540 tons to 39,234 tons, also a 16-percent drop. The amount of photoengraving plate produced was less than 400 tons under that of 1969, at 10,364 tons; however, the strip and foil rolled was down over 8,000 tons, or 26 percent below that of 1969. In 1970, there was a 16.5 percent increase in the unit value of rolled zinc produced, which almost balanced the loss in quantity of products. Imports of rolled products—plate, sheet, and strip—dropped 18 percent to 692 tons, and exports fell 48 percent to 1,412 tons. The unit values of imports and exports also increased 40 percent and 29 percent, respectively. The total tonnage rolled in 1970, including 18,300 rerolled from scrap, was 57,310 tons, compared with 70,900 tons in 1969.

Consumption of slab zinc by States was headed by Illinois, again with 14 percent of the total, followed by Ohio, Pennsylvania, Michigan, Indiana, and New York. The industries using zinc in these six States accounted for 68 percent of the total slab zinc consumed. The largest uses were for diecastings in Michigan, Illinois, New York, and Ohio and galvanizing in Ohio, Pennsylvania, Indiana, and Illinois. Connecticut, Illinois, and Michigan showed the largest quantities used for brass mill products.

ZINC PIGMENTS AND SALTS

Production.—Production of zinc pigments and compounds at 329,000 tons in 1970 was 4 percent below that of 1969. Total shipments were 6 percent lower than production, which indicated an increase in producers stocks. Production of lead-free zinc oxide was up 3,400 tons over 1969 production, a 1.5 percent increase to 223,770 tons; leaded zinc oxide increased 5 percent to 5,200 tons. The zinc chloride produced was approximately 46,800 tons, or 2 percent less than in 1969; zinc sulfate dropped to 53,170 tons, 15,300 tons below production of the previous year.

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: 60 percent was produced from ores by the American process, 24 percent from metal by the French process, and 16 percent was derived from secondary materials and residues. The zinc contained in zinc oxide produced from ore was 107,273 tons and in zinc sulfate, 8,278 tons; 77 percent of the zinc oxide was from domestic ores and 23 percent was from imported ores; 43 percent of the zinc sulfate was from domestic ores and 57 percent was from imported ores. The amount of zinc in pigments produced from the zinc in domestic ores represented 16 percent of the domestic mine production, the same percentage as in 1969. Leaded zinc oxide was produced solely from ores, zinc chloride from slab zinc and scrap, and zinc sulfate from ores and scrap.

Four grades of leaded zinc oxide, classified according to lead content, were produced. Only a very small quantity of 5 percent or less leaded zinc oxide and a minor quantity containing 35 to 50 percent and over were produced; the more than 5 to 35 percent grade made up most of the production. Some lithopone, a coprecipitate of zinc sulfide and barium sulfate, was produced, but quantities are withheld to avoid disclosing individual company confidential data.

Consumption and Uses.—The shipment of zinc oxide for various uses in 1970 was 3 percent lower than that of 1969. Rubber accounted for 52 percent of the total requirement and used approximately 4,500 tons less than in the previous year. The quantities for paints, chemicals, and agriculture were substantially below those of 1969, but for photocopying and other uses major increases were recorded. The 16-percent rise for photosensitive copying paper, to 31,850 tons, reflects almost a threefold expansion of this use in the last 5 years.

Consumption of leaded zinc oxide was almost equal to that of 1969, but the use for paint, which accounted for 75 percent of the total, increased 6 percent, and the

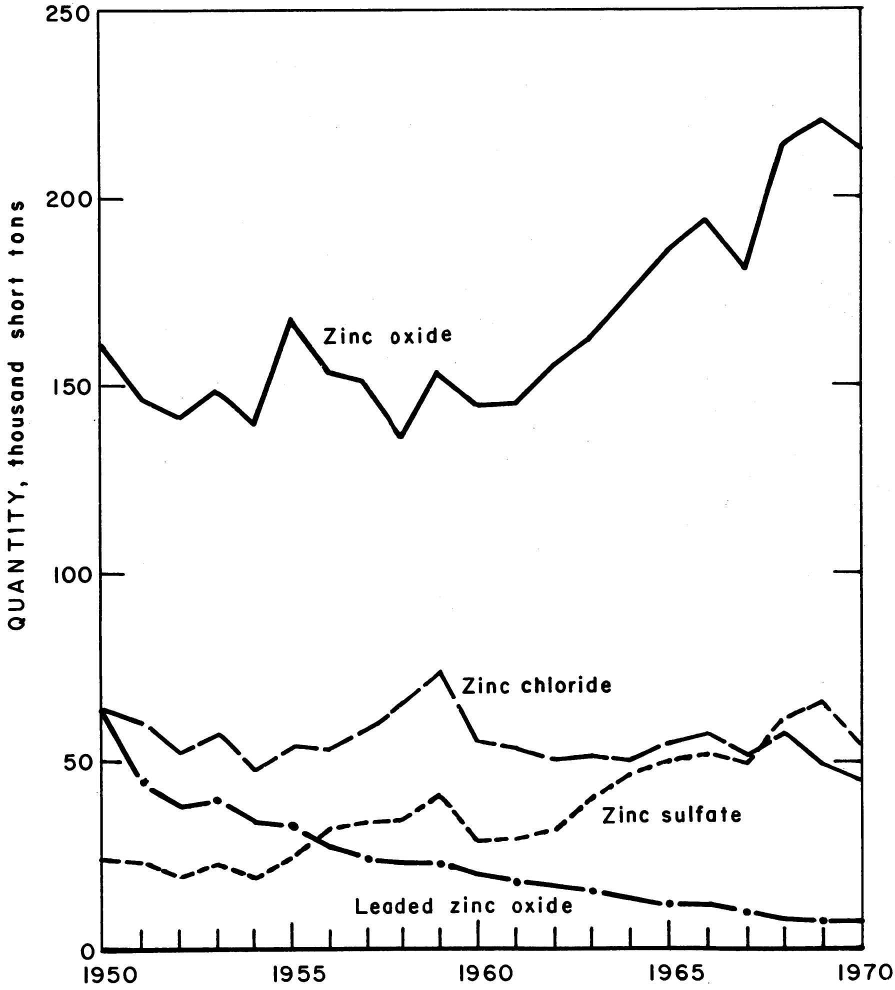

Figure 2.—Trends in shipments of zinc pigments.

balance for other uses dropped 15 percent. The total zinc sulfate shipment was 16 percent lower than that of 1969 because the requirement for agriculture declined 10 percent and for other uses 19 percent.

Prices.—The prices of American-process, lead-free zinc oxide and all other grades were established October 1, 1970, when a 0.5-cent increase raised the quotation for American-process zinc oxide to 17 cents per pound; and for French process lead-free, high-purity, and electrophotographic to 17.5 cents, 18.0 cents, and 19.75 cents per pound, respectively. The prices of leaded zinc oxide were 14 cents per pound for 12 percent grade, 15 cents for 18 percent, and 16.75 cents for 35 percent grade.

Zinc sulfate, granular monohydrate, industrial-grade 36 percent in 100-pound bags was quoted at 10 cents per pound throughout the year. The price of zinc chloride, 50 percent, in tank cars, was increased in the first week of July from 6.20 to 6.40 cents per pound for 100-pound lots, where it remained through December.

Foreign Trade.—Exports of zinc oxide to 41 countries in 1970 amounted to 6,326 tons, a 67-percent increase over 1969. West Germany was the largest customer with 1,308 tons, followed by Canada with 1,298 tons, Australia with 789 tons, and Belgium with 449 tons. Lithopone exports to 36 countries increased 42 percent, to 1,541 tons. The leading recipient was again South Vietnam with 1,392 tons, followed by Canada and Venezuela with 42 tons and 16 tons, respectively. The total value of exported pigments was $2,866 million, up 75 percent over that of 1969.

Imports of zinc pigments and compounds decreased in 1970 to 20,766 tons, down from 23,518 in 1969. The decline was accounted for principally by the 17-percent drop in receipts of zinc oxide. Zinc oxide accounted for 12,073 tons; 6,200 tons came from Mexico. Canada was the next largest supplier, 4,400 tons; the Netherlands followed with 800 tons; Belgium, 222 tons; Spain, 165 tons; and smaller amounts were supplied by the United Kingdom, West Germany, France, and Poland. Seventy-seven tons of lithopone, down 71 percent from 1969, came from West Germany and the Netherlands. Zinc chloride imports were down 16 percent at 1,151 tons and followed the 1969 pattern; the greater portion came from West Germany, 781 tons; Belgium, 295 tons; and 75 tons from Canada, the Netherlands, and the United Kingdom. Zinc sulfate imports increased slightly to 6,298 tons; Mexico supplied 3,365 tons and Australia supplied 2,813 tons. The total value of imported zinc pigments and compounds was $4,106 million, compared with $4,476 million in 1969.

STOCKS

Producer Stocks.—The buildup of stocks of slab zinc at primary smelters and refineries that began in the last quarter of 1969 continued to increase progressively in the early months of 1970, reaching a high at the end of May. The cutbacks of production at smelters and refineries begun in February effected reductions in stocks in June and through September to the lowest for the year. Further slackening in demand, owing principally to the automobile strike, caused a decrease in shipments, and stocks rose in October, November, and December to 97,576 tons. Inventories at secondary smelters fell from 885 tons on January 1 to 555 tons at the end of March. Accumulations in the next 3 months increased stocks to the year's high of 1,157 tons at the end of June. Reduced production and larger shipments in the third quarter lowered inventories to 413 tons at the end of September. Production, shipments, and inventories increased in the last quarter as yearend stocks rose to 738 tons.

Consumers Stocks.—The total of slab zinc inventories at consumer plants declined 12 percent in 1970, to 89,551 tons. Declines in all grades except intermediate contributed to the 12,500-ton drop.

PRICES

The East St. Louis quoted price of prime-western-grade slab zinc established September 15, 1969, at 15.5 cents per pound continued unchanged in 1970 until August 20, when one company reduced its price 0.5 cent to 15 cents per pound. All other producers lowered their prices by August 24 when the East St. Louis basis became quotable at the new rate. This price continued through the end of the year. The foreign producers' price was lowered from £130 per metric ton (U.S. equivalent 14.15 cents per pound) to £127.95 per metric ton (13.93 cents per pound) on January 1, 1970, where it remained throughout the year. This 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. The London Metal Exchange (LME) average monthly quotation varied throughout the year within a 0.5-cent range from a high of 13.60 cents per pound in September and the low of 13.11 cents per pound for December.

FOREIGN TRADE

Exports of slab zinc in 1970 dropped drastically from 9,300 tons to just under 300 tons. Exports of rolled zinc products, sheets, plates strips, etc., was almost halved to 1,400 tons, down from 2,700 tons in 1969. Canada received 1,006 tons, and the balance went to 13 other countries and some unidentified destinations.

General imports of zinc in ore and of zinc metal decreased 13 percent and 17 percent, respectively, in 1970; ore accounted for 525,759 tons and metal, 270,413 tons. Canada, Mexico, and Peru continued to be the ranking sources of ore supply. Canada, Japan, Peru and Australia were the major suppliers of metal. Canada accounted for 60 percent of the imported zinc in ore and 45 percent of the total imported metal. Mexico followed with 25 percent in ore and 3 percent in metal; Peru supplied 9 percent of the zinc in ore and 12 percent of the metal; Japan furnished 12 percent of the metal and Australia contributed 11 percent. Imports for consumption followed the same pattern, but the totals of ores and metal were 75,000 and 10,000 tons less, which indicated that some zinc imported prior to 1970 was released from a warehouse.

There were no changes in the tariff rates in 1970. 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 includes diecasting alloys, is 19 percent ad valorem.

WORLD REVIEW

Algeria.—Work was started on an electrolytic zinc refinery at Ghozaouet. Planned refined zinc capacity is reportedly about 45,000 tons per year. A sulfuric acid plant was also planned.

Argentina.—Compania Minera Aguilar, S.A., an affiliate of St. Joe Minerals, completed expansion of its mine and mill facilities in 1970, and zinc concentrate production was increased to 84,276 tons from 46,662 tons in 1969. Compania Metalurgica Austral (43-percent owned by Aguilar) produced a record 15,675 tons of zinc metal at the Comodoro Rivadavia electrothermic smelter. Capacity production of about 15,000 tons of zinc was also attained at the Rosario electrolytic plant of Compania Sulfacid, S.A. (50-percent owned by Aguilar), and planned expansion is expected to double its capacity by the end of 1971.[30]

Australia.—In 1970 production of zinc in concentrates was approximately 560,000 tons, slightly higher than in 1969. The

[30] St. Joe Minerals Corp. Annual Report. 1970, p. 12.

Broken Hill companies (North Broken Hill Ltd., Broken Hill South Ltd., and New Broken Hill Consolidated Ltd.) produced 9 percent less in 1970 than in the previous year. However, output by Mount Isa Mines, Ltd., was up 16 percent and the marginally higher output by the Electrolytic Zinc Co. of Australasia, Ltd., accounted for the small rise in Australian zinc concentrate production.

At the Mount Isa mine zinc-lead-silver reserves were increased by 7 million tons. Because no change was indicated for the reserves at the Hilton mine, drilling at closer intervals was started to develop information for a reassessment of the ore reserves. New intersections with the ore body reveal a high zinc content in relation to lead and silver values. Zinc reserves at the Mount Isa mine in June 1970 were 52 million tons of 5.9 percent zinc and at the Hilton mine 35 million tons of 9.6 percent zinc.[31]

Broken Hill South is one of the four producers of zinc-lead-silver ore at Broken Hill. In 1970, 206,660 tons was extracted from the No. 7 shaft and Browne shaft sections of the mine and mill, yielding 31,184 tons of zinc concentrate averaging 51.9 percent zinc that was sold to Electrolytic Zinc of Australasia. Cobar Mines Pty. Ltd. (76-2/3 percent owned by the Broken Hill South) produced 16,949 tons of zinc concentrates assaying 50.3 percent zinc from ore taken from the C.S.A. mine. The concentrates were exported to Japan.[32]

New Broken Hill Consolidated is the largest producer of zinc, lead, and silver at Broken Hill. In 1970 the amount of ore milled was down 12,000 tons, to 1,093,000 tons, and the zinc content of concentrate produced was 16,300 tons lower at 147,900 tons than that of 1969. Ore reserves were essentially unchanged from 1969 with 6 million tons assaying 14.0 percent zinc, 9.5 percent lead and 2.5 ounces of silver per ton.[33]

North Broken Hill mined 516,700 tons of ore in 1970, milled 518,400 tons and produced 48,524 tons of zinc concentrate, which was 1,500 tons less than in 1969. Exploration and development over the past 12 years have replenished the ore reserve just slightly more than the rate of mining.[34]

The Zinc Corp. Ltd., a wholly owned subsidiary of Conzinc Riotinto of Australia, is the fourth producer at Broken Hill. This company treated 897,000 tons of ore producing 78,000 tons of zinc in zinc concentrate, an increase of about 4 percent over that of 1969.

Electrolytic Zinc Co. of Australasia is the operating company for E. Z. Industries Ltd., which controls the Rosebery, Farrell, and Hercules mines in western Tasmania and the smelter and refinery near Hobart. In 1970, 314,400 tons of ore was mined, averaging 17.3 percent zinc. From the milling of 311,500 tons of ore, 85,700 tons of zinc concentrate was produced averaging 55 percent zinc. Zinc production capacity of the electrolytic plant at Risdon was increased 12 percent during the year by installing an additional rectifier and cooling tower on one cell unit and uprating the rectifier on three other cell units; the leaching and purification sections were enlarged accordingly. Output of the principal products at the refinery was as follows: Zinc 168,232 tons; cadmium, 390 tons; sulfuric acid, 238,270 tons; superphosphate, 134,494 tons; and ammonium sulfate, 39,922 tons.

Bolivia.—In 1970, Mina Matilde, a recently developed high-grade underground zinc mine was operated under a 20-year contract by a U.S. consortium. The Bolivian Government revoked the concession to this property in April 1971.

Brazil.—Companhia Mercantile Industrial Inga successfully modified the process of their electrolytic zinc plant on the Ilha da Maderia near Sepetiba Bay. In 1970, after several years of experimenting using silicate ore from Vazante, Minas Gerais, the plant produced 99.99 percent zinc at the rate of 22 tons per day for the first time. Zinc powder and zinc oxide were also produced. The ore at the mine reportedly averages 7 percent zinc and is upgraded to a 30-percent concentrate. The company planned to expand capacity to 30 tons per day by the end of 1971 and to 100 tons per day by the end of 1972. Zinc concentrates will be imported from Peru to insure sufficient supply for the plant. Cadmium is being recovered as a byproduct.

A second electrolytic zinc plant recently constructed and operating on Vazante sili-

[31] Mount Isa Mines Ltd. Annual Report. 1970, pp. 10–11.
[32] Broken Hill South Ltd. Annual Report. 1970, pp. 6, 11.
[33] New Broken Hill Consolidated Ltd. Annual Report. 1970, pp. 15–16.
[34] North Broken Hill Ltd. Annual Report. 1970, p. 17.

cate ore is located at Tres Marias, Minas Gerais. The plant reportedly was designed for a capacity of 12,000 tons per year but encountered problems and produced far less in 1970.

Total output of both plants was about 12,000 tons in 1970 and is expected to reach 20,000 tons in 1971. Imports of 46,000 tons of zinc was required to meet Brazilian demand in 1970, which was slightly less than in 1969.

Canada.—Mine production in 1970 increased 4 percent to 1,366,000 tons. The following eight new mines started production in 1970; four in western Canada, Columbia Metals, Copperhill, Silmonac, and Venus; two in Manitoba, Fox and Dickstone; and two in Quebec, D'Estrie and Weedon. Expansion at three established mines, Anvil, Heath Steele, and Reeves MacDonald, and production from the new mines more than offset the closing of the Zenmac and Canadian Exploration and the lower production at a few older mines. Some production was lost at Bathurst and Manitouwadge because of strikes.

Refined zinc production totaled 460,000 tons, 6,000 tons below that of 1969 and 85,500 tons below rated smelter and refinery capacities. Construction of the electrolytic zinc plant at Timmins, Ontario, began in 1970; completion was scheduled for early 1972. The plant will have an annual capacity of 120,000 tons of refined zinc and will operate on concentrates produced from the Kidd Creek zinc-copper-lead-silver mine at Timmins.[35]

Anvil Mining Corporation Ltd. began production at its 6,600 ton per day mill in September 1969 and in 1970 produced 165,000 tons of 50-percent zinc concentrate, 105,000 tons of 64-percent lead concentrate, and about 5,000 tons of a bulk lead-zinc concentrate containing approximately 50 percent combined lead and zinc. The lead and zinc concentrates are sent to Japanese smelters under an 8-year contract. Ore reserves are estimated at 63 million tons containing 9 percent combined lead and zinc and 1.2 ounces of silver per ton.[36]

Brunswick Mining and Smelting Corp. Ltd. owns zinc-lead-copper-silver deposits in Gloucester County, near Bathurst. In 1970 a total of 1,481 tons of ore from the No. 12 underground mine and 1,100,700 tons from the No. 6 open pit mine were milled in two concentrators near the No. 12 mine. Separate zinc, lead, and copper concentrates and a bulk lead-zinc concentrate were produced. The bulk concentrate and some of the lead concentrate were treated in the Imperial Smelting Furnace at Belledune; lead concentrate was also shipped to custom smelters in Canada and Europe. The zinc concentrates were shipped to custom smelters in Belgium and the copper concentrates were smelted at Murdochville, Quebec. Zinc-lead ore reserves at the No. 12 mine totaled 69.6 million tons averaging 8.7 percent zinc, 3.5 percent lead, 0.28 percent copper, and 2.5 ounces of silver per ton; at the No. 6 mine reserves were 13.1 million tons of 5.9 percent zinc, 2.2 percent lead, 0.3 percent copper, and 1.8 ounces of silver per ton. The East Coast Smelting and Chemical Co. Ltd., a wholly owned subsidiary, operated the Imperial Smelting Plant at Belledune, 30 miles north of the Brunswick mines. Annual rated capacity is 42,000 tons of zinc and 33,000 tons of lead; the 1970 production was 36,614 tons of zinc and 20,072 tons of lead.[37]

In 1970, Cominco Ltd. produced 221,600 tons of slab zinc, 219,396 tons of lead, 630 tons of metallic cadmium, and 6 million ounces of silver. Annual rated capacities of the electrolytic zinc plant and the lead smelter at Trail, British Columbia, are 263,000 tons of zinc and 190,000 tons of lead. Ore reserves at Cominco's British Columbia mines (Sullivan, Bluebell, and A. B.) declined slightly at the end of 1970 to 66 million tons containing 7.2 million tons of lead and zinc. Reserves at the Pine Point mine in the Northwest Territories increased 4 percent, to 43.5 million tons containing 3.6 million tons of lead and zinc. Exploration and development work continued at the Caribou zinc-lead-copper-silver deposit in New Brunswick in which Cominco has a 25-percent interest.[38]

During 1970, the Hudson Bay Mining and Smelting Co. Ltd. increased reserves 1 million tons at its Flin Flon and Snow Lake mines to 19 million tons, assaying 3.3 percent zinc. A new copper-zinc mine, the Dickstone, began production in 1970. The

[35] Mining Journal (London). Mining. Annual Review. 1971, p. 251.
[36] Cyprus Mines Corp. Annual Report. 1970, p. 16.
[37] Mining Journal (London). Mining. Annual Review. 1971, p. 257.
[38] Mining Journal (London). Mining. Annual Review. 1971, p. 259.

concentrator treated 1.71 million tons of ore, averaging 3.9 percent zinc, and produced 102,000 tons of 47.4 percent zinc concentrates. The 1970 output of the electrolytic zinc refinery was 78,622 tons, 1,100 tons less than that of 1969. Oxide fume recovered at the copper smelter, which amounted to 8,650 tons and assayed 29.6 percent zinc, and 32,500 tons of zinc oxide produced at the slag fuming plant, which contained 23,431 tons of zinc were processed to slab zinc. Pilot plant testing of the Sherritt Gordon-patented pressure leach process on Hudson Bay Mining Co. concentrates is planned if laboratory results confirm expectations. Should this process prove favorable, conventional roasting of zinc concentrates and generation of sulfur dioxide fumes will be eliminated.[39]

Noranda Mines Ltd's. Geco mine resumed production on February 2, 1970, after a 73-day strike. During the balance of 1970, the mill treated 1,366,000 tons of ore averaging 3.89 percent zinc and produced zinc concentrates containing 41,880 tons of zinc. The ore and concentrates were delivered to Canadian Electrolytic Zinc at Valleyfield, Quebec. Ore reserves increased 400,000 tons, to 29.2 million tons averaging 4.63 percent zinc. Mill capacity was expanded to 5,000 tons per day. Noranda has substantial interests in other mining companies including Brunswick Mining and Smelting, Mattagami Lake Mines Ltd., and Orchan Mines Ltd. The Mattagami mill treated 1.4 million tons of ore averaging 9.1 percent zinc. At the end of 1970 ore reserves were 16,696,000 tons containing 9.2 percent zinc. An ore body found by Mattagami near Sturgeon Lake in Northwestern Ontario was taken over by Mattabi Mines, Ltd. (60-percent owned by Mattagami). Indicated ore reserves are 12,866,000 tons averaging 7.6 percent zinc. Over 8 million tons grading 8.9 percent zinc will be mined by open pit methods. Orchan Mines milled 414,500 tons of Orchan ore averaging 11.1 percent zinc, 125,000 tons were mined from its subsidiaries, New Hosco Mines and Bell Allard Mines, which were closed in May and November, respectively, when ore reserves were exhausted. Ore reserves at the Orchan Mine at the end of 1970 were 2.5 million tons averaging 9.7 percent zinc. Canadian Electrolytic Zinc Ltd., (62.5 percent owned by Mattagami Lake, 18.7 percent by Orchan Mines, 9.7 percent by Kerr Addison, and 9.1 percent by Noranda) produced 124,130 tons of slab zinc in 1970.[40]

Texas Gulf Sulphur Co. owns the Kidd Creek zinc-copper-silver-lead open pit mine 15 miles north of Timmins, Ontario. The Mill at Hoyle, Ontario, 17.5 miles away, has three 3,000-ton-per-day circuits. The Kidd Creek property is operated by Ecstall Mining Ltd., a wholly owned subsidiary of Texas Gulf. In 1970 the concentrator treated 3,586,000 tons of ore and produced 582,800 tons of 52-percent-zinc concentrates. These concentrates are shipped to custom smelters and refineries in the United States, Europe, and Japan. The electrolytic zinc refinery currently under construction is designed to process about half the zinc concentrate output and to produce 120,000 tons of slab zinc. The plant also includes a sulfuric acid unit with a capacity of 230,000 tons per year.[41]

Wilroy Mines Ltd. mined 476,970 tons of ore averaging 3.97 percent zinc and 1.8 ounces of silver per ton from its three Manitouwadge operations. In 1970, 388,000 tons of ore was milled yielding 15,824 tons of zinc. Ore reserves as of December 31, 1970, were 1,051,963 tons, which averaged 3.6 percent zinc, 1.25 percent copper, and 1.62 ounces of silver per ton.

Finland.—Outokumpu Oy began zinc concentrate production at its Vihanti mine in 1954 and at the Pyhasalmi in 1962. Until 1969, when their electrolytic zinc plant at Kokkola started production, the concentrates were exported. Finland's zinc metal production in 1970 was 69,000 tons.[42]

Honduras.—The New York and Honduras Rosario Mining Co. had another year of expansion at the El Mochito mine, a silver-gold-lead-zinc property. Ore reserves were increased 16 percent, to 2,125,000 tons of ore, which averaged 9.73 percent zinc, 9.23 percent lead, 12.3 ounces of silver per ton, and 0.008 ounce of gold per ton. The mill processed 270,025 short dry tons of ore, which was 11 percent more than that of 1969. The zinc content of zinc concentrates produced was 17,272 tons.[43]

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[39] Hudson Bay Mining and Smelting Co. Ltd. Annual Report. 1970, pp. 15–17.

[40] Noranda Mines Ltd. Annual Report. 1970, p. 9.

[41] Texas Gulf Sulphur Co. Annual Report. 1970, p. 4.

[42] Mining Magazine. V. 123, No. 4, October, 1970, p. 365. Outokumpu Oy. Annual Report. 1970, p. 6.

[43] New York and Honduras Rosario Mining Co. Annual Report. 1970, pp. 5–7.

Japan.—Slab zinc capacity is being raised from 760,000 tons to 806,000 tons. Production in 1970 was 745,000 tons, compared with 785,000 tons in 1969. Industry growth is reportedly restricted by public complaints against pollution principally associated with byproduct cadmium production. Japan is the free world's second largest consumer of zinc. The annual level of demand is expected to reach 1 million tons in 1974.

Mexico.—In 1970, zinc production increased 4.8 percent, to 291,000 tons. Exports of zinc concentrates increased 13,000 tons, to 326,400 tons in 1970; imports of refined zinc decreased 3,000 tons, to 38,100 tons. The planning of two electrolytic zinc refineries was interrupted due to the weakening in the zinc price. Industrias Peñoles S.A. started constructing its Torreón plant late in 1970 but advanced the completion date to mid-1973. The estimated cost of the plant was $52 million. ASARCO was expected to begin constructing a similar plant in late 1971. No location has been announced.

Peru.—Cerro de Pasco Corp. produced 75,830 tons of refined zinc in 1970, 12 percent more than in 1969, but concentrate production for export and refining at 67,825 tons (zinc content) declined 17 percent. The San Vincente zinc deposit owned by Cía. Minera San Vincente and operated by Cía. Minera San Ignacio de Morococha S.A., began production in 1970 with an output of more than 70,000 tons of ore containing 20 percent zinc. Concentrates are trucked to Callao for export to Japan. The Homestake Mining Co. arranged the financing of $6.5 million for Companía Minera del Madrigal with the Japanese company Marubeni Iida for the Madrigal project. Total investment is about $11 million to open up the Santa Rosa vein, which has 1.03 million tons of proven and probable ore averaging 6.1 percent zinc and 4.2 ounce per ton of silver. Homestake has a 57-percent interest in Companía Minera del Madrigal through a subsidiary Companía Madrigal.

Tunisia.—In 1970 production of zinc in ore was 7 percent less than in 1969. Italy continued to be the best customer for zinc ore followed by Switzerland, Poland, and Romania. No significant new investment was made in 1970 for zinc production.

TECHNOLOGY

Zinc Abstracts, a monthly publication, prepared jointly by the Zinc Development Association (London) and Zinc Institute, Inc. (New York), review 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—Diecast 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 [44] and the Geological Survey.[45]

[44] Powell, H. E., L. L. Smith, and A. A. Cochran. Solvent Extraction of Nickel and Zinc From Waste Phosphate Solution. BuMines Rept. of Inv. 7336, 1970, 14 pp.
Neumeier, L. A., and J. S. Risbeck. Influence of Rolling Temperature and Copper Content on Creep and Other Properties of Zinc-Copper and Zinc-Titanium-Copper Alloys. BuMines Rept. of Inv. 7363, 1970, 45 pp.
Schwaneke, Alfred E., Wilbert L. Falke, and Orrin K. Crosser. A New High-Temperature Soft Solder System. BuMines Tech. Prog. Rept. 29, 1970, 18 pp.

[45] Cox, D. P. Lead-Zinc-Silver Deposits Related to the White Mountain Plutonic Series in New Hampshire and Maine. U.S. Geol. Survey Bull. 1312–D, 1970, pp. D1–D18.
McKnight, E. T., and R. P. Fisher. Geology and Ore Deposits of the Picher Field, Oklahoma and Kansas. U.S. Geol. Survey Prof. Paper 588, 1970, 165 pp.
McKnight, E. T., W. L. Newman, and A. V. Heyl, Jr. Zinc in the United States, Exclusive of Alaska and Hawaii. U.S. Geol. Survey Min. Res. Map Mr–19, 1962 (Reprinted 1970).

Table 2.—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1966	1967	1968	1969	1970
Arizona	15,985	14,330	5,441	9,039	9,618
California	335	441	3,525	3,327	3,514
Colorado	54,822	52,442	50,258	53,715	56,694
Idaho	60,997	56,528	57,248	55,900	41,052
Illinois	15,192	20,416	18,182	13,765	16,797
Kansas	4,769	4,765	3,012	1,900	1,186
Kentucky	6,586	6,317	4,603	4,988	4,189
Maine	-------	-------	5,099	7,639	9,114
Missouri	3,968	7,430	12,301	41,099	50,721
Montana	29,120	3,341	3,778	6,143	1,457
Nevada	5,827	3,035	2,104	941	127
New Jersey	25,237	26,041	25,668	25,076	28,683
New Mexico	29,296	21,380	18,686	24,308	16,601
New York	73,454	70,555	66,194	58,728	58,577
Oklahoma	11,237	10,670	6,921	2,744	2,650
Pennsylvania	28,080	35,067	30,382	33,035	29,554
South Dakota	-------	-------	-------	-------	1
Tennessee	103,117	113,065	124,039	124,532	118,260
Utah	37,323	34,251	33,153	34,902	34,688
Virginia	17,666	18,846	19,257	18,704	18,063
Washington	24,772	21,540	13,884	9,738	11,956
Wisconsin	24,775	28,953	25,711	22,901	20,634
Total	572,558	549,413	529,446	553,124	534,136

Table 3.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1969	1970	Month	1969	1970
January	42,205	44,137	August	47,289	45,266
February	43,040	44,754	September	47,403	42,478
March	45,076	47,677	October	47,303	42,192
April	48,112	47,144	November	46,325	42,360
May	48,067	44,534	December	45,467	42,397
June	47,151	45,305			
July	45,686	45,892	Total	553,124	534,136

Table 4.—Production of zinc and lead in the United States in 1970, by States and class of ore, from old tailings, etc., in terms of recoverable metals

(Short tons)

State	Zinc ore: Gross weight (dry basis)	Zinc ore: Zinc content	Zinc ore: Lead content	Lead ore: Gross weight (dry basis)	Lead ore: Zinc content	Lead ore: Lead content	Zinc-lead ore: Gross weight (dry basis)	Zinc-lead ore: Zinc content	Zinc-lead ore: Lead content
Arizona	450	63	1	360	2	31	2,010	100	36
California	---	---	---	---	---	---	(1)	(1)	(1)
Colorado	295,321	31,456	2,390	1,429	2	37	357,247	13,315	10,337
Idaho	(2)	(2)	(2)	36,085	509	3,225	[2] 927,449	[2] 39,608	[2] 56,113
Kansas	61,654	1,173	71	---	---	---	634	13	9
Missouri	---	---	---	[3] 8,815,880	50,721	[4] 421,764	---	---	---
Montana	4,994	1,361	147	11,390	39	636	26	2	3
Nevada	---	---	---	3,697	78	266	556	24	27
New Jersey	168,723	28,683	---	---	---	---	---	---	---
New Mexico	(2)	(2)	(2)	---	---	---	[2] 162,190	[2] 16,054	[2] 3,546
New York	175,965	15,810	---	---	---	---	566,306	42,767	1,280
Oklahoma	64,367	1,865	427	---	---	---	---	---	---
Oregon	---	---	---	---	---	---	---	---	---
Pennsylvania	622,499	29,554	---	---	---	---	---	---	---
South Dakota	---	---	---	---	---	---	---	---	---
Tennessee	4,156,482	107,922	---	---	---	---	---	---	---
Utah	---	---	---	(5)	(5)	(5)	[5] 456,676	[5] 31,529	[5] 40,105
Virginia	670,395	18,063	3,356	---	---	---	---	---	---
Washington	(6)	(6)	(6)	---	---	---	[6] 661,872	[6] 11,956	[6] 6,784
Wisconsin	749,488	20,634	761	---	---	---	---	---	---
Other States	325,094	11,205	536	---	---	---	---	---	---
Total	7,295,432	267,789	7,689	8,868,841	51,351	425,959	3,134,966	155,368	118,240
Percent of total zinc-lead	---	50	1	---	10	75	---	29	21

State	Copper-zinc, copper-lead, and copper-zinc-lead ores: Gross weight (dry basis)	Copper-zinc, copper-lead, and copper-zinc-lead ores: Zinc content	Copper-zinc, copper-lead, and copper-zinc-lead ores: Lead content	All other sources [7]: Gross weight (dry basis)	All other sources [7]: Zinc content	All other sources [7]: Lead content	Total: Gross weight (dry basis)	Total: Zinc content	Total: Lead content
Arizona	130,953	9,402	210	40,314,819	51	7	40,448,592	9,618	285
California	---	---	---	[1] 104,215	[1] 3,514	[1] 1,772	104,215	3,514	1,772
Colorado	361,002	10,553	7,180	118,078	1,368	1,911	1,133,077	56,694	21,855
Idaho	---	---	---	574,392	935	1,873	1,537,926	41,052	61,211
Kansas	---	---	---	---	---	---	62,288	1,186	80
Missouri	---	---	---	---	---	---	8,815,880	50,721	421,764
Montana	---	---	---	31,037	55	210	47,447	1,457	996
Nevada	673	13	28	103,384	12	43	108,310	127	364
New Jersey	---	---	---	---	---	---	168,723	28,683	---
New Mexico	---	---	---	1,127,137	547	4	1,289,327	16,601	3,550
New York	---	---	---	---	---	---	742,271	58,577	1,280
Oklahoma	---	---	---	8,297	785	370	72,664	2,650	797
Oregon	---	---	---	300	---	(8)	300	---	(8)
Pennsylvania	---	---	---	---	---	---	622,499	29,554	---
South Dakota	---	---	---	49	1	3	49	1	3
Tennessee	1,680,070	10,338	---	---	---	---	5,836,552	118,260	---
Utah	115,762	3,101	5,117	11,322	58	155	583,760	34,688	45,377
Virginia	---	---	---	---	---	---	670,395	18,063	3,356
Washington	---	---	---	(6)	(6)	(6)	661,872	11,956	6,784
Wisconsin	---	---	---	---	---	---	749,488	20,634	761
Other States	214,148	9,114	---	348,171	9,781	996	887,413	30,100	1,532
Total	2,502,608	42,521	12,535	42,741,201	17,107	7,344	64,543,048	534,136	571,767
Percent of total zinc-lead	---	8	2	---	3	1	---	100	100

[1] Lead-zinc ore and ore from "Other Sources" combined to avoid disclosing individual company confidential data.
[2] Zinc and lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Includes minor amount of lead tailings commingled with ore at mill; excludes barium sulfate ore.
[4] Includes lead recovered from barium sulfate ore.
[5] Lead and lead-zinc ores combined to avoid disclosing individual company confidential data.
[6] Zinc ore and ore from "Other Sources" combined with lead-zinc ore to avoid disclosing individual company confidential data.
[7] Lead and zinc recovered from copper, gold, silver, fluorspar, and uranium ores, and from smelter slags, mill tailings, and miscellaneous cleanups.
[8] Less than ½ unit.

Table 5.—Twenty-five leading zinc-producing mines in the United States in 1970, 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	Friedensville	Lehigh, Pa.	do.	Do.
4	Sterling Hill	Sussex, N.J.	do.	Do.
5	Young	Jefferson, Tenn.	American Zinc Co.	Do.
6	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co.	Lead-zinc ore, lead-zinc tailings.
7	Austinville and Ivanhoe	Wythe, Va.	The New Jersey Zinc Co.	Zinc ore.
8	Immel	Knox, Tenn.	American Zinc Co.	Do.
9	Zinc Mine Works	Jefferson, Tenn.	United States Steel Corp.	Do.
10	New Market	do.	New Market Zinc Co.	Do.
11	Buick	Iron, Mo.	Missouri Lead Operating Co.	Lead ore.
12	Edwards	St. Lawrence, N.Y.	St. Joe Minerals Corp.	Zinc ore.
13	Burgin	Utah, Utah	Kennecott Copper Corp.	Lead, lead-zinc ores.
14	Jefferson City	Jefferson, Tenn.	The New Jersey Zinc Co.	Zinc ore.
15	Star-Morning	Shoshone, Idaho	Hecla Mining Co.	Lead-zinc ore.
16	Ground Hog	Grant, N. Mex.	American Smelting and Refining Co. (ASARCO).	Do.
17	Viburnum	Crawford, Iron, and Washington, Mo.	St. Joe Minerals Corp.	Lead ore.
18	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead, lead-zinc ores.
19	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co.	Copper-lead-zinc ores.
20	Copperhill	Polk, Tenn.	Tennessee Copper Co.	Copper-zinc ore.
21	Penobscot Unit	Hancock, Maine	Callaham Mining Corp.	Do.
22	Shullsburg	Lafayette, Wis.	Eagle-Picher Industries, Inc.	Zinc ore.
23	Fletcher	Reynolds, Mo.	St. Joe Minerals Corp.	Lead ore.
24	Flat Gap	Hancock, Tenn.	The New Jersey Zinc Co.	Zinc ore.
25	Mascot No. 2	Knox, Tenn.	American Zinc Co.	Do.

Table 6.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1966	1967	1968	1969	1970
Primary:					
From domestic ores	523,580	438,553	499,491	458,754	403,953
From foreign ores	501,486	500,277	521,400	581,843	473,858
Total	1,025,066	938,830	1,020,891	1,040,597	877,811
Redistilled secondary	83,263	73,505	79,865	70,553	77,156
Total (excludes zinc recovered by remelting)	1,108,329	1,012,335	1,100,756	1,111,150	954,967

Table 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by methods of reduction

(Short tons)

Method of reduction	1966	1967	1968	1969	1970
Electrolytic primary	433,576	371,267	398,265	453,539	393,280
Distilled	591,490	567,563	622,626	587,058	484,531
Redistilled secondary:					
At primary smelters	71,560	58,341	67,101	60,607	65,776
At secondary smelters	11,703	15,164	12,764	9,946	11,380
Total	1,108,329	1,012,335	1,100,756	1,111,150	954,967

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

Grade	1966	1967	1968	1969	1970
Special high	452,722	436,849	449,659	468,792	401,273
High	139,814	92,956	117,224	136,416	109,025
Intermediate	23,555	26,522	56,686	57,180	52,480
Brass special	103,184	91,079	75,840	89,306	71,811
Prime western	389,054	364,929	401,347	359,456	320,378
Total	1,108,329	1,012,335	1,100,756	1,111,150	954,967

Table 9.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

State	1966	1967	1968	1969	1970
Idaho	90,983	92,134	102,946	105,700	95,637
Illinois	96,809	115,659	119,657	131,243	110,835
Montana	174,821	111,834	142,929	174,034	148,697
Oklahoma	165,162	163,826	172,174	143,575	124,811
Pennsylvania and West Virginia	291,403	271,192	302,884	286,164	222,096
Texas	205,888	184,185	180,301	199,881	175,735
Total	1,025,066	938,830	1,020,891	1,040,597	877,811

Table 10.—Primary slab zinc plants by group capacity in the United States in 1970

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
American Smelting and Refining Co. (ASARCO)	Corpus Christi, Tex.	453,000
American Zinc Co	Sauget, Ill	
The Anaconda Company	Great Falls, Mont	
The Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Co. (ASARCO)	Amarillo, Tex	707,000
American Zinc Co	Dumas, Tex	
Blackwell Zinc Co., American Metal Climax, Inc. (AMAX)	Blackwell, Okla	
National Zinc Co	Bartlesville, Okla	
Vertical-retort plants:		
Matthiessen & Hegeler Zinc Co	Meadowbrook, W. Va	
The New Jersey Zinc Co	Depue, Ill	
Do	Palmerton, Pa	
St. Joe Minerals Corp	Josephtown, Pa	

Table 11.—Secondary slab zinc plants by group capacity in the United States in 1970

Company	Plant location	Slab zinc capacity (short tons)
American Smelting and Refining Co. (ASARCO)	Sand Springs, Okla	35,300
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	
General Smelting Co	Bristol, Pa	
Gulf Reduction Co	Houston, Tex	
H. Kramer Co	El Segundo, Calif	
Pacific Smelting Co	Torrance, Calif	
Sandoval Zinc Co	Sandoval, Ill	
Superior Zinc Corp	Bristol, Pa	
Wheeling-Pittsburgh Steel Corp	Martins Ferry, Ohio	

Table 12.—Stocks and consumption of new and old zinc scrap in the United States in 1970

(Short tons)

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	113	527	597	--------	597	43
Old zinc	471	6,510	--------	6,242	6,242	739
Engravers' plates	245	3,245	--------	3,202	3,202	288
Skimmings and ashes	11,621	71,470	72,274	--------	72,274	10,817
Sal skimmings	114	403	298	--------	298	219
Die-cast skimmings	2,823	5,429	6,090	--------	6,090	2,162
Galvanizers' dross	12,851	73,331	62,581	--------	62,581	23,601
Diecastings	3,374	38,629	--------	39,043	39,043	2,960
Rod and die scrap	1,227	1,902	--------	2,270	2,270	859
Flue dust	3,600	6,057	7,230	--------	7,230	2,427
Chemical residues	4,067	11,500	7,036	--------	7,036	8,531
Total	40,506	219,003	156,106	50,757	206,863	52,646
Chemical plants, foundries, and other manufacturers:						
New clippings	--------	--------	--------	--------	--------	--------
Old zinc	2	30	--------	21	21	11
Engravers' plates	--------	--------	--------	--------	--------	--------
Skimmings and ashes	2,290	9,868	8,786	--------	8,786	3,372
Sal skimmings	5,441	11,155	8,614	--------	8,614	7,982
Die-cast skimmings	--------	--------	--------	--------	--------	--------
Galvanizers' dross	--------	--------	--------	--------	--------	--------
Diecastings	18	369	--------	373	373	14
Rod and die scrap	14	50	--------	57	57	7
Flue dust	489	3,620	3,090	--------	3,090	1,019
Chemical residues	1,305	23,315	20,825	--------	20,825	3,795
Total	9,559	48,407	41,315	451	41,766	16,200
All classes of consumers:						
New clippings	113	527	597	--------	597	43
Old zinc	473	6,540	--------	6,263	6,263	750
Engravers' plates	245	3,245	--------	3,202	3,202	288
Skimmings and ashes	13,911	81,338	81,060	--------	81,060	14,189
Sal skimmings	5,555	11,558	8,912	--------	8,912	8,201
Die-cast skimmings	2,823	5,429	6,090	--------	6,090	2,162
Galvanizers' dross	12,851	73,331	62,581	--------	62,581	23,601
Diecastings	3,392	38,998	--------	39,416	39,416	2,974
Rod and die scrap	1,241	1,952	--------	2,327	2,327	866
Flue dust	4,089	9,677	10,320	--------	10,320	3,446
Chemical residues	5,372	34,815	27,861	--------	27,861	12,326
Total	50,065	267,410	197,421	51,208	248,629	68,846

[1] Figures partly revised.

Table 13.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Product	1966	1967	1968	1969	1970
Redistilled slab zinc	83,263	73,505	79,865	r 70,553	77,156
Zinc dust	34,326	32,801	37,903	33,747	29,605
Remelt spelter	6,970	4,831	3,580	3,978	3,494
Remelt die-cast slab	13,003	14,520	14,570	16,979	16,686
Zinc-die and diecasting alloys	4,333	3,882	4,128	4,401	4,361
Galvanizing stocks	1,585	1,690	2,107	1,849	762
Secondary zinc in chemical products	39,834	38,289	45,654	45,298	40,668

r Revised.

Table 14.—Zinc recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

Kind of scrap	1969	1970	Form of recovery	1969	1970
New scrap:			As metal:		
Zinc-base	134,668	131,859	By distillation:		
Copper-base	156,381	132,159	Slab zinc [1]	68,677	75,453
Aluminum-base	3,494	3,145	Zinc dust	33,241	29,191
Magnesium-base	221	211	By remelting	5,639	4,210
Total	294,764	267,374	Total	107,557	108,854
Old scrap:			In zinc-base alloys	19,980	19,703
Zinc-base	40,284	41,255	In brass and bronze	196,244	163,625
Copper-base	37,975	27,868	In aluminum-base alloys	6,853	6,242
Aluminum-base	3,288	2,959	In magnesium-base alloys	459	435
Magnesium-base	80	71	In chemical products:		
			Zinc oxide (lead-free)	21,049	20,186
Total	81,627	72,153	Zinc-sulfate	11,986	9,171
			Zinc chloride	10,917	10,606
Grand total	376,391	339,527	Miscellaneous	1,346	705
			Total	268,834	230,673
			Grand total	376,391	339,527

[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)	Average per pound
1966	55,485	$20,418	$0.184
1967	50,273	18,098	.180
1968	61,566	22,041	.179
1969	55,055	21,361	.194
1970	51,136	20,045	.196

Table 16.—Consumption of zinc in the United States

(Short tons)

	1966	1967	1968	1969	1970
Slab zinc	r 1,423,666	r 1,250,673	r 1,350,656	r 1,385,380	1,186,951
Ores (recoverable zinc content)	[1] 126,696	[1] 114,301	[1] 124,109	[1] 126,712	124,781
Secondary (recoverable zinc content) [2]	269,650	240,888	270,592	302,075	259,864
Total	r 1,820,012	r 1,605,862	r 1,745,357	r 1,814,167	1,571,596

r Revised.
[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 uses

(Short tons)

Industry and product	1966	1967	1968	1969	1970
Galvanizing:					
Sheet and strip	r 277,781	r 250,000	r 273,276	r 268,682	253,155
Wire and wire rope	39,114	36,745	36,089	32,348	30,857
Tubes and pipe	68,848	61,792	63,621	65,898	64,479
Fittings (for tube and pipe)	10,150	11,768	13,801	11,418	9,498
Tanks and containers	4,285	4,137	3,815	5,561	3,924
Structural shapes	17,838	18,779	20,238	19,454	18,761
Fasteners	4,340	4,234	4,826	5,536	5,318
Pole-line hardware	11,400	9,985	9,050	9,409	9,938
Fencing, wire cloth, and netting	15,821	16,544	15,984	17,984	18,114
Other and unspecified uses	59,859	58,486	58,074	57,091	60,205
Total	r 509,436	r 472,470	r 498,774	r 493,381	474,249
Brass products:					
Sheet, strip, and plate	97,095	67,237	86,185	90,777	61,672
Rod and wire	60,079	40,759	49,888	56,989	41,459
Tube	12,148	8,884	9,818	10,928	9,086
Castings and billets	3,378	2,295	2,286	5,958	4,606
Copper-base ingots	9,352	8,121	12,153	13,642	9,946
Other copper-base products	3,500	4,241	1,576	1,175	978
Total	185,552	131,537	161,906	179,469	127,747
Zinc-base alloy:					
Diecasting alloy	596,371	525,960	551,896	565,839	453,490
Dies and rod alloy	495	420	807	504	87
Slush and sand casting alloy	9,170	8,738	10,243	10,048	10,059
Total	606,036	535,118	562,946	576,391	463,636
Rolled zinc	52,612	45,443	48,943	48,650	41,065
Zinc oxide	28,438	29,774	34,937	41,447	43,829
Other uses:					
Desilverizing lead	2,776	1,394	2,973	3,957	3,642
Light-metal alloys	10,239	8,805	8,422	7,562	3,985
Other [1]	28,577	26,132	31,755	34,523	28,798
Total	41,592	36,331	43,150	46,042	36,425
Grand total	r 1,423,666	r 1,250,673	r 1,350,656	r 1,385,380	1,186,951

r Revised.
[1] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, wet batteries, and miscellaneous uses not elsewhere mentioned.

Table 18.—Slab zinc consumption in the United States in 1970, by grades and industry uses

(Short tons)

Industry	Special high grade	High grade	Intermediate	Brass special	Prime western [1]	Remelt	Total
Galvanizing	24,103	24,080	1,697	106,171	315,985	2,213	474,249
Brass and bronze	36,993	57,416	192	5,741	27,292	113	127,747
Zinc-base alloys	460,470	1,169	12	196	1,365	424	463,636
Rolled zinc	15,344	12,461	5,829	--------	7,431	--------	41,065
Zinc oxide	7,697	6,380	--------	--------	29,752	--------	43,829
Other	14,876	2,843	299	5,810	12,554	43	36,425
Total	559,483	104,349	8,029	117,918	394,379	2,793	1,186,951

[1] Includes select grade.

Table 19.—Rolled zinc produced and quantity available for consumption in the United States

	1969			1970		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per pound		Total (thousands)	Average per pound
Production:[1]						
Photoengraving plate	10,745	$7,958	$0.370	10,364	$7,812	$0.377
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	31,970	14,151	.221	23,570	12,052	.256
Rod and wire	W	W	W	W	W	W
Total rolled zinc	46,540	25,850	.278	39,234	25,447	.324
Exports	2,714	1,746	.322	1,412	1,173	.415
Imports	966	418	.216	692	419	.303
Available for consumption	44,974	----	----	38,016	----	----
Value of slab zinc (all grades)	----	----	.147	----	----	.153
Value added by rolling	----	----	.131	----	----	.171

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Figures represent net production. In addition, 24,388 tons in 1969 and 18,076 tons in 1970 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 1970, by industries and States

(Short tons)

State	Galvanizers	Brass mills[1]	Die-casters[2]	Other[3]	Total
Alabama	40,587	W	----	W	41,979
Arizona	W	----	----	W	W
Arkansas	----	----	----	W	W
California	29,806	2,282	13,373	1,106	46,567
Colorado	W	W	W	W	3,489
Connecticut	3,475	30,277	W	W	40,373
Delaware	W	W	W	W	2,652
Florida	W	----	W	----	3,517
Georgia	W	----	W	----	W
Hawaii	W	----	----	----	W
Idaho	----	----	W	W	W
Illinois	43,633	22,796	76,509	23,210	166,148
Indiana	56,488	W	24,954	W	112,947
Iowa	W	----	----	W	1,090
Kansas	----	W	W	----	W
Kentucky	W	W	----	W	W
Louisiana	W	----	----	W	1,670
Maine	W	----	----	----	W
Maryland	W	----	----	W	W
Massachusetts	3,079	W	----	W	8,079
Michigan	W	12,370	110,159	W	126,906
Minnesota	W	W	----	----	2,354
Mississippi	W	----	----	----	W
Missouri	11,221	W	7,854	W	20,918
Montana	----	----	----	W	W
Nebraska	1,375	W	----	W	2,088
New Hampshire	----	W	----	----	W
New Jersey	2,809	5,327	W	W	15,558
New York	11,208	W	66,817	W	92,394
North Carolina	W	----	W	W	W
Ohio	90,370	W	61,751	W	160,086
Oklahoma	8,422	----	W	W	12,869
Oregon	725	W	W	W	826
Pennsylvania	62,929	12,647	22,970	52,655	151,201
Rhode Island	W	----	----	W	W
South Carolina	W	----	----	----	W
Tennessee	W	----	W	W	2,690
Texas	14,261	W	W	W	41,341
Utah	W	W	----	----	W
Virginia	W	W	W	W	339
Washington	868	----	----	489	1,357
West Virginia	28,681	W	----	W	32,071
Wisconsin	1,380	W	9,023	W	16,575
Undistributed	60,719	41,935	69,802	43,816	76,074
Total[4]	472,036	127,634	463,212	121,276	1,184,158

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	1969 Production (short tons)	1969 Shipments Short tons	1969 Shipments Value [2] Total (thousands)	1969 Shipments Value [2] Average per ton	1970 Production (short tons)	1970 Shipments Short tons	1970 Shipments Value [2] Total (thousands)	1970 Shipments Value [2] Average per ton
Zinc oxide [3]	220,358	219,723	$65,492	$298	223,769	213,283	$58,531	$274
Leaded zinc oxide [3]	4,949	6,956	1,609	231	5,201	6,951	1,588	228
Zinc chloride, 50° B [4]	47,909	48,909	W	W	46,834	45,444	W	W
Zinc sulfate	68,482	64,592	12,135	188	53,170	54,069	7,225	134

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes lithopone; figure 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.
[4] Includes zinc chloride equivalent of zinc ammonium chloride and chromated zinc chloride.

Table 22.—Zinc content of zinc pigments [1] and compounds produced by domestic manufacturers, by sources

(Short tons)

Pigment or compound	1969 Ore Domestic	1969 Ore Foreign	1969 Slab zinc	1969 Secondary material	1969 Total zinc in pigments and compounds	1970 Ore Domestic	1970 Ore Foreign	1970 Slab zinc	1970 Secondary material	1970 Total zinc in pigments and compounds
Zinc oxide	82,643	23,949	41,362	28,115	176,069	82,446	24,827	43,829	27,851	178,953
Leaded zinc oxide	1,705	1,539	------	------	3,244	1,531	1,977	------	------	3,508
Total	84,348	25,488	41,362	28,115	179,313	83,977	26,804	43,829	27,851	182,461
Zinc chloride [2]	------	------	W	W	11,632	------	------	W	W	10,607
Zinc sulfate	5,503	5,342	------	10,897	21,742	3,548	4,730	------	8,156	16,434

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.
[2] Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 23.—Distribution of zinc oxide and leaded zinc oxide shipments, by industries

(Short tons)

Industry	1966	1967	1968	1969	1970
Zinc oxide:					
Rubber	104,866	94,388	111,797	115,988	111,421
Paints	27,100	24,547	25,864	25,170	21,894
Ceramics	12,147	9,850	10,226	9,469	9,011
Chemicals	13,678	17,509	22,769	22,775	19,435
Agriculture	1,559	5,048	5,044	4,007	2,246
Photocopying	11,405	14,039	21,564	27,566	31,850
Other	22,910	16,105	16,562	14,748	17,426
Total	193,665	181,486	213,826	219,723	213,283
Leaded zinc oxide:					
Paints	10,462	8,644	6,356	4,905	5,212
Rubber; Other and unspecified	1,095	1,662	1,639	2,051	1,739
Total	11,557	10,306	7,995	6,956	6,951

Table 24.—Distribution of zinc sulfate shipments, by industries
(Short tons)

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1966	18,659	16,562	19,334	16,891	13,705	9,372	51,698	42,825
1967	W	W	17,156	14,803	31,644	24,742	48,800	39,545
1968	W	W	20,472	17,631	r 39,175	r 30,265	r 59,647	r 47,896
1969	W	W	19,029	16,424	r 45,563	r 33,861	r 64,592	r 50,285
1970	W	W	17,213	14,803	36,856	26,572	54,069	41,375

r Revised. 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)

	1966	1967	1968	1969	1970
At primary reduction plants	63,626	81,307	64,695	r 64,903	97,576
At secondary distilling plants	1,172	609	684	885	738
Total	64,798	81,916	65,379	r 65,788	98,314

r Revised.

Table 26.—Consumer stocks of slab zinc at plants, Dec. 31, by grades
(Short tons)

Date	Special high grade	High grade	Intermediate	Brass special	Prime western	Remelt	Total
Dec. 31, 1969 r	38,595	8,397	628	8,643	45,565	179	102,007
Dec. 31, 1970	36,617	6,866	974	7,014	37,908	172	89,551

r Revised.

Table 27.—Average monthly quoted prices of 60-percent-zinc concentrate at Joplin, and common zinc (prompt delivery or spot), East St. Louis and London [1]

Month	1969			1970		
	60-percent-zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)		60-percent-zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)	
		East St. Louis	London [2]		East St. Louis	London [2]
January	$84.00	13.84	12.19	$100.00	15.50	13.72
February	84.00	14.00	12.10	100.00	15.50	13.51
March	88.00	14.00	12.27	100.00	15.50	13.44
April	88.00	14.02	12.35	100.00	15.50	13.31
May	92.00	14.50	12.62	100.00	15.50	13.24
June	92.00	14.50	12.73	100.00	15.50	13.29
July	92.00	14.50	12.84	100.00	15.50	13.39
August	92.00	14.50	13.17	100.00	15.33	13.45
September	96.80	15.38	13.42	100.00	15.00	13.49
October	100.00	15.50	13.53	100.00	15.00	13.83
November	100.00	15.50	14.01	100.00	15.00	13.14
December	100.00	15.50	14.04	100.00	15.00	13.00
Average for year	92.40	14.65	12.96	100.00	15.32	13.42

[1] Joplin: Metal Statistics, 1970. East St. Louis: Metal Statistics, 1970. London: Metals Week.
[2] Conversion of English quotations into U.S. money based on average rates of exchange recorded by Federal Reserve Board. Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

Table 28.—U.S. exports of slab and sheet zinc, by countries

Destination	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Slabs, pigs, and blocks:						
Australia	1	$1	20	$6	---	---
Canada	326	165	670	191	69	$34
Chile	130	46	69	22	29	10
Colombia	5	2	2	1	---	---
Germany, West	4	2	17	8	22	4
Honduras	---	---	13	4	20	8
India	32,345	9,507	8,409	2,337	---	---
Iran	12	4	---	---	---	---
Liberia	---	---	3	1	21	9
Netherlands	2	1	2	1	21	4
Philippines	122	35	5	3	---	---
Spain	---	---	---	---	41	7
Taiwan	23	11	---	---	---	---
Venezuela	7	4	26	9	33	12
Other	34	19	62	29	32	26
Total	33,011	9,797	9,298	2,612	288	114
Sheets, plates, strips, or other forms, n.e.c.:						
Argentina	38	32	22	20	41	35
Australia	32	26	1	2	3	4
Brazil	20	18	7	6	4	6
Canada	1,976	1,414	1,188	909	1,006	825
Chile	35	27	27	21	5	5
Colombia	69	64	18	15	17	18
Denmark	12	10	2	2	---	---
Germany, West	115	84	27	20	---	---
India	1	1	361	164	---	---
Israel	36	26	5	4	1	1
Mexico	17	18	14	13	13	11
New Zealand	7	7	7	5	12	11
Pakistan	177	90	779	346	23	20
Philippines	9	7	1	1	1	1
South Africa, Republic of	87	76	1	1	14	11
Taiwan	47	34	33	22	54	25
Venezuela	103	94	87	81	87	79
Other	267	200	134	114	131	121
Total	3,048	2,228	2,714	1,746	1,412	1,173

Table 29.—U.S. exports of zinc, by classes

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.	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1968	33,011	$9,797	3,048	$2,228	2,293	$886	15,000	$3,840
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

Table 30.—U.S. exports of zinc pigments

Kind	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Zinc oxide	3,779	$1,341	6,326	$2,343
Lithopone	1,086	300	1,541	523
Total	4,865	1,641	7,867	2,866

Table 31.—U.S. imports of zinc, by countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
ORES						
Australia	2,267	$410	2,940	$628	2,324	$518
Bolivia	6,011	1,004	2,069	347	2,904	439
Canada	310,586	46,625	367,529	54,213	317,992	47,153
Chile	74	15	421	76	1,056	201
Germany, West	5,942	881	--------	--------	--------	--------
Guatemala	--------	--------	525	79	4	1
Honduras	12,959	1,759	15,272	2,138	19,267	2,845
Mexico	142,313	16,352	143,747	17,001	128,949	16,921
Morocco	15,715	1,426	5,988	614	--------	--------
Netherlands	3,313	418	--------	--------	--------	--------
Peru	39,899	6,071	57,087	8,597	48,037	7,644
South Africa, Republic of	4,287	643	6,525	866	5,096	772
Other	--------	--------	17	1	130	18
Total	543,366	75,604	602,120	84,560	525,759	76,512
BLOCKS, PIGS, OR SLABS						
Australia	19,915	4,627	34,237	8,896	30,335	9,359
Belgium-Luxembourg	16,500	4,080	13,296	3,416	14,371	3,876
Canada	r 116,874	r 30,186	r 148,851	r 39,578	120,611	34,329
Congo (Kinshasa)	8,146	1,850	10,621	2,742	6,300	1,695
Germany, West	--------	--------	--------	--------	3,198	886
Japan	45,735	11,115	52,502	13,239	32,525	8,764
Mexico	19,034	4,150	12,092	2,642	7,358	1,746
Mozambique	1,098	267	1,256	301	661	170
Netherlands	--------	--------	--------	--------	7,725	2,143
Norway	6,272	1,555	4,481	1,206	1,343	395
Peru	53,729	13,655	30,204	8,201	31,923	9,143
Poland	9,454	2,366	9,495	2,498	7,729	2,284
Spain	2,877	691	--------	--------	--------	--------
United Kingdom	r 3,261	r 760	r 1,041	r 259	1,054	294
Yugoslavia	--------	--------	385	93	114	32
Zambia	277	63	3,817	953	1,773	493
Other	1,404	345	r 2,498	r 597	3,393	937
Total	r 304,576	r 75,710	r 324,776	r 84,621	270,413	76,546

r Revised.

Table 32.—U.S. imports for consumption of zinc, by countries

Country	1968 Short tons	1968 Value (thousands)	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
ORES [1]						
Algeria	727	$122	-------	-------	-------	-------
Australia	1,236	235	4,387	$700	1,893	$366
Bolivia	8,619	1,455	9,407	1,489	4,098	595
Canada	301,306	44,459	326,929	48,552	263,287	40,230
Chile	126	29	1,025	213	1,331	267
Germany, West	-------	-------	3,701	658	10,438	1,638
Honduras	6,531	925	11,517	1,614	10,001	1,342
Mexico	101,554	11,204	141,720	16,036	101,871	13,430
Morocco	15,675	1,897	8,848	873	-------	-------
Netherlands	3,313	418	-------	-------	-------	-------
Peru	40,237	7,368	54,925	8,591	51,269	8,330
South Africa, Republic of	5,466	857	1,959	421	5,040	764
Sweden	-------	-------	593	65	-------	-------
Other	13	2	223	30	1,542	202
Total	484,803	68,971	565,234	79,242	450,770	67,164
BLOCKS, PIGS, OR SLABS						
Australia	19,915	4,627	34,237	8,896	30,335	9,359
Belgium-Luxembourg	16,611	4,109	r 13,296	r 3,416	14,371	3,876
Canada	r 116,874	r 30,186	r 148,851	r 39,578	120,611	34,329
Congo (Kinshasa)	8,146	1,850	10,621	2,742	6,300	1,695
Germany, West	-------	-------	-------	-------	442	122
Japan	45,735	11,115	52,502	13,239	32,525	8,764
Mexico	19,034	4,150	12,092	2,642	7,358	1,746
Mozambique	1,098	267	1,256	301	661	170
Netherlands	-------	-------	-------	-------	200	56
Norway	6,272	1,555	4,481	1,206	1,343	395
Peru	53,729	13,655	30,204	8,201	31,923	9,143
Poland	9,454	2,366	9,495	2,498	7,729	2,284
Spain	2,877	691	-------	-------	-------	-------
United Kingdom	r 3,261	r 760	r 1,041	r 259	1,054	294
Yugoslavia	-------	-------	385	93	114	32
Zambia	277	63	3,799	949	1,773	493
Other	1,404	345	r 2,498	r 597	3,393	937
Total	r 304,687	r 75,739	r 324,758	r 84,617	260,132	73,695

r Revised.
[1] Does not include zinc ores and concentrates imported for refining and export; 1968: Canada 10,496 short tons ($1,586,637); Morocco 410 short tons ($56,875). 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).

Table 33.—U.S. imports for consumption of zinc, by classes

Year	Ore (zinc content) Short tons	Ore (zinc content) Value (thousands)	Blocks, pigs, and slabs Short tons	Blocks, pigs, and slabs Value (thousands)	Sheets, plates, strips, and other forms Short tons	Sheets, plates, strips, and other forms Value (thousands)
1968	484,803	$68,971	r 304,687	r $75,739	754	$290
1969	565,234	79,242	r 324,758	r 84,617	r 840	r 380
1970	450,770	67,164	260,132	73,695	692	419

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)
1968	878	$119	581	$63	8,100	$2,443	r $147,625
1969	1,770	255	716	67	8,251	2,652	167,213
1970	1,497	192	418	92	9,359	3,161	144,723

r Revised.
[1] In addition, manufactures of zinc were imported as follows: 1968–$446,555; 1969–r $489,430; 1970–$1,276,276.

Table 34.—U.S. imports for consumption of zinc pigments and compounds

Kind	1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	14,565	$3,059	12,073	$2,764
Zinc sulfide	355	119	349	109
Lithopone	261	40	77	19
Zinc chloride	1,367	233	1,151	228
Zinc sulfate	6,236	675	6,298	651
Zinc cyanide	124	83	143	96
Zinc compounds, n.s.p.f	610	267	675	239
Total	23,518	4,476	20,766	4,106

Table 35.—Zinc: World mine production (content of ore), by countries

(Short tons)

Country [1]	1968	1969	1970 p
North America:			
Canada	1,273,261	1,316,416	1,365,991
Guatemala	----------	1,026	----------
Honduras	16,295	17,644	22,090
Mexico	264,578	279,298	291,379
United States	529,446	553,124	534,136
South America:			
Argentina	r 29,016	34,927	42,990
Bolivia	12,371	28,875	51,239
Brazil	5,264	5,952	e 13,900
Chile	1,383	1,629	1,456
Colombia	717	466	e 429
Ecuador	126	229	e 230
Peru	321,218	331,027	348,893
Europe:			
Austria	r 13,889	15,690	17,314
Bulgaria	r 82,122	84,878	e 99,000
Czechoslovakia	r 10,858	11,530	e 11,600
Finland	72,091	78,044	69,015
France	r 24,037	22,156	20,503
Germany, East e	r 11,000	11,000	11,000
Germany, West	r 121,686	122,069	135,227
Greece	r 11,477	10,128	10,325
Hungary e	3,900	5,300	5,300
Ireland	r 55,698	107,453	106,373
Italy	r 154,323	145,836	120,262
Norway	13,052	12,333	e 11,650
Poland	r 180,889	188,275	209,329
Portugal	398	1,203	2,155
Romania e [2]	28,000	33,000	43,900
Spain	82,230	92,978	105,171
Sweden	r 89,641	99,318	103,397
U.S.S.R. e	r 595,000	672,000	672,000
Yugoslavia	105,242	106,624	111,493
Africa:			
Algeria	r 21,140	22,587	18,689
Congo (Brazzaville) e	r 800	400	80
Congo (Kinshasa)	119,342	95,503	115,833
Morocco	35,033	37,343	19,923
South Africa, Republic of	----------	----------	e 8
South-West Africa, Territory of [3]	27,332	51,412	73,640
Tunisia	r 5,623	10,313	9,612
Zambia (smelter)	r 57,732	55,297	58,925
Asia:			
Burma	r 5,088	5,393	4,483
China, mainland e	110,000	110,000	110,000
India	7,681	8,165	9,090
Iran [4]	r 59,472	r e 58,600	e 63,600
Japan	291,389	296,979	308,293
Korea, North e	r 132,000	138,000	143,000
Korea, Republic of	21,319	22,688	26,433
Philippines	2,472	3,622	3,517
Thailand e	1,200	800	600
Turkey e	r 11,100	25,100	23,400
Oceania: Australia	r 465,609	559,031	533,731
Total	r 5,483,540	5,891,661	6,060,604

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] Recoverable.
[3] Data for year ending June 30 of that stated.
[4] Year beginning March 21 of year stated.

Table 36.—Zinc: World smelter production, by countries

(Short tons)

Country [1]	1968	1969	1970 [p]
North America:			
Canada	426,932	466,356	460,663
Mexico	88,227	88,477	88,915
United States	1,020,891	1,040,597	877,811
South America:			
Argentina	[r] 23,080	27,115	35,274
Brazil	3,866	5,497	[e] 11,600
Peru	72,519	68,649	75,717
Europe:			
Austria [2]	16,859	17,121	17,657
Belgium [2]	[r] 274,456	287,254	265,877
Bulgaria [2]	82,783	83,555	[e] 86,000
Finland	-----	1,195	61,531
France	[r] 228,635	279,480	250,555
Germany, East [e] [2]	[r] 17,000	18,000	17,300
Germany, West	[r] 159,116	162,195	165,593
Italy	123,761	143,654	156,618
Netherlands	[r] 46,381	51,397	50,952
Norway	66,260	64,788	67,704
Poland [2]	223,200	228,700	230,400
Romania [e]	28,000	33,000	43,900
Spain	[r] 83,099	88,513	98,328
U.S.S.R. [e]	634,000	672,000	672,000
United Kingdom	[r] 157,500	166,441	161,595
Yugoslavia [2]	87,058	89,352	71,676
Africa:			
Congo (Kinshasa)	68,975	70,252	70,272
South Africa, Republic of	-----	13,057	40,234
Zambia	[r] 57,732	55,297	58,925
Asia:			
China, mainland (refined) [e]	100,000	100,000	110,000
India	22,817	25,409	25,805
Japan	667,510	785,051	745,437
Korea, North [e]	88,000	66,000	99,000
Korea, Republic of	2,705	2,546	2,535
Oceania: Australia	229,591	271,525	287,255
Total	[r] 5,100,953	5,472,473	5,407,129

[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 Robert G. Clarke [1]

Zircon production and sales by domestic mining companies were about 20 percent less in 1970 than in 1969, but imports were only slightly less than in 1969. Ouput of zirconium sponge metal decreased, but production of zirconium-bearing compounds for chemicals and refractories increased.

Legislation and Government Programs.—The Statistical Supplement to the Stockpile Report to the Congress, Dec. 31, 1970, showed no objectives for zirconium and hafnium materials. Stocks of the 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 1970 yearend inventories of approximately 1,060 tons of zirconium sponge, 65 tons of Zircaloy as ingot, and 39 tons of hafnium crystal bar.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

Product	1966	1967	1968	1969	1970
Zircon:					
Production	W	W	W	W	W
Exports	2,311	2,729	2,026	5,395	4,335
Imports	57,976	59,303	59,900	95,414	94,759
Consumption [e]	132,000	134,000	143,000	160,000	145,000
Stocks, yearend, dealers and consumers [1]	38,000	48,000	46,000	[r] 53,000	52,000
Zirconium oxide:					
Production [2]	4,000	[r] 3,865	3,864	5,702	4,957
Producers' stocks, yearend [2]	1,169	[r] 1,267	1,077	1,005	1,050

[e] Estimate. [r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Excludes foundries.
[2] Excludes oxide produced by zirconium metal producers.

DOMESTIC PRODUCTION

Byproduct zircon from the processing of titanium-mineral-bearing sands was obtained at the dredging and milling facilities owned and operated by E. I. du Pont de Nemours & Co., Inc., near Starke, Fla., and by Humphreys Mining Co. for Du Pont, near Folkston, Ga. Production data are withheld from publication to avoid disclosing individual company confidential data.

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 production and also zirconium sponge metal production were about 40 percent of that of 1969.

Four firms produced 45,800 tons of milled (ground) zircon, an increase of 2.2 percent over 1969 production. Four companies, excluding those that produce metal, produced 4,957 tons of zirconium oxide. Production of zirconium-bearing refractories totaled 30,500 tons, of which the zirconium oxide content varied from 33 percent to 90 percent. Hafnium crystal bar output, which is produced by several firms, amounted to 35 tons, compared with 28 tons in 1969.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Producers of zirconium and hafnium materials, 1970

Company	Location	Materials
ZIRCONIUM MATERIALS		
Amax Specialty Metals, Inc	Akron, N.Y	Ingot.
Do	Parkersburg, W. Va	Sponge metal.
The Carborundum Co	Falconer N.Y	Refractories.
Corhart Refractories Co	Buckhannon, W. Va	Do.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
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.
M & T Chemicals, Inc	Andrews, S.C	Milled zircon.
National Lead Co., Titanium Alloy Manufacturing Div. (TAM)	Niagara Falls, N.Y	Milled zircon, chloride, oxide, other compounds, powder, alloys, refractories.
Norton Co	Huntsville, Ala	Oxide.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	Alloys.
Frank Samuel & Co., Inc	Camden, N.J	Milled zircon.
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.
Union Carbide Corp	Alloy, W.Va., and Niagara Falls, N.Y	Alloys.
Ventron Corp	Beverly, Mass	Do.
Wah Chang Albany Corp	Albany, Oreg	Oxide, chloride, sponge metal, ingot, powder.
Walsh Refractories Corp	St. Louis, Mo	Refractories.
Zirconium Corp. of America	Cleveland, Ohio	Oxide and refractories.
Continental Mineral Processing Corp	Sharonville, Ohio	Milled zircon.
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.

CONSUMPTION AND USES

Zircon consumption in the United States in 1970 was estimated at 145,000 tons. Consumption of zircon concentrate and milled zircon was 100,000 tons for foundries, 22,000 tons for refractories, and 23,000 tons for all other uses.

Preliminary Bureau of Census figures for 1970 show that shipments of zircon and zirconia brick and shapes made predominantly of either of these materials totaled 1.8 million brick, expressed in terms of equivalent 9-inch bricks, valued at $6.7 million. In 1969, final figures for shipments were 2.3 million brick valued at $7 million.[2]

Dealers and other firms indicated shipments of milled zircon and concentrate in 1970 to the following markets: Foundry use 68,300 tons; refractories and ceramics 40,800 tons; and chemical, metal, alloys, compounds, and other uses 11,700 tons.

Zirconium metal was used in nuclear reactors, in chemical plants for corrosion resistant construction material, and in photography for flash bulbs. Zirconium compounds were used in refractories, glazes, enamels, welding rod, ferroalloys, and sandblasting.

Hafnium metal, alloys, and compounds continued to have few uses, but research and development was intensified. The metal was used in nuclear reactors for control rods and was also used in special refractory alloys.

[2] U.S. Department of Commerce, Bureau of the Census. Current Industrial Reports. Refractories. First Quarter 1970, Series MQ-32C(70)-1, July 6, 1970; Second Quarter 1970, Series MQ-32C(70)-2, Sept. 2, 1970; Third Quarter 1970, Series MQ-32C(70)-3, Dec. 16, 1970; Fourth Quarter 1970, Series MQ-32C(70)-4, Feb. 19, 1971. Each report 4 pp. ———. Refractories, Summary for 1969. Series MQ-32C(70)-5, Oct. 13, 1970, 6 pp.

Table 3.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	Yearend 1969	Yearend 1970
Zircon concentrate held by dealers and consumers, excluding foundries	r 46,000	46,000
Milled zircon held by dealers and consumers, excluding foundries	6,700	6,400
Zirconium:		
Oxide	1,835	1,788
Sponge	438	625
Ingot	241	442
Scrap	575	351
Powder	W	W
Alloys	635	274
Refractories	8,602	7,495
Hafnium:		
Oxide	W	W
Sponge	31	30
Crystal bar	5	11

r Revised. W Withheld to avoid disclosing individual company confidential data.

PRICES

Published prices of zircon, zirconium hydride, zirconium metal powder and sponge, and hafnium metal products were unchanged from 1969. Quoted prices for zirconium oxide were unchanged except for glass-polishing grade, opacifier grade, and stabilized oxide. Zirconium metal strip was quoted at $12 to $16 in 1970 compared with $13 to $16 in 1969.

Table 4.—Published prices of zirconium and hafnium materials, 1970

Specification of material	Price
Zircon:	
Domestic, f.o.b. Starke, Fla. bags, per short ton [1]	$56.00–57.00
Imported, sand, containing 65 percent ZrO_2, c.i.f. Atlantic ports, in bags, per long ton [1]	70.00
Domestic, granular, 1- to 5-ton lots, from works, in bags, per pound [2]	.04875
Domestic, milled, 1- to 5-ton lots, from works, in bags, per pound [2]	.055
Zirconium oxide: [2 3]	
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	.92
After March 23	.71
Opacifier grade, 100-pound bags, 85–90 percent ZrO_2, per pound	.41
After March 23	.42
Stabilized oxide, 100-pound bags, 91 percent ZrO_2, milled, per pound	0.75–0.85
After March 23	0.80–1.10
Zirconium hydride: [2]	
Electronic grade, powder, drums, from works, per pound	14.50–16.00
Zirconium: [4]	
Powder, per pound	12.00–13.00
Sponge, per pound	5.50–7.00
Sheets, strip, bars, per pound	12.00–16.00
Hafnium: [4]	
Sponge, per pound	75.00
Bar and plate, rolled, per pound	120.00

1 Metals Week. V. 41, Nos. 1–52, January–December 1970.
2 Oil, Paint and Drug Reporter. V. 197, Nos. 1–26, January–June 1970; v. 198, Nos. 1–26, July–December 1970.
3 Oil, Paint and Drug Reporter. V. 197, No. 13, Mar. 30, 1970. New quotes.
4 American Metal Market. V. 77, Nos. 166–249, Aug. 31–Dec. 30, 1970.

FOREIGN TRADE

Exports.—Exports of zirconium oxide amounted to 717,136 pounds valued at $599,954 and were made to 20 countries. The three major recipients were Canada, 19 percent; Japan, 17 percent; and, Mexico, 12 percent.

Imports.—Imports for consumption of zircon, 92 percent from Australia, were only slightly less than the record quantity imported during 1969. The average value of imported zircon at foreign ports was $39.08 per short ton, compared with $40.43 per ton in 1969.

Table 5.—U.S. exports of zirconium ores and concentrates and zirconium bearing materials

Destination	1969 r		1970	
	Pounds	Value	Pounds	Value
Ores and concentrates:				
Argentina	259,400	$38,286	247,816	$31,669
Austria	---------	---------	15,700	2,593
Belgium-Luxembourg	6,000	708	---------	---------
Brazil	49,867	3,740	76,000	4,875
Canada	4,019,667	158,823	6,890,860	236,698
Chile	45,200	5,330	30,800	3,288
Colombia	14,400	2,184	250	620
Ecuador	30,800	4,886	33,000	4,950
France	11,000	592	39,909	4,586
Germany, West	11,023	725	---------	---------
Israel	---------	---------	6,800	1,840
Italy	349,900	45,023	254,912	33,743
Japan	7,600	591	1,131,541	263,127
Mexico	555,000	30,831	---------	---------
South Africa, Republic of	35,600	3,201	---------	---------
United Kingdom	---------	---------	32,587	2,994
Total	5,395,457	294,920	8,760,175	590,983
Zirconium and zirconium alloys, wrought:				
Australia	1,789	4,741	573	8,338
Belgium-Luxembourg	501	18,292	314	7,756
Brazil	78	552	72	523
Canada	262,876	4,506,601	228,439	2,792,249
Congo (Kinshasa)	---------	---------	68	1,170
Denmark	88	6,030	232	8,612
Dominican Republic	---------	---------	4,400	47,899
France	592	7,674	4,816	51,164
Germany, West	4,324	46,674	49,491	665,186
India	4,993	120,329	4,089	81,351
Israel	---------	---------	137	1,000
Italy	702	30,088	5,601	108,961
Japan	21,362	181,251	46,505	579,527
Netherlands	1,706	11,040	2,971	19,223
Norway	446	13,327	2,220	21,738
Pakistan	96	938	47	525
Portugal	585	6,435	---------	---------
South Africa, Republic of	25	660	---------	---------
Spain	96	938	---------	---------
Sweden	9,701	198,426	16,075	250,207
Switzerland	---------	---------	561	2,860
Taiwan	72	1,375	---------	---------
Turkey	110	1,236	---------	---------
United Kingdom	26,094	174,847	15,233	310,858
Total	336,236	5,331,454	381,844	4,959,147
Zirconium, unwrought and waste and scrap:				
Australia	64	490	---------	---------
Belgium-Luxembourg	---------	---------	291	4,755
Brazil	2,840	11,550	4,990	21,134
Canada	1,371	6,143	1,505	21,636
France	36,383	187,439	20,671	145,546
Germany, West	14,507	103,883	21,773	146,828
Guatemala	---------	---------	94	937
India	---------	---------	660	4,620
Italy	1,100	6,534	2,200	12,647
Japan	6,223	33,560	31,944	177,821
Netherlands	2,170	9,906	1,261	5,647
Norway	---------	---------	393	4,255
Spain	---------	---------	98	441
Sweden	---------	---------	20,586	194,703
Switzerland	1,024	4,588	5,905	26,453
Taiwan	750	7,400	---------	---------
Turkey	---------	---------	974	3,926
United Kingdom	40,794	208,410	104,846	553,508
Total	107,226	579,903	218,191	1,324,857

r Revised.

Table 6.—U.S. imports for consumption of zirconium and hafnium materials, 1970

Country	Pounds	Value
Zirconium, wrought:		
Canada	280	$2,945
France	12,940	106,421
United Kingdom	1	269
Total	13,221	109,635
Zirconium, unwrought and waste and scrap:		
Canada	7,405	6,070
France	120,060	456,574
Germany, West	251	580
Japan	111,330	464,230
Netherlands	457	653
United Kingdom	10,406	4,753
Total	249,909	932,860
Zirconium alloys, unwrought:		
Canada	31,539	71,283
Germany, West	1,912	14,430
United Kingdom	1,928	656
Total	35,379	86,369
Zirconium oxide:		
France	150	342
Germany, West	1,168	1,517
Japan	18,051	6,848
Switzerland	17	888
United Kingdom	136,172	78,238
Total	155,558	87,833
Zirconium compounds, n.e.c.:		
Canada	120	1,473
France	499	1,051
Germany, West	11,458	81,168
Japan	66,614	10,993
Netherlands	2,276	2,537
United Kingdom	833,144	288,262
Total	914,111	385,484
Hafnium, unwrought and waste and scrap:		
Germany, West	36	3,550
Japan	222	21,459
Total	258	25,009
Hafnium, wrought: France	6	629

Table 7.—U.S. imports for consumption of zircon, by countries

Country	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	58,812	$1,963	87,743	$3,510	86,816	$3,265
Canada [1]	904	35	3,818	93	3,104	98
French Pacific Islands	------	------	3,358	60	------	------
Malaysia	------	------	112	3	------	------
South Africa, Republic of	28	8	383	192	355	134
Syrian Arab Republic	45	3	------	------	------	------
United Kingdom [1]	111	5	------	------	4,484	207
Total	59,900	2,014	95,414	3,858	94,759	3,704

[1] Believed to be country of shipment rather than country of origin.

WORLD REVIEW

Australia.—Naracoopa Rutile Limited maintained its schedule for the startup of a beach sand mining and concentrating plant at Naracoopa on King Island, between Tasmania and the Australian mainland. The plant, which went on stream April 9, 1969, will produce 10,000 tons of rutile and 10,000 tons of zircon per year.

It incorporates streamlined flow-sheets of modern wet and dry concentrating equipment, including high-tension separators, low and high intensity magnetic separators, spiral concentrators, impinging attritioners, and dry and wet tables. Sand currently mined has a heavy mineral content of about 60 percent. The present plan will not require a primary concentration stage until 1971, when lower grade mineral is anticipated. The ore is mined by dragline and trucked to a wet storage pile at the plant.[3]

Mineral Deposits Pty. Ltd. (85 percent owned by National Lead Co. of the United States) commissioned a new 300 ton-per-hour plant north of Tuncurry, New South Wales. The plant will enable dredges now working in low-grade areas to continue to operate at minimum cutoff grades; this will make possible the full utilization of reserves.[4]

Canada.—Eldorado Nuclear Ltd. began making pure nuclear grade zirconium and alloy ingot in its new $8.3 million plant at Port Hope, Ontario, rated at 300 tons per year. The production process is basically new in that zirconium metal is extracted from zircon sand and bypasses the conventional sponge stage to reactor-grade zirconium alloys. The plant is also equipped to manufacture billets and has facilities to carry out pickling and machining operations when required.[5]

Ceylon.—The Mineral Dressing Laboratory of the Ceylon Geological Survey has produced zircon in the course of pilot studies of heavy mineral sands from the west and south-west coasts of the Island. In addition to zircon, the concentrates have included monazite and rare-earth oxides containing thoria.[6]

France.—France's Ugine Kuhlmann and Sweden's Sandvik Steel formed a $2 million venture, with Ugine taking a 65-percent interest and Sandvik a 35-percent interest, to build a new zirconium sponge plant in Jarrie, near Grenoble, France. No capacity or target date has been disclosed.[7]

Germany.—Three companies formed a partnership to produce zirconium tubing for the Common Market and are building a plant in Sprendlingen, West Germany. The venture, known as Sandvik-Universal Tube, is owned 40 percent by Sandvik, 40 percent by Universal Oil Products Co., and 20 percent by Ugine Kuhlmann.[8]

India.—Indian Rare Earths Ltd. (IRE) recovered zircon sand as a byproduct of ilmenite at two plants in the state of Kerala in Southern India. The concentrates will be further processed at a proposed plant to be established at Cochin by Ferro Coatings and Colours, Ltd., a subsidiary of Ferro Corporation. Ferro intends to provide its plants in Europe with milled zircon for conversion to zirconia and zirconium compounds.[9]

South Africa, Republic of.—Probably the largest deposit of baddeleyite in the world today is located at Phalaborwa (pronounced Palabora) in the Letaba district of the Eastern Transvaal Lowveld. The Phosphate Development Corp. Ltd.—FOSKOR—operates an open pit mine from which the main materials recovered are phosphate, copper, and magnetite. The baddeleyite mineral content is about 0.2 percent but is economically reclaimable from the tailings of the other ores for which the deposit was originally developed.[10]

[3] Engineering and Mining Journal. Naracoopa's Zircon-Rutile Plant Includes High-Tension, Gravity, Magnetic Units. V. 171, No. 9, September, 1970, pp. 141–142.
[4] Industrial Minerals. No. 37, October 1970, p. 27.
[5] Mining in Canada. September 1970, p. 5.
[6] Ceylon Administration Reports, 1968–69 (Part IV—Education, Science and Art) Geological Survey, Colombo, Ceylon, June 1970, p. U32.
[7] Metals Week. V. 41, No. 44, November 22, 1970, p. 23.
[8] Metals Week. V. 41, No. 44, Nov. 22, 1970, p. 23.
[9] Industrial Minerals. No. 36, September 1970, p. 34.
[10] The South African Mining and Engineering Journal. V. 81, No. 4034, Pt. 1, May 29, 1970, pp. 1085–1091.

Table 8.—Zirconium concentrates: Free world production, by countries

(Short tons)

Country	1968	1969	1970
Australia	332,956	411,021	e 403,000
Brazil	3,083	3,874	NA
Ceylon	28	75	123
Malaysia	1 1,241	1 1,562	2 998
Thailand	3,549	276	2 2,469
United States	W	W	W
Total	340,857	416,808	406,590

e Estimate. NA Not available. W Withheld to avoid disclosing individual company confidential data.
1 Exports of zircon from Malaysia.
2 Imports of zircon and zirconium sand by Japan from country listed.

TECHNOLOGY

A Bureau of Mines report summarized preliminary progress on an investigation to determine the occurrence and recoverability of heavy minerals in sand and gravel operations in Alabama.[11] It was found that the sands and gravels studied contained heavy minerals similar to those recovered from Florida beach sands. Further studies for economic feasibility were indicated.

As part of a continuing project to develop refractory metal alloys for high-temperature structural applications, the Bureau of Mines applied solid solution and precipitation strengthening techniques to improve the properties of columbium alloys with hafnium, tungsten, and boron additions.[12] Strength and oxidation resistance of columbium alloys were increased by hafnium and tungsten; in contrast, the alloys oxidized more readily with increasing boron content.

In response to the dramatic increase in interest in offshore minerals, samples were collected from beaches and dunes around the British Isles in a search for heavy minerals and metals with mostly negative results indicated for economic deposits.[13]

Because hafnium is becoming increasingly available as a byproduct from the production of pure zirconium for reactor uses, its compounds are also more available. For example, hafnium carbide has the highest melting point (3890° C) of any of the transition metal carbides and was determined to have a uniquely stable crystal lattice at high temperatures, compared with other transition metal carbides. Microstrains anneal out at nearly double the temperature of tungsten carbide and indicate great potential for high-temperature applications where hardness is important.[14]

By carefully planning the degree of stabilization of zirconia, superior thermal shock resistant properties may be optimized.[15]

Hafnia and zirconia are similar in chemical and physical properties, except that at high temperatures, the monoclinic-tetragonal inversion occurs approximately 600°C higher in hafnia.[16]

Comprehensive summaries of current studies on zirconium and hafnium metals, alloys, and compounds, amounting to 483 references, were published during the year.[17]

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[11] Sullivan, G. U., and James S. Browning. Recovery of Heavy Minerals From Alabama Sand and Gravel Operations. BuMines TPR 22, March 1970, 14 pp.

[12] Babitzke, Herbert R., Lawrence L. Oden, and Hal J. Kelly. Columbium Alloy Development With Boron, Hafnium, and Tungsten. BuMines Rept. of Inv. 7388, 1970, 30 pp.

[13] Hill, Patrick A., and Andrew Parker. Tin and Zirconium in the Sediments Around the British Isles: A Preliminary Reconnaissance. Econ. Geol., v. 65, No. 4, June–July 1970, pp. 409–416.

[14] Lewis, D., and L. J. Porter. Plastic Deformation in Hafnium Carbide. J. of Less-Common Metals, v. 22, No. 4, December 1970, pp. 439–444.

[15] Johns, H. L., and A. G. King. Zirconia Tailored for Thermal Shock Resistance. Ceram. Age, v. 86, No. 5, May 1970, pp. 29–31.

[16] Ruh, Robert and Peter W. A. Corfield. Crystal Structure of Monoclinic Hafnia and Comparison With Monoclinic Zirconia. J. Am. Ceram. Soc., v. 53, No. 3, March 1970, pp. 126–129.

[17] Zr-Hf Newsletter. AMAX Specialitv Metals Division, American Metal Climax Inc., Akron, N.Y., April 1970, 18 pp.; and November 1970, 17 pp.

Minor Metals

By the Staff of the Division of Nonferrous Metals

CONTENTS

ARSENIC [1]

Legislation and Government Programs.—The Tax Reform Act of 1969 set the depletion allowance on both domestic and foreign produced arsenic at 14 percent.

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. Output in 1970 was greater than in 1969, but actual quantities cannot be published. Shipments declined and yearend stocks were substantially more than at the end of 1969.

Consumption and Uses.—Apparent consumption of arsenic, essentially all as white arsenic (As_2O_3), decreased for the third successive year. 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 qualitites in the agricultural industry for insecticides, selective plant killers, defoliants, and for parasitic control in chicken feed. However, evidence that persistent pesticides are adversely affecting various life forms has resulted in diminished use of arsenical pesticides.

About 3 percent of the arsenic consumed is used as metal for alloying with lead and copper. Small quantities of high-purity arsenic are used in the electronics industry where a new doped gallium arsenide laser has been developed. The new laser can be operated continuously at room temperature, whereas previously, heat generated in semiconductor lasers was too great to permit operation for more than a fraction of a second.[2]

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 £518 per long ton (55.6 cents per pound) until August 4, when the quotation changed to £600 nominal (64.3 cents per pound) for 99.5-percent black, lumpy arsenic.

Lead arsenate in 50-pound bags was quoted at 26 to 29 cents per pound throughout 1970. The price of sodium arsenate, 60 percent arsenic pentoxide, in 200-pound drums was unchanged at 30 cents per pound; and sodium arsenite, 94-percent-soluble pink powder, 75-percent arsenous acid, in 100-pound drums was quoted at 23 cents per pound during 1970.

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[1] By Gertrude N. Greenspoon, mineral specialist, Division of Nonferrous Metals.
[2] American Metal Market. New, Cooler Laser Developed. V. 77, No. 169, Sept. 3, 1970, p. 15.

Foreign Trade.—No exports of arsenic metal or white arsenic have been reported since 1945.

Imports of white arsenic were 3 percent higher than in 1969 but except for that year were the smallest since 1966. Sweden, the leading supplier of white arsenic, furnished 43 percent of the total, followed by Mexico with 41 percent and France with 14 percent. The remaining 2 percent came from Peru and the Republic of South Africa.

Receipts of arsenic metal rose 32 percent over 1969. Sweden continued to be the major supplier with 89 percent of the total. Canada furnished 6 percent, Denmark 4 percent, and small quantities were received from Japan, West Germany, and the United Kingdom.

Tariff.—The duty on arsenic metal was reduced under the General Agreement on Tariffs and Trade (GATT) from 2.5 cents per pound, effective June 30, 1958, to 2.2 cents on January 1, 1968. The rate was further reduced to 2.0 cents on January 1, 1969 and again to 1.7 cents on January 1, 1970. Arsenic oxide (white arsenic) enters duty free.

Table 1.—U.S. imports for consumption of white arsenic (As_2O_3) content, by countries

Country	1968		1969		1970	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	254	$41	17	$4	---	---
Canada	8	2	---	---	---	---
France	6,424	600	4,336	420	2,650	$274
Germany, West	14	3	---	---	---	---
Japan	199	14	---	---	---	---
Mexico	7,159	716	7,361	875	7,750	867
Peru	644	52	255	19	110	65
South Africa, Republic of	1,134	105	121	13	111	13
Sweden	9,315	1,090	6,071	732	8,142	870
U.S.S.R.	44	3	---	---	---	---
Western Africa, n.e.c	---	---	10	1	---	---
Total	25,195	2,626	18,171	2,064	18,763	2,089

Table 2.—U.S imports for consumption of arsenicals, by classes

(Thousand pounds and thousand dollars)

Class	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
White arsenic (As_2O_3)	50,390	$2,626	36,341	$2,064	37,525	$2,089
Metallic arsenic	819	583	692	568	912	1,876
Sulfide	50	12	19	5	17	5
Sheepdip	---	---	44	9	---	---
Sodium arsenate	75	6	110	11	186	23
Lead arsenate	---	---	45	6	---	---
Arsenic compounds, n.e.c	---	---	10	43	42	50

World Review.—*Brazil.*—All white arsenic produced in Brazil in 1970 was recovered as a byproduct of the treatment of gold ore by one company–Mineração Morro Velho, S.A.

Mexico.—Asarco Mexicana, S.A., and Metalúrgica Mexicana Peñoles account for most of the arsenic production in Mexico. At the Asarco plant in Chihuahua, speiss, containing about 30 percent arsenic, is recovered from processing lead ore and concentrate in a reverberatory furnace. Arsenic is recovered also from flue dusts from the Chihuahua smelter. From 660 to 770 tons of speiss is sent monthly to the smelter in San Luis Potosi. After treatment of the speiss, arsenic and antimony are processed in a Godfrey furnace, and black arsenic (95 percent As) is produced. Nearly 400 tons of arsenic (metal content) is recovered monthly.

The Peñoles smelter at Torreón recovers from 120 to 165 tons of arsenic monthly from flue dusts and ships more than 600 tons of speiss to the Asarco Chihuahua smelter for treatment.

Table 3.—White arsenic [1] (arsenic trioxide): World production by countries

(Short tons)

Country [2]	1968	1969	1970 [p]
Brazil	344	331	328
Canada	[r] 337	[r] 170	100
France	15,232	[e] [r] 15,000	[e] 15,000
Germany, West	[r] 746	[r] 648	[e] 460
Japan	789	786	974
Mexico	14,915	[r] 8,800	7,625
Peru	1,353	530	851
Portugal	[r] 207	[r] 272	[e] 275
South-West Africa [3]	[r] 2,450	[r] 2,444	4,478
Spain	143	110	[e] 110
Sweden	23,259	[r] 18,188	18,078
U.S.S.R.[e]	[r] 7,770	[r] 8,630	7,880
United States	W	W	W
Total	[r] 67,545	[r] 55,909	56,159

[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.
[2] In addition to the countries listed, Argentina, Austria, Belgium, China (mainland), Czechoslovakia, East Germany, Finland, Hungary, Southern Rhodesia, 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 year stated; data given are white arsenic equivalent of reported black arsenic oxide production.

CESIUM AND RUBIDIUM [3]

Domestic Production.—No cesium or rubidium ores were produced in the United States in 1970. W. R. Grace & Co. and Penn Rare Metals Division of Kawecki Berylco Industries, Inc., shipped pollucite from stocks at plants at Erie, Mich., and Revere, Pa.

Although cesium and rubidium were not produced as metal, the production of their compounds increased. The raw material sources of all cesium and rubidium compounds produced in the United States were imported pollucite and ALKARB, a residue from past lithium compound production.

Cesium and rubidium compounds were produced by Penn Rare Metals; American Potash & Chemical Corp., Trona, Calif.; Cooper Chemical Co., Long Valley, N.J.; and Rocky Mountain Research, Inc., Denver, Colo. MSA Research Corp., Calley, Pa., and Penn Rare Metals shipped cesium and rubidium metal from inventories.

Consumption and Uses.—Statistical data on the consumption and uses of cesium and rubidium metal and compounds were not available.

Cesium and rubidium were probably used primarily in research and development. Of special interest was there use in magnetohydrodynamic generators and thermionic converters. The development of these devices for commercial application could result in large increases in the use of cesium.

Various forms of cesium and rubidium had applications in pharmaceuticals, photoelectric cells, photomultiplier tubes, scintillation counters, magnetometers, vacuum tubes, infrared lamps, ultracentrifuges, and chemical processes as a catalyst. Cesium and rubidium and their compounds can be used as alternatives for each other in some cases.

Prices.—Domestic prices of cesium and rubidium ores were not published. Metal Bulletin quoted a nominal price for pollucite concentrates, f.o.b. source, containing a minimum of 24 percent Cs_2O, at $11.64 per long ton unit (22.4 pounds) of Cs_2O. The American Metal Market Quotation on cesium metal, 99+ percent, was unchanged at

[3] By Horace F. Kurtz, industry economist, Division of Nonferrous Metals.

$100 to $375 per pound. The quotation on rubidium metal, 99.5+ percent, was also unchanged at $300 per pound.

Table 4.—Prices of selected cesium and rubidium compounds

Item	Base price per pound[1]	
	Technical grade	High-purity grade
Cesium bromide	$28	$65
Cesium carbonate	29	67
Cesium chloride	30	68
Cesium fluoride	35	75
Cesium hydroxide	35	75
Rubidium carbonate	45	75
Rubidium chloride	46	76
Rubidium fluoride	51	83
Rubidium hydroxide	51	83

[1] Excludes packaging cost, 50 to 100 pound quantities, f.o.b. Revere, Pa.

Source: Kawecki Berylco Industries, Inc.

Foreign Trade.—Pollucite was imported from Africa during the year, but data on quantities and value were not available. Imports of cesium compounds declined 4 percent, reflecting reduced receipts of cesium chloride. Imports of rubidium metal and compounds were negligible.

Table 5.—U.S. imports for consumption of cesium compounds, by countries

Country	Cesium chloride		Cesium compounds, n.s.p.f.	
	Pounds	Value	Pounds	Value
Germany, West	1,278	$46,949	3,709	$137,477
Netherlands	------	-------	23	1,398
Switzerland	------	-------	4	255
United Kingdom	57	1,316	58	1,661
Total	1,335	48,265	3,794	140,791

World Review.—Two hundred tons of pollucite, averaging over 20 percent Cs_2O, was shipped from Canada to the U.S.S.R. during 1970 and the latter part of 1969 by Tantalum Mining Corporation of Canada Ltd. The ore originated at the Bernic Lake mine, Manitoba, Canada.

Technology.—A method has been developed to produce very high purity cesium and rubidium metal for electronic structure studies.[4] In this technique, purified chloride is reduced using calcium metal.

GALLIUM[5]

Domestic Production.—Gallium metal was produced as a byproduct of alumina production by the Aluminum Company of America at its Bauxite, Ark., plant. Gallium metal, oxide, and trichloride were produced by Eagle-Picher Industries, Inc., at its Quapaw, Okla., plant.

Consumption and Uses.—The largest consumption of gallium is in electronic applications. When alloyed with phosphorus, arsenic, and antimony, gallium forms versatile semiconducting materials. Gallium semiconducting compounds are used in transistors and diodes, and to dope other semiconductor materials. Gallium is used in the construction of high-temperature quartz-tube thermometers. Other uses for gallium are as a sealant for glass joints, as a constituent of solders, as backing for mirrors, as a low temperature lubricant, as a component of dental alloys, and in research.

Prices.—Market prices, per gram, of galium from bauxite sources in 1970 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, waste and scrap) were as follows:

Country of origin	Pounds	Value
Belgium-Luxembourg	108	$14,181
Canada	111	3,739
Germany, West	14	1,349
Japan	1	304
Netherlands	15	7,699
Switzerland	1,869	361,126
United Kingdom	213	39,669
Total	2,331	428,067

World Review.—Toho Zinc of Japan has established a gallium plant in its Fujioka smelter. The plant will have a target production of 600 kilograms of gallium per year.

[4] Schmidt, P. H. The Purification of Cesium and Rubidium Metals by Chloride Reduction Under High Vacuum Conditions. J. Electrochem. Soc., v. 116, No. 9, September 1969, pp. 1279–82.

[5] By E. Chin, chemist, Division of Nonferrous Metals.

Technology.—A new semiconductor laser, developed by Bell Telephone Laboratories, operates on ordinary dry cells, needs no cooling system, and is capable of operating continuously at room temperature.[6] This semiconductor device consists of a very thin layer of gallium arsenide sandwiched between layers of aluminum gallium arsenide. When current is applied, near-visible infrared light is emitted. The problem with previous semiconductor lasers has been that the required high currents generated so much heat that the lasers could operate only in short bursts.

GERMANIUM [7]

The shortage of germanium that developed in 1969 continued until mid-1970. This shortage caused a 53-percent increase in the price of domestic zone refined (intrinsic) germanium metal and a 70-percent increase in the price of electronic grade germanium dioxide. A significant decline in demand started in July, and continued through the year. Evidently this decline followed the general weakening of overall business activity. Consumption of transistors and semiconductor diodes decreased 35 and 15 percent, respectively, from that of 1969. The decrease was greater for germanium than for silicon.

Domestic Production.—Primary germanium output was obtained from smelter residues resulting from the retorting and refining of zinc concentrates for the Kansas-Oklahoma area and from zinc concentrates from fluorspar-zinc-lead ores of the Kentucky-Illinois area. The domestic producers of germanium from primary and secondary sources were Eagle-Picher Industries, Inc., of Miami, Okla., Sylvania Electric Products, Inc., of Towanda, Pa., and Kawecki Berylco Industries, Inc., of Revere, Pa.

Consumption and Uses.—Germanium is principally used by the electronics industry; most of the germanium goes into semiconductors. The increased use of silicon in the semiconductor field may be a factor in the decline in the germanium market late in 1970. Although sales were up approximately 50 percent over 1969, significant quantities of germanium were stockpiled by the users. These consumer stockpiles could result in a decrease in demand for 1971.

A new prospect for germanium is its use in optics for infrared transmission. It is probable that these optics could demand an amount of germanium equal to the amount used in semiconductors. Gallium-doped germanium is being used for nuclear particle detection. In superconductors, Nb_3(Al-Ge) was found to have a higher transition temperature than previously tested materials.

Prices.—On January 15, the price of zone refined (intrinsic) germanium metal was increased from $201.50 per kilogram to $226.75, and for electronic-grade germanium oxide from $105 per kilogram to $122.50. On April 1, one company again raised the metal and oxide prices to $269.50 and $151 per kilogram, respectively; the other two producers followed with their price increases on April 15 and May 1. Finally, on June 8, the metal and oxide increased to $293 and $167.50.

Foreign Trade.—U.S. imports of germanium metal (unwrought, waste and scrap) increased 149 percent in quantity to 19,549 pounds, and 121 percent in value to $2,101,096. The first recorded imports from the U.S.S.R. were in 1969. In 1970, this bloc country was the leading supplier with 9,057 pounds, or 46 percent of the total U.S. germanium imports.

[6] Chemical Engineering News. Lasers: The Heat's Off. V. 48, No. 38, Sept. 7, 1970, p. 13.
[7] By Herbert R. Babitzke, physical scientist, Division of Nonferrous Metals.

Table 6.—U.S. imports for consumption of germanium, by countries

Country	Pounds	Value
	Unwrought, waste and scrap	
Belgium-Luxembourg	1,984	$646,304
Canada	6	276
Czechoslovakia	770	57,634
Denmark	738	62,485
France	112	9,491
Germany, West	2,267	201,519
Italy	165	18,000
Japan	2,009	183,516
United Kingdom	2,441	153,166
U.S.S.R.	9,057	768,705
Total	19,549	2,101,096
	Wrought	
Belgium-Luxembourg	4	1,856

World Review.—The Democratic Republic of the Congo (Kinshasa) continued production of germanium in 1970. The principal source was the Prince Leopold mine near Kipushi where renierite, (Cu, Ge, Fe, Zn, As) S, is associated with copper and zinc minerals. The concentrates were shipped to Belgium-Luxembourg for recovery of refined germanium metal or dioxide.

No production data are available from the U.S.S.R., the largest exporter of germanium to the United States.

INDIUM [8]

Domestic Production.—The American Smelting and Refining Company was the only domestic producer of indium during the year. Output was recorded at its plants at Perth Amboy, N.J., and Denver, Colo. Indium is produced from certain smelter flue dusts and residues in which recoverable amounts of indium have been concentrated during treatment of zinc ores.

Uses.—Indium was used mainly in electronic devices as a component of solder for connecting lead wires to germanium in transistors and in intermetallic germanium semiconductors as a property-modifying agent. The compounds of indium (arsenides, antimonides, and phosphides) were used in other semiconductor applications. Use for indium was also found as a component in special solders, glass-sealing alloys, and in dental alloys. Although indium use as a coating for bearings in aircraft appeared to be lessening, it was reported that some interest in indium for bearing use was expressed by the automotive industry.

Stocks.—Producer stocks of indium decreased during the year, partly because one of the domestic producers ceased production.

Prices.—Market quotations held steady throughout the year; indium metal was $2.50 per troy ounce, in lots of less than 100 ounces, $2.05 in lots of 100 ounces, and at $1.95 in lots of 1,000 ounces. In lots of 5,000 ounces the price was $1.85 per troy ounce.

Foreign Trade.—No indium was exported from the United States. The following tabulation shows indium imported for consumption during 1970, by source:

Country	Troy ounces	Value
	Unwrought, waste and scrap	
Canada	207,731	$280,640
Netherlands	59,126	69,856
Peru	52,082	91,137
Japan	49,778	71,133
Germany, West	25,246	29,976
Belgium-Luxembourg	6,415	22,865
United Kingdom	650	8,738
Total	401,028	574,345
	Wrought	
United Kingdom	6	814

Canada was the largest supplier with 52 percent of total imports; the Netherlands, with 15 percent of total imports, increased its shipments to U.S. markets by nearly 115-fold over the 1969 figure. The remaining 33 percent of imports was supplied by five different countries in varying quantities.

Under the General Agreement on Tariffs and Trade, import duties on unwrought waste and scrap metal in 1970 were 7 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 levied at 12.5 percent ad valorem for the most-favored-nation rate, and 45 percent ad valorem for imports from Bloc countries, except Yugoslavia.

RADIUM [9]

Although radium may find limited use throughout the world, it is used very little in the United States since less expensive and less dangerous radioactive substitutes have become available.

Legislation and Government Programs.—The status of health programs with respect to radium and radioisotope usage and

[8] By Burton E. Ashley, physical scientist, Division of Nonferrous Metals.

[9] By John A. Stock, mining engineer, Division of Nonferrous Metals.

control were reviewed in pamphlets issued by the U.S. Department of Health, Education, and Welfare.

Domestic Production.—No radium has been produced in the United States for many years. The principal dealer is the Radium Chemical Co., Inc., New York. Radium Chemical also offers a reincapsulation service for radium.

Uses.—The continuing use of radium in the therapeutic treatment of cancer is due primarily to the penetrative power of its gamma radiation. During 1970, radium was used in radiobiological research for a comparison of relative biological effectiveness (RBE) of californium-252.[10] Research has indicated that the fast neutrons from californium-252 may be more effective in treating some types of cancer than gamma rays from radium. Experiments showed that californium-252 was about three times as effective as radium with oxygenated tissue culture, and also more effective with oxygen deficient tissue.

Prices.—Radium prices have not been quoted for several years. They have been as high as $21.50 per milligram and as low as $2 per milligram. Because of efforts to license and limit the use of radium, some former users have offered radium salts at low prices or free of charge in order to dispose of the material.

RHENIUM [11]

Rhenium production increased during the year to meet the increasing demand for rhenium-platinum catalysts in the petrochemical industry. As a result of this situation, there was an increase in rhenium prices during 1970 and some dealer prices were about double those quoted by domestic producers.

Domestic Production.—Production of rhenium, a secondary byproduct recovered from molybdenite (MoS_2) associated with Southwestern porphyry copper ores, increased during 1970 to an estimated 5,900 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.), was the country's major rhenium producer during the year. Rhenium salts were recovered for CRM at Kennecott's molybdenite roasting facility near Garfield, Utah, from domestic molybdenite concentrates and from MoS_2 imported from Chile. In addition, CRM processed rhenium scrap imported in 1969 from West Germany. Shattuck Chemical Co., Denver, Colo., a subsidiary of Engelhard Minerals & Chemicals Corp., recovered rhenium salts from the MoS_2 recovered from domestic porphyry copper ores. During 1970, M&R Refractories Inc., Springfield, N.J., a subsidiary of Whittaker Corp., became the third domestic rhenium producer and recovered rhenium from molybdenite associated with Arizona porphyry copper ores.

Porphyry copper deposits in Canada, Chile, Congo (Kinshasa), Mexico, Peru, the United States, and the U.S.S.R. represent the only significant or potential sources of rhenium. Rhenium metal recovery facilities existed at molybdenite roasting plants in Belgium, France, Sweden, the Soviet Union, the United Kingdom, the United States, and West Germany.

Consumption and Uses.—Approximately 75 percent of the estimated rhenium consumption of 3,150 pounds was used as rhenium and rhenium-platinum catalysts replacing the more expensive platinum catalysts used in the cracking of petroleum hydrocarbons.[12] This application received added impetus from the development of

[10] U.S. Atomic Energy Commission. Californium-252. No. 4, August 1970, p. 9.
[11] By Richard F. Stevens, Jr., physical scientist, Division of Ferrous Metals.
[12] Chemical and Engineering News. New Catalysts Increase Reformer Yields. V. 48, No. 26, June 22, 1970, pp. 62–63.

Table 7.—Salient rhenium statistics

(Pounds of contained rhenium)

	1966	1967	1968	1969	1970
Production (in rhenium salts) [e]	1,620	1,725	2,400	3,500	5,900
Consumption (metal) [e]	1,040	850	775	2,000	3,150
Imports (metal and scrap) gross weight	84	96	436	[r] 9,780	210
Stocks, Dec. 31, (metal) [e]	600	40	130	1,710	2,580

[e] Estimate. [r] Revised.

lead-free gasolines to reduce air pollution from internal combustion engines.

Other applications of rhenium continued to be in high-temperature thermocouples, flashbulb filament wires, and coatings. The development of ductile, high-temperature tungsten and molybdenum-base rhenium alloys decreased significantly during the year.

A comprehensive survey was published of the mineralogy, geology, and metallurgy of molybdenum and rhenium found in porphyry copper deposits around the world. It describes the current technology associated with recovering molybdenum and rhenium.[13]

A complete translation of a Soviet publication on rhenium-refractory metal alloys became available. It discusses rhenium production, alloy development, chemical, physical, and mechanical properties, heat treatment, weldability, corrosion resistance, catalytic properties, high-temperature applications, and the phase diagrams of these binary and ternary alloys.[14]

A second translated Soviet publication that became available during the year contains a section that describes the properties and history of rhenium, rhenium occurrence and recovery, current technology, and uses of rhenium.[15]

Prices.—In February 1970, Cleveland Refractory Metals (CRM) increased prices for rhenium metal powder. The new producer prices for contract customers were as follows:

	Per pound
Rhenium metal powder, 99.99 percent purity, up to 1 pound	$1,200
Rhenium metal powder, over 1 pound but not more than 5 pounds	1,100
Rhenium metal powder, over 5 pounds but not more than 20 pounds	1,050
Rhenium metal powder, over 20 pounds but not more than 50 pounds	1,000
Rhenium metal powder, over 50 pounds	875

As a result of increased demand for rhenium metal powder, traders were reportedly selling rhenium of foreign origin for $1,200 to $1,400 per pound.

The increased price of rhenium metal was reflected by consumers who use rhenium to make tungsten-rhenium wire. New price schedules, reflecting increases ranging from 4 to 63 percent depending upon the wire size, were issued during the year.

Foreign Trade.—Revised imports of unwrought rhenium metal and scrap in 1969 totaled 9,780 pounds, gross weight, valued at $352,108. Of this quantity, 9,059 pounds valued at $84,809 was imported from West Germany in the form of rhenium scrap. The remaining 721 pounds represented rhenium metal powder, which was imported primarily from the U.S.S.R. (31 percent), Sweden (30 percent), West Germany (24 percent), and France, (15 percent).

During 1970, imports of unwrought rhenium metal and scrap decreased to 210 pounds, gross weight, valued at $111,629. These imports, all of which represented rhenium metal powder, came from West Germany (38 percent), the U.S.S.R. (35 percent), and France, (27 percent). There were no imports of rhenium scrap during the year. The rhenium from France and West Germany is believed to have been recovered from molybdenite obtained from porphyry copper ores from Chile. Rhenium from the Soviet Union is presumed to have been recovered from flue dusts of Russian molybdenite roasters. The average price of unwrought rhenium metal imports from France and West Germany during the year, excluding the U.S. duty of 7 percent ad valorem, ranged from $927 to $435 per pound, respectively. The average price of imported unwrought rhenium metal from the U.S.S.R. excluding the 25 percent ad valorem duty applicable to Communist countries, was $321 per pound in 1970. There were no imports of wrought rhenium during the year, and exports of rhenium in all forms were less than 10 pounds.

As part of the 5-year program of tariff reductions agreed upon at the "Kennedy round" Tariff Negotiations, the duties on unwrought and wrought rhenium from non-Communist countries were further reduced. Effective January 1, 1971, the duty on unwrought rhenium metal and scrap was reduced from 7 to 6 percent ad valorem and that for wrought rhenium from 12.5 to 10.5 percent ad valorem. The duty on unwrought rhenium from Communist Bloc countries remained unchanged at 25

[13] Sutulov, Alexander. Molybdenum and Rhenium Recovery From Porphyry Copper Ores. University of Concepción, Concepción, Chile, 1970, 259 pp.

[14] Savitskii, E.M., M.A. Tylkina and K.B. Povarova. Splavy reniya (Rhenium Alloys). Moscow, 1965. Available from the National Technical Information Service, Springfield, Va., TT 69-55081, 1970, 358 pp.

[15] Songina, O.A. Izdatel'stvo "Metallurgyiya" (Rare Metals). Moscow, 1964. Available From the National Technical Information Service, Springfield, Va. TT 70-50021, 1970, pp 15-32.

Table 8.—U.S. imports for consumption of rhenium (including scrap), by countries
(Gross weight)

Country	1968		1969		1970	
	Pounds	Value	Pounds	Value	Pounds	Value
France	17	$6,722	109	$53,045	58	$53,789
Germany, West	419	142,217	r 9,230	153,358	79	34,373
Sweden	---------	---------	215	72,681	---------	---------
U.S.S.R.	---------	---------	222	71,660	73	23,467
United Kingdom	(1)	269	4	1,364	---------	---------
Total	436	149,208	r 9,780	352,108	210	111,629

r Revised.
1 Less than ½ unit.

percent ad valorem and that on wrought rhenium remained unchanged at 45 percent ad valorem.

During both 1969 and 1970 the import duty on rhenium scrap was suspended.

Technology.—Investigations conducted by Bureau of Mines engineers indicated that both rhenium and tungsten metal powder could be reclaimed from scrap tungsten alloys containing about 25 percent rhenium.[16] By oxidizing the scrap at 950 °C the volatile rhenium heptoxide could be separated from tungsten trioxide, with an overall recovery efficiency of approximately 96 percent.

Studies conducted by CRM evaluated the technology of rhenium chemicals, the advances in rhenium catalysts, and the use of rhenium as an electrical contact material.[17]

New platinum-rhenium catalysts were developed. Because of their unique high stability, they give excellent temperature stability, high yield, excellent regeneration stability, and can be recovered from a temporary presence of catalytic poisons.[18]

The use of coated powders in the production of dense homogeneous tungsten-rhenium (W-Re) and molybdenum-rhenium (Mo-Re) alloys is more practical, reproducible, and economical than standard powder metallurgy techniques.[19]

Rhenium-coated tungsten powder particles having some alloying at the Re-W interface were developed using a special coreduction process. The most significant advantage of using this coated powder process is the reduction of the sigma phase and the corresponding increase in both strength and ductility.

As a result of the increased demand for rhenium, studies were conducted to determine new methods of recovering rhenium by solvent extraction using ion-exchange techniques, and methods for recovering rhenium from used catalysts and other secondary sources.[20]

[16] Ferrante, M.J., F.E. Block, A.D. Fugate, and F.A. Skirvin. Recovery of Rhenium From Tungsten-Rhenium Alloys. BuMines Rept. of Inv. 7254, April 1969, 11 pp.

[17] Davenport, William H., Jon W. Spleman, and Howard J. Vaeth. Rhenium Chemicals—Their Properties and Applications. Cleveland Refractory Metals, Solon, Ohio, 1969, 78 pp.

Davenport, William H., Valerie Kollonitsch, and Charles H. Kline. Recent Advances in Rhenium Catalysts. Cleveland Refractory Metals, Solon, Ohio, 34 pp.

Peters, John E. Rhenium as an Electrical Contact Material. Cleveland Refractory Metals, Solon, Ohio, (paper presented to ASTM Committee B-4, Subcommittee IV at meeting in Pittsburgh, Pa., on Mar. 4, 1969), 27 pp.

[18] Field, Sanford. Development in Aromatics Processing. Proc. API Division of Refining, v. 50, 1970, pp. 340–365.

Jacobson, R.L., and C.S. McCoy. High-Severity RHENIFORMING: Route to Maximum Aromatics. Proc. API Division of Refining, v. 50, 1970, pp. 324–339.

Jacobson, R.L., H.E., Kluksdahl, C.S. McCoy, and R.W. Davis. Platinum-Rhenium Catalysts: A Major New Catalytic Development. Proc. API Division of Refining, v. 49, 1969, pp. 504–521.

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.

Stormont, D.H. New Reforming Catalyst Features Imported Stability, High Yields. Oil & Gas J., v. 67, No. 17, Apr. 28, 1969. pp. 63–65.

Sutton, E. A. Commercial Experience With Recently Developed Platforming Catalysts. Proc. API Division of Refining, v. 50, 1970, pp. 293–303.

[19] Peters, John E. Recent Developments in Rhenium and Rhenium Alloy Powder Metallurgy. J. of Metals, v. 21, No. 4, April 1969, pp. 27–30.

[20] Dueros, Robert, and Pierre LeGross. Influence of Oxidation on the Low-Pressure, High-Temperature Decomposition of Ethylene on Tungsten and Rhenium Surfaces. Surface Sci., (Amsterdam, the Netherlands), v. 15, No. 3, March 1969, pp. 425–442.

Platzke, R. N., and J. D. Prater (assigned to Kennecott Copper Corp., New York). Process for the Recovery of Molybdenum Values. Canadian Pat. 852,133, Sept. 22, 1970.

———. (assigned to Kennecott Copper Corp., New York). Process for the Recovery of Molybdenum Values as High Purity Ammonium Paramolybdate From Impure Molybdenum-Bearing Solutions With Optional Recovery of Rhenium Values If Present. U.S. Pat. 3,458,277, July 29, 1969.

Sakurai, Hyoichiro (assigned to Mitsubishi Petrochemical Co., Ltd., Tokyo, Japan). Recovery of Rhenium From Catalysts Containing Nickel or Iron. West German Pat. 1,942,191, Feb. 26, 1970.

The kinetics of molybdenite roasting and rhenium volatilization were evaluated in a multiple-hearth furnace.[21]

The lattice dilation of W-Re, chromium-rhenium (Cr-Re) and Mo-Re alloys plays an insignificant role in the rhenium ductilizing effect in the Group VIA refractory metals.[22]

Bend test evaluations of the weldability of arc-cast W-25Re and W-25Re-30Mo alloys indicated that the W-Re alloy had improved thermal shock resistance, but the W-Re-Mo alloy exhibited extensive hot tearing and poor weldability. However, W-25Re-30-Mo alloy made by standard powder metallurgical techniques exhibited excellent weldability.[23]

SCANDIUM [24]

Scandium, produced in small quantities as a byproduct of uranium processing, is being used commercially in small but increasing amounts in the manufacture of a recently developed high-intensity lamp. Depleted domestic supply of raw materials is slowly being replaced by imports. Prices for the materal and its compounds have declined because of the lower costs of raw materials.

Domestic Production.—During 1970, a reduced number of specialty chemical firms were engaged in the production, refining, and sales of scandium. Research Chemicals, a division of Nuclear Corp. of America, Phoenix, Ariz., produced and refined scandium on a regular basis. Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carlé Place, N.Y., deals in scandium and produced intermittently. Sales of scandium are handled by Alfa Inorganics, Inc., Beverly, Mass., and King Products, Inc., Arlington, N.J.

Several kilograms of scandium were produced at about the same level as in previous years. Although scandium has been extracted from the mineral thortveitite, the primary commercial source since 1960 has been concentrate from waste solutions derived from uranium processing. Domestic uranium mills have not produced scandium-bearing solutions since 1964. Output of scandium has come from producers' stocks or concentrates imported from Australia and Canada.

Potential supplies of scandium from domestic uranium ore are large, but unavailable from current processing methods. Other domestic sources of scandium are phosphate rock and tungsten concentrate, but the limited scandium market does not make it profitable to extract. Small amounts of thortveitite may still be imported from Norway. The only thortveitite found in the United States was reported in 1963 to be near Darby, Mont.[25]

Uses.—Two companies are employing scandium in a new form of metal halide lamp. One version recently developed by Sylvania Electric Products, Inc., is called Metalarc. Westinghouse Electric Corp. is currently manufacturing a similar lamp. Basically mercury vapor lamps containing sodium oxides, these high-intensity lamps also use small amounts of high-purity scandium metal because of the multilined spectrum of incandescent scandium vapor. The combination of materials provides high illuminating efficiency and a color range close to natural sunlight. Presently being used at night sporting events, especially those televised in color, and for automobile showrooms, it is expected that usage will continue to expand into areas where strong lighting and natural color rendering are important. These lamps have the disadvantage of costing several times more and having about one-third the life of a straight mercury vapor lamp. Competition may also come from lamps using dysprosium and thallium. General Electric Co. has a lamp employing sodium, thallium, and indium. Despite the possibility of competition from other materials, it is estimated that the several kilograms of scandium now used for these lamps will

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[21] Coudurier, Lucien, Igor Wilkomirsky, and Georges Morizot. Molybdenite Roasting and Rhenium Volatilization in a Multiple-Hearth Furnace. Inst. of Min. & Met. Trans./Sec. C., (London), v. 79, No. 760, March 1970, pp. C34–C40.

[22] Garfinkle, Marvin. Effect of Rhenium Alloying On Lattice Dilation of the Group VIA Refractory Metals. Met. Trans., (Met. Soc. of AIME), v. 1, No., 1, 1970, pp. 1062–1063.

[23] Lessmann, G. G., and R. E. Gold. Weldability of Tungsten-Base Alloys. Welding J., v. 48, No. 12, December 1969, 15 pp.

[24] By John A. Stock, mining engineer, Division of Nonferrous Metals.

[25] Parker, R. L., and R. G. Havens. Thortveitite Associated With Fluorite, Ravalli County, Mont. U.S. Geol. Survey Research, Prof. Paper 475–B, 1963, pp. B–10, B–11.

triple in the next five years. Production of mercury-sodium-scandium lamps is also underway in the United Kingdom by a subsidiary of Sylvania and by companies in Germany, Holland, and Japan.

Other uses of scandium are for security classified research supported by the Government, and for tracing fluid flows in oil wells with milligram quantities of the radioisotope Sc^{46}. This latter use may face competition from californium-252, which has been studied in the field as a tracer.[26]

Prices.—The metal has been quoted at from $4.40 to $10 per gram, the oxide from $2.80 to $3.50 per gram, and salts (chlorides, nitrates, sulfates, oxalates, and acetates) from $2 to $2.50 per gram. Scandium foil was priced from $25 to $123 per gram, and quotations for punched disks ranged from $110 to $140 per gram (high purity). Comparisons with other years show significant reduction in prices in 1970.

Technology.—Little information was available on developments in technology during the year, but a patent was granted for the recovery of scandium values from rare-earths by ion exchange.[27]

SELENIUM [28]

Following a strong trend in the first quarter, production and shipments of selenium during the fourth quarter declined 60 and 57 percent, respectively.

On March 4, the Office of Emergency Preparedness reduced the stockpile objective for selenium from 475,000 pounds to zero. Since the inventory equals the objective, this quantity became available for sale after congressional approval had been attained.

Domestic Production.—Selenium was produced at four plants operated by the following major electrolytic copper refiners: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Co., 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 use of selenium in the production of rectifiers declined, but remained about the same as in 1969 in xerography, where it is used in an arsenic alloy as the photoconductive material.

Prices.—The producers prices for commercial and high-purity selenium were raised from $7 and $8.50 per pound to $8 and $9.50 on January 1. On October 5 the price was raised to $9 and $10.50 per pound. Dealers' quotations dropped from $20 to $25 per pound in January to a level near producers' prices during the remainder of the year.

Foreign Trade.—Imports for consumption of selenium declined 17 percent but

[26] U.S. Atomic Energy Commission. Californium-252 Progress. No. 4, August 1970. p. 15.
[27] Orlandini, K. A., and J. Korkisch (assigned to the U.S. Atomic Energy Commission, January 1971). U.S. Pat. 3,554,693, Jan. 12, 1971, 2 pp.
[28] By John W. Cole, physical scientist, Division of Nonferrous Metals.

Table 9.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1966	1967	1968	1969 r	1970
United States:					
Production	620	598	633	1,247	1,005
Shipments to consumers	845	659	941	1,429	1,056
Imports for consumption	286	301	583	546	454
Stocks, Dec. 31, producers	797	736	428	240	189
Price per pound, commercial grade	$4.50–$6	$4.50–$6	$4.50–$6	$7–$8.50	$9–$10.50
World: Production	1,973	2,051	1,946	2,789	2,392

r Revised.

the value of imports increased 29 percent. Canada continued to be the principal supplier as shown in the following list:

U.S. imports for consumption of selenium, by countries

(Thousand pounds and thousand dollars)

Country	Quantity	Value
	Unwrought, waste and scrap	
Australia	5	$40
Canada	428	4,056
Germany, West	(1)	3
Peru	1	6
Total	434	4,105
	Oxide (selenium content)	
Canada	12	116
Germany, West	(1)	1
United Kingdom	8	101
Total	20	218

[1] Less than ½ unit.

Exports were about 25 percent less than in 1969.

World Review.—The United States, Canada, and Japan continued to lead the world in selenium production, with 42, 26, and 19 percent, respectively, of the free world production. A selenium refinery with a capacity of 20,000 pounds per year was added to the Government-owned Las Ventanas copper refinery, Valparaiso, Chile.

Technology.—Abstracts were published covering more than 2.600 published books and scientific papers that contain references to selenium and tellurium.[29] A patent was issued [30] covering the use of niobium (columbium) diselenide ($NbSe_2$) mixed with carbon and resin to produce a self-lubricating brush that is useful for high altitude or vacuum applications.

A comprehensive study of the technology of selenium and selenides [31] became generally available to researchers. Results of original research are discussed as well as information from Soviet and foreign literature.

Table 10.—Selenium: World production, by countries [1]

(Thousand pounds of contained selenium)

Country [2]	1968	1969	1970 p
Australia e	4	4	4
Belgium-Luxembourg [3]	54	46	53
Canada	636	r 796	604
Finland	16	14	15
Japan	399	435	449
Mexico	2	42	42
Peru	13	15	15
Sweden	r 168	e 170	170
United States	633	r 1,247	1,005
Yugoslavia	r 21	20	35
Total	r 1,946	r 2,789	2,392

e Estimate. p Preliminary. r Revised.

[1] Insofar as possible, data relate to refinery output only. Thus countries such as Chile, Congo (Kinshasa), Philippines, and Zambia that produce major quantities of selenium in copper ores and concentrates, but do not recover elemental selenium, are 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, but available information is inadequate to make reliable estimates of output levels.

[3] Exports.

TELLURIUM [32]

Demand for tellurium was about 8 percent less than in 1969, which resulted in decreases in production, and imports. Shipments by producers increased and yearend stocks of refined tellurium declined to the lowest level since 1963.

Domestic Production.—Production of tellurium was reported by the following companies: American Metal Climax. Inc., Carteret, N.J.; American Smelting and Refining Co., 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.

Foreign Trade.—Imports for consumption of tellurium decreased 43 percent in

[29] Selenium and Tellurium Development Association, Inc. Selenium and Tellurium Abstracts, New York, 1970.

[30] Boes, David J., William Dwight Johnston, and Lawrence E. Moberly (assigned to Westinghouse Electric Corp.). Electrically Conductive Niobium Diselenide Solid Lubricant Members. U.S. Pat. 3,523,079, Aug. 4, 1970.

[31] Chizhikov, D. M., and V. P. Shchastlivyi. Selenium and Selenides. Selenium and Tellurium Development Association, Inc., New York, 1968, 403 pp.

[32] By John W. Cole, physical scientist, Division of Nonferrous Metals.

Table 11.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1966	1967	1968	1969 r	1970
United States:					
Production, primary and secondary	199	135	121	234	158
Shipments to consumers	215	172	201	182	209
Stocks, Dec. 31, producers	195	186	157	177	128
Imports	18	91	71	112	64
Price per pound, commercial grade	$6	$6	$6	$6	$6
World: Production	334	270	258	395	357

r Revised.

quantity and 41 percent in value; they were as follows:

U.S. imports for consumption of tellurium, by country

(Thousand pounds and thousand dollars)

Country	Quantity	Value
Canada	29	$168
Germany, West	(1)	(1)
Peru	35	184
Switzerland	(1)	1
Total	64	353

[1] Less than ½ unit.

World Review.—The United States produced 44 percent of the free world production of tellurium; Japan moved up to second place with 22 percent; and Peru was third with 17 percent.

Technology.—A comprehensive study of tellurium and tellurides was published in English.[33] Results of original research are described as well as information from Soviet and foreign literature.

Table 12.—Tellurium: World production, by countries [1]

(Thousand pounds of contained tellurium)

Country [2]	1968	1969	1970 p
Canada	71	72	59
Japan	31	51	78
Peru	35	38	62
United States	121	234	158
Total	258	395	357

p Preliminary.

[1] Insofar as possible, data relate to refinery output only. Thus countries such as Chile, Congo (Kinshasa), and Zambia that produce major quantities of tellurium in copper ores and concentrates, but do not recover elemental 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, but available information is inadequate to make reliable estimates of output levels.

THALLIUM [34]

The applications of thallium or its compounds are at the present time limited. The toxic nature of thallium seems to deter its use.

Domestic Production.—The American Smelting and Refining Co., Denver, Colo., was the only domestic producer of thallium and thallium compounds. The company produced less thallium or thallium compounds than in 1969. Shipments to consumers were also less than in 1969.

Consumption and Uses.—Thallium is used principally for electronics and low-melting alloys with the consumption being divided equally (40 percent for each). Even with the curtailment of thallium compounds as agricultural pesticides, about 10 percent of the thallium is still being released to this end use. Organometallic chemistry consumes about 5 percent of the thallium. Organothallium compounds are used for synthesizing new organic compounds. Finally, about 5 percent is being used in development research.

Prices.—The price for thallium in 25-pound lots has been $7.50 per pound since December 1957.

Foreign Trade.—Imports for consumption of thallium (unwrought, waste and scrap) have doubled those of 1969, to 1,250 pounds at a value of $4,556. Thallium containing compounds amounted to 2,050 pounds valued at $7,235.

Technology.—New developments for thallium are the thallium oxide resistive glazes for printed circuits. Interest has developed in the use of thallium in low tem-

[33] Chizhikov, D. M., and V. P. Shchastlivyi. Tellurium and Tellurides. Selenium and Tellurium Development Association, Inc., New York, 1970, 297 pp.

[34] By Herbert R. Babitzke, physical scientist, Division of Nonferrous Metals.

Table 13.—U.S. imports for consumption of thallium, by countries

Country of origin	Compounds (gross weight)		Unwrought, and waste and scrap	
	Pounds	Value	Pounds	Value
Belgium-Luxembourg	57	$527	450	$1,696
France	500	1,062	----	----
Germany, West	1,451	3,290	800	2,860
Japan	8	1,031	----	----
United Kingdom	34	1,325	----	----
Total	2,050	7,235	1,250	4,556

perature alloys. Tl-Hg alloy has a low melting eutectic at —59° C,[35] and the ternary Tl-In-Hg alloy system has even a lower melting eutectic of —63° C, [36] which makes these alloys useful materials for low-temperature thermometry.

[35] Hansen, Max. Constitution of Binary Alloys. Metallurgy and Metallurgical Engineering Series. McGraw-Hill Book Co., Inc., New York, 2d ed., 1958, 842 pp.

[36] Freeberg, Benjamin F. (assigned to Vapor Corporation, Lombard, Ill.). Alloys of Mercury. U.S. Pat. 3,087,811, Apr. 30, 1963.

Minor Nonmetals

By Staff, Bureau of Mines

CONTENTS

GREENSAND [1]

Domestic production of greensand (glauconite) increased 10 percent in quantity and 20 percent in value compared with that of 1969. The average annual production for 1966–70 was 3,276 short tons valued at $216,000. The material was used for soil conditioning and water softening.

Greensand was produced by Kaylorite Corp., near Dunkirk, Md., and by Inversand Co., near Sewell, N.J. Information on production and sales for 1970 is withheld to avoid disclosing individual company confidential data.

A cooperative agreement between the Bureau of Mines and the State of Delaware (Geological Survey) to sample and evaluate Delaware greensand for potential uses continued.

IODINE [2]

Consumption of crude iodine established a record high in 1970 for the third year in a row. Domestic output remained at the same level, but imports increased slightly in tonnage and sharply in value, as compared with 1969.

Crude iodine production in the free world rose by 29,000 pounds or approximately 18 percent, almost all accounted for by Japan, which gained ground as the world's leading producer. This increase, however, was still not adequate to meet demand. The short-supply situation caused radical advances in iodine price, which stood at $1.24 to $1.30 per pound in December 1969 as compared with $1.45 to $1.59 in December 1970. Japan, holding at $1.45 near the end of the year, was trying to decide on an appropriate boost in price.

Legislation and Government Programs.—On December 31, 1970, the Government strategic stockpile contained 2,955,692 pounds of crude iodine and 5,056,147 pounds of supplemental stockpile for a total of 8,011,839 pounds. The stockpile objective for iodine, established by the Office of Emergency Preparedness, is 8 million pounds. There were no deliveries or withdrawals of iodine in the Government stockpile program in 1970.

Depletion allowances for domestic iodine producers were changed under terms of the Tax Reform Act of 1969. Effective with taxable years beginning after October 9, 1969, the depletion allowance for iodine from both domestic and foreign production is 14 percent of gross income, not to exceed 50 percent of net income without the depletion deduction.

Domestic Production.—The Dow Chemical Co., the only domestic producer, employed a process that has been in use since the start of operations in 1964 to recover crude iodine from well brines at Midland, Mich., as a coproduct with bromine, cal-

[1] By Donald E. Eilertsen, physical scientist, Division of Nonmetallic Minerals.
[2] By K. P. Wang, supervisory physical scientist, Division of Nonmetallic Minerals.

cium and magnesium compounds, and potash. Production was practically the same as in 1969, but value increased by nearly 14 percent.

Consumption and Uses.—Based on returns from questionnaires, approximately 4.9 million pounds of crude iodine was consumed by 38 firms in 14 States. Leading iodine-consuming States in 1970, 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.

This information is indicative of the use pattern, but is not necessarily completely comprehensive. Imports alone have been consistently higher than reported consumption, with net differences as follows, in thousands of pounds: 1968—1,432; 1969—803; and 1970—989. A more exact estimate of apparent consumption cannot be published because U.S. production figures for crude iodine cannot be revealed.

Increases were reported in the amount of crude iodine consumed in producing resublimed iodine, potassium iodide, 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.—Mid-1970 prices for crude iodine, c.i.f. United States, were increased from $1.30 to $1.45 per pound by the Mitsubishi International Corporation for Japanese iodine. The Chilean Nitrate Sales Corporation for Chilean iodine and the Dow Chemical Co. for domestic iodine increased prices to $1.59. Prices for resublimed iodine and iodine compounds increased accordingly. Late in the year, higher prices were imminent because of the world iodine shortage. Quoted prices for iodine and iodine compounds at yearend 1970 were as follows:

	Per pouud
Crude iodine, drums	$1.45–$1.59
Resublimed iodine, U.S.P., drums, f.o.b. works	3.49–3.51
Calcium iodate, drums, delivered	2.10–2.20
Calcium iodide, 35-pound drums, f.o.b. works	5.98
Potassium iodide, U.S.P., crystals, drums, 300 to 999 pounds, delivered	2.23
Potassium iodide, U.S.P., crystals, drums, smaller lots, delivered	2.25
Sodium iodide, U.S.P., crystals, 300-pound drums, freight equalized	3.01

Source: Oil, Paint and Drug Reporter.

Foreign Trade.—Crude iodine imported into the United States in 1970 increased 3.5 percent in quantity and 18.5 percent in value over 1969 figures. The average value of imported crude iodine rose from $1.01 per pound in 1969 to $1.15 per pound in 1970, reflecting increases in price by all suppliers. More than 5.9 million pounds of crude iodine was imported, 72 percent of which was from Japan and 27 percent from Chile. Imports of resublimed iodine were nominal as compared with imports of crude iodine.

On January 1, 1971, tariff rates were lowered from 7 to 6 cents per pound on resublimed iodine and from 17 to 15 cents per pound on potassium iodide. These reductions were part of a program to reduce the tariffs on resublimed iodine and potassium iodide to 5 and 12 cents per pound,

Table 1.—Crude iodine consumed in the United States

Products	1969			1970		
		Crude iodine consumed			Crude iodine consumed	
	Number of plants	Thousand pounds	Percent of total	Number of plants	Thousand pounds	Percent of total
Resublimed iodine	8	410	8	6	117	2
Potassium iodide	9	1,893	39	10	1,907	39
Sodium iodide	4	W	W	4	W	W
Other inorganic compounds	15	733	15	19	971	20
Organic compounds	26	1,866	38	21	1,921	39
Total	[1] 40	4,902	100	[1] 38	4,916	100

W Withheld to avoid disclosing individual company confidential data; included with "Other inorganic compounds."

[1] Nonadditive total because some plants produce more than one product.

respectively, by January 1, 1972. Crude iodine enters the United States duty free.

World Review.—*Chile.*—Production of crude iodine in 1970 was 2,750 short tons (preliminary), about 2 percent more than in 1969. The Chilean nitrate industry, which produces iodine as a byproduct, went through a 44-day strike that ended April 28. However, this did not seriously affect iodine extraction since adequate nitrate was available for processing. At yearend 1970 Chile's iodine production capacity was about 3,500 short tons per year. In view of the difficulties in selling nitrate, there were no immediate plans to expand costly iodine processing facilities.

Japan.—Japan strengthened its position as the world's foremost iodine producer during 1970. Its output of 6,497 short tons of crude iodine (5,092 tons in 1969) was approximately 2.35 times that of Chile, the only other major world producer. More than two-thirds of the Japanese production was exported, principally to the United States, which took about 2,100 short tons in 1970. Japan's other iodine markets included European Economic Community (EEC) countries, the United Kingdom, India, mainland China, and Canada.

Japan's iodine was produced from natural gas brines by six firms operating 15 plants.[3] All of the plants are located on Chiba Peninsula east of Tokyo, except one in the north, Niigata. Two plants came on stream in 1970, one in March with 660 short tons per year, and another in July with 290 tons per year. One manufacturer has a 22-mile long pipeline on Chiba to deliver brine to its processing plant.

At yearend 1970 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 70 ppm. Initially, the activated carbon process was used, and later on, the ion-exchange process. Further improved methods, developed by the Mitsui Toatsu Chemicals Co. and the Ise Chemical Industries Co., indicate that the cutoff grade can be lowered to 40 ppm. This means that gas brines of Niigata analyzing 40 to 60 ppm might well be utilized. In fact, Teikoku Oil Company, Japan's largest natural gas producer with facilities in Niigata, was considering entry into the business of iodine extraction.

Japan's iodine producers have been prosperous, paying 10 to 30 percent dividends in recent years. An export cartel called the Japan Iodine Export Corporation was organized in 1959 to control prices and tonnages. This body has been responsible for holding the price line at $1.45 per pound of iodine at yearend. Such a price may not continue too long, however, since Chilean Nitrate and Dow Chemical will both raise prices to $2.27 in early 1971. Undoubtedly, Japan will raise its price to what the world market can stand, which most likely would be slightly lower than prices set by its competitors.

The outlook for the Japanese iodine industry was particularly bright at yearend. Reserve estimates were raised severalfold, to 3 million tons of iodine in 2 billion cubic feet of natural gas. Japan's output of iodine had already risen 29 percent in 1969 and another 28 percent in 1970. Despite subsidence and pollution-control difficulties in some operations, Japanese iodine production is likely to increase considerably in the next few years, in view of the good resources available, the rising world demand, and the probability that Chilean output will remain at a stationary level. To further strengthen their supply position, the Japanese have signed a contract to produce iodine from Indonesian brines.

[3] U.S. Embassy, Tokyo, Japan. State Department Airgram A–51, Jan. 22, 1971, 3pp.

Table 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1968		1969		1970	
	Quantity	Value	Quantity	Value	Quantity	Value
Chile	2,426	$2,080	2,308	$2,215	1,585	$2,061
Germany, West	3	1	-----	-----	-----	-----
Hong Kong	-----	-----	-----	-----	70	74
Japan	3,454	3,513	3,397	3,538	4,250	4,684
Total	5,883	5,594	5,705	5,753	5,905	6,819

Technology.—Treatment of oil-well waste brines to recover iodine became more attractive from an economic viewpoint because of the presence of many valuable elements, requirements of pollution control, and higher iodine prices.[4]

Recent weather modification research has greatly increased understanding of cloud processes and the effects of various cloud seeding treatments.[5] The most significant research advancements were in simulation models and classification of cloud data. The effects of seeding, mainly with silver iodide, depend on factors like temperature, cloud nuclei present, and where and how new nuclei are added.

A process involving the use of an aqueous solution of lithium iodide-lithium bromide as the refrigerant in an absorption refrigeration system was patented.[6]

LITHIUM [7]

Domestic output of lithium minerals, including lithium carbonate from brines, increased substantially over that of 1969 and was the largest ever reported. Imports for consumption of lithium ore were about 55 percent greater than the quantity imported in 1969.

Legislation and Government Programs.—Ad valorem tariffs on lithium metal were 17 percent and on lithium compounds 7 percent during 1970; lithium mineral concentrates are imported duty free. At yearend 6,490 short tons of lithium hydroxide monohydrate were held by General Services Administration under the Federal Property Act; although a small quantity was offered for sale during 1970, none was sold.

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. Lithium carbonate was approved by the Food and Drug Administration for treatment of the manic phase of manic-depressive psychosis.

Lithium Corp. of America announced the development of a new family of butadiene resins suited for use in rubber, paints, and coatings.[8]

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	.52
Lithium chloride, anhydrous, carlots, truck loads, delivered, in drums	.87
Lithium fluoride, carlots, truck loads, delivered, in drums	1.55
Lithium hydride, carlots, truck loads, delivered	7.80
Lithium hydroxide, monohydrate, carlots, truck loads, delivered, in drums	.59
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

Foreign Trade.—Exports of lithium hydroxide during 1970 were 1,366,415 pounds valued at $614,180. Quantitative data on U.S. exports of lithium minerals and lithium metal, alloys, and other compounds were not available. U.S. imports of lithium minerals were 55 percent greater than in 1969. The Republic of South Africa sup-

[4] Collins, A. G. Finding Profits in Oil-Well Waste Waters. Chem. Eng., V. 77, No. 20, Sept. 21, 1970, pp. 165–168.
[5] Science (AAAS). Weather Modification: A Technology Coming of Age. V. 172, No. 3983, May 7, 1971, pp. 548–549.
[6] Harlowe, W. W., and W. E. Hensel. Lithium Bromide-Lithium Iodide Compositions for Absorption Refrigeration System. U.S. Pat. 3,524,815, Aug. 18, 1970.
[7] By Donald C. Wininger, physical scientist, Division of Nonmetallic Minerals.
[8] The Lithium Age. Lithium Creates New Family Of Polymer Resins. Autumn 1970, pp. 1–2.

plied 78 percent of all the mineral imports. As a result of trade sanctions, there were, for the second year, no domestic imports from Southern Rhodesia.

Imports of lithium (unspecified form) were 244 pounds valued at $764, principally from West Germany with a minor quantity from the United Kingdom.

There was 55,812 pounds of lithium compounds valued at $125,681 imported primarily from France (99.5 percent), with small amounts from the United Kingdom and West Germany.

World Review. — *Canada.* — Tantalum Mining Corporation of Canada supplied sample quantities of spodumene from their Bernic Lake deposit in Manitoba to a U.S. glassmaker for concentration.

Chile.—The Chilean government announced that large deposits of lithium and potassium salts were found in the Salar de Antacoma in Northern Chile. Reserves are estimated to be 1.2 million tons of lithium salts.[9]

Technology.—A new reverse flotation technique for concentrating spodumene was developed by the Canadian Dept. of Energy, Mines, and Resources. The process uses a commercially available surfactant that floats the gangue, leaving a tailings concentrate that contains over 6 percent lithium oxide and less than 1 percent iron. An additional benefit is that the reagent is readily biodegradable.[10]

According to several articles in the Journal of the Electrochemical Society, research continues on the use of lithium in various ways in battery and fuel-cell generation of electrical power.

[9] The Mining Journal (London). Chilean Lithium-Potassium. V. 274, No. 7036, June 26, 1970, p. 597.

[10] Chemical Week. A Commercial Surface-Active Agent Plays a Key Role. V. 107, No. 10, Sept. 2, 1970, p. 90.

Table 3.—U.S. imports for consumption of lithium ore, by country of origin and U.S. customs district

Country and customs district	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Canada:			467	$10
Buffalo	-----	---		
Pembina	200	$2	-----	---
Total	200	2	467	10
South Africa, Republic of: Baltimore	1,188	64	1,678	118
Total	1,388	66	2,145	128

Table 4.—Lithium minerals: Free world production, by countries

(Short tons)

Country[1]	Mineral produced	1968	1969	1970 p
Argentina	Not specified	140	388	e 400
Australia	do	827	795	e 820
Brazil [2]	do	------	1,709	NA
Canada [3]	Spodumene	------	200	467
Mozambique	Lepidolite	824	461	111
Rhodesia, Southern e [4]	Not specified	67,000	67,000	67,000
South Africa, Republic of	do	r 41	39	10
South-West Africa, Territory of e [5]	do	1,340	4,372	7,616
Uganda	Amblygonite	49	------	------
United States	Not specified	W	W	W

e Estimated. 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 output is unreported and general information is inadequate to make reliable estimates fo output levels.

[2] Exports.

[3] U.S. imports.

[4] Output has not been reported since 1964, but presumably has continued. Estimates given are simply the 1964 total output rounded to the nearest thousand tons, and are presented only to indicate order of magnitude, there being no assurance that the level of output has not varied (See also footnote 5). 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.

[5] Output has not been reported since 1966, but presumably has continued, inasmuch as a number of countries record imports from "South Africa" that 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 4) 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; lepidoite—365; petalite—1,344.

MEERSCHAUM [11]

U.S. demand for meerschaum continued to be supplied by imports in 1970. The quantity imported for consumption was 24,218 pounds, a 13-percent increase over that of 1969. However, a lower average unit value resulted in a 29-percent decrease in value to $29,760. Sources of the imports, as in 1969, were Turkey and the Somali Republic; the latter supplied 98 percent. Until 1969, Turkey was the major supplier of meerschaum to the United States. Exports of meerschaum in raw form for electrical insulation and exhaust gas purification have now been forbidden by Turkey.[12]

The primary domestic use of meerschaum continued to be in pipes and cigarette holders.

QUARTZ CRYSTAL [13]

Electronic-Grade

The consumption of raw quartz crystal, both natural and manufactured, declined 12 percent from that of 1969. Manufactured quartz consumption declined 21 percent. The production of finished units declined slightly.

Legislation and Government Programs.—The Government continued to maintain a stockpile objective of 320,000 pounds of electronic-grade quartz, but continued to sell excess material through the General Services Administration. At yearend the Defense Materials Inventory contained 4.66 million pounds of stockpile-grade material and 400,642 pounds of nonstockpile-grade material.

Domestic Production.—There was no known production of natural electronic-grade quartz crystal in 1970. At yearend, six companies reported production of manufactured quartz for use by the electronic 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; Thermo Dynamics Corp., Shawnee Mission, Kans.; and Western Electric Co., Inc., North Andover, Mass. These companies produced a total of 131,039 pounds of manufactured quartz, compared with 125,423 pounds in 1969. Sawyer Research Products, Inc., and Thermodynamics Corp. were the major producers.

Consumption and Uses.—Raw quartz crystal consumption declined from 187,605 pounds in 1969 to 164,941 pounds in 1970. The consumption of manufactured quartz also declined from 84,261 pounds in 1969 to 66,802 pounds in 1970. Almost 19 million finished crystal units were fabricated from the raw quartz crystal consumed during the year. The 1970 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 cut natural quartz only, 12 cut manufactured quartz only, and 12 cut both natural and manufactured.

Thirteen consumers in four States accounted for 83 percent of the raw quartz crystal consumption. Pennsylvania was the leading quartz-consuming State with 45 percent of the total, followed by Illinois, Massachusetts, and Kansas. Piezoelectric units were manufactured by 38 producers in 16 States. Sixteen of these producers worked from partially processed quartz crystal blanks and did not consume raw

[11] By Arthur C. Meisinger, industry economist, Division of Nonmetallic Minerals.
[12] What's Going On In World Mining. World Mining, V. 6, No. 9, August 1970, p. 52.
[13] By Benjamin Petkof, physical scientist, Division of Nonmetallic Minerals.

Table 5.—Salient electronic- and optical-grade quartz crystal statistics

	1968	1969	1970
Imports of electronic- and optical-grade quartz crystal			
Quantity ---------- thousand pounds--	286	237	94
Value ---------- thousands--	$339	$278	$100
Consumption of raw electronic-grade quartz crystal ---- thousand pounds--	247	188	165
Production, piezoelectric units, number ---------- thousands--	24,586	19,562	18,971

material. Thirteen plants in four States supplied nearly 75 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 held by consumers totaled 137,417 pounds. Of this total, about 93,000 pounds was natural material and the remainder was manufactured quartz.

Prices.—At yearend the Engineering and Mining Journal quoted the price of piezoelectric and optical-grade quartz crystal at $2.50 to $50 per pound. Fusing-grade quartz crystal was quoted in a range of $330 to $1,100 per ton.

The selling price of manufactured quartz ranged from $18 to $30, depending on the axial specification and the cross-sectional area of the crystal.

Foreign Trade.—Imports of electronic- and optical-grade quartz crystal (valued at more than $0.50 per pound) declined from 237,224 pounds, valued at $277,649 in 1969, to 93,920 pounds, valued at $100,210 in 1970. About 99 percent of U.S. imports was supplied by Brazil; the remainder by the Malagasy Republic and the United Kingdom.

A total of 881,759 pounds of lasca valued at $321,023 was imported, a decline of 16 percent in quantity, but an increase of 61 percent in value over that of 1969. Lasca was used to produce fused quartz and as a nutrient material for the manufacture of quartz crystal. Brazil provided almost all of the imported lasca.

The United States exported 230,698 pounds of natural quartz crystals, valued at $1,396,000 in 1970. In addition, 55,382 pounds of manufactured quartz crystals valued at $727,240 were also exported. Thus a total of 286,080 pounds of manufactured and natural quartz valued at about $2.12 million was exported in 1970, compared with 204,986 pounds valued at $2.16 million in 1969. Comparison of exports of individual classes cannot be made because individual data were not available prior to 1970.

World Review.—*Brazil.*—Exports of raw quartz crystal suitable for electronic use totaled 166,888 pounds in 1969 valued at $2.29 million. In addition, almost 8.3 million pounds of lasca, valued at $1.89 million was also exported. Both varieties of quartz were shipped to East Germany, France, West Germany, Hong Kong, Japan, the Netherlands, the United States, and the United Kingdom.

STAUROLITE [14]

Staurolite, a complex silicate of iron and aluminum, was produced commercially only in Florida as one of the products recovered from Clay County sand in the Highland and Trail Ridge plants of E. I. du Pont de Nemours & Co., Inc. Production increased both in quantity and value by 25 percent over that of 1969. The principal use was as a sand blast abrasive with minor use as an ingredient in certain portland cement mixes. In some deposits, amateur rock collectors recovered twinned crystals, "fairy crosses," as semiprecious stones.

STRONTIUM [15]

Legislation and Government Programs.—The Government sold 1,479 short tons of stockpile-grade and 2,980 short tons of nonstockpile-grade celestite during 1970. Government stockpiles contained 12,062 tons of stockpile-grade and 13,787 tons of nonstockpile-grade celestite at yearend.

Domestic Production.—For the 11th consecutive year no strontium minerals were produced in the United States. However, imports of strontium minerals were 34 percent more than those of 1969, which reflected the continuing strong rise in demand for strontium compounds. Firms that produced various compounds from imported celestite included Chemical Products Corporation, Cartersville, Ga.; E. I. du Pont de Nemours & Co., Inc., Grasselli, N.J.; Foote Mineral Co., Exton, Pa.; FMC Corp., Modesto, Calif.; and Sherwin-Williams Co., Ashtabula, Ohio.

[14] By Robert G. Clarke, physical scientist, Division of Nonmetallic Minerals.
[15] By Donald C. Wininger, physical scientist, Division of Nonmetallic Minerals.

Table 6.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1969 Short tons	1969 Value (thousands)	1970 Short tons	1970 Value (thousands)
Malagasy Republic	------	----	(2)	(2)
Mexico	21,402	$404	29,228	$589
Spain	2,252	45	3,360	69
United Kingdom	4,149	146	4,666	169
Total	27,803	595	37,254	827

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.
[2] Less than ½ unit.

Consumption and Uses.—The principal uses of strontium were in the manufacture of glass for color television tubes, for pyrotechnics and signals, and in hard-ferrite permanent magnets. Miscellaneous chemical applications for strontium compounds included greases, ceramics, plastics, medicines, paint filler, welding rod coatings, and in making high-purity zinc. In vacuum-tube manufacture, strontium metal and alloys of strontium were used as getters for the removal of gas. Quantitative information concerning consumption was not available.

Prices.—At yearend, prices quoted in the Oil, Paint and Drug Reporter were as follows: Strontium carbonate—technical, drums, works, at 13 to 21 cents per pound; strontium nitrate—bags, carlots, works, at $14 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 $22 per ton.

World Review.—*Canada.*—Kaiser Aluminum & Chemical Corp. began surface mining a large celestite ore reserve on Cape Breton Island, Nova Scotia.[16] Construction continued on the preconcentration and processing plants, which are expected to be completed early in 1971 and will produce approximately 30,000 tons of strontium compounds annually along with about 70,000 tons of byproducts.

Table 7.—Strontium minerals: Free world production, by countries
(Short tons)

Country [1]	1968	1969	1970 p
Argentina	77	14	e 15
Italy	858	1,020	931
Mexico	3,806	19,937	29,211
Pakistan	r 717	851	e 330
United Kingdom	8,695	e 8,800	e 8,800
Total	r 14,153	30,622	39,287

e Estimate. p Preliminary. r Revised.
[1] In addition to the countries listed, West Germany, Poland, Spain, and the U.S.S.R. produce strontium minerals, but information is insufficient to make reliable estimates of output levels.

WOLLASTONITE [17]

Sales of domestic wollastonite declined in 1970 to the lowest level in recent years, approximately 13 percent below the corresponding figures for 1969 in both tonnage and total value. Consumption of wollastonite in floor and wall tile, one of the principal outlets, was retarded by slackness in the construction industry. Importation of foreign tile also continued to be a significant restraint. The only active wollastonite producer in the United States in 1970 was International Pipe & Ceramics Corp. (INTERPACE), operating the Willsboro mine and a processing plant of 60,000-ton-per-year nominal capacity, in Essex County, N.Y. For the first time in more than a decade, the activities of former producers in Riverside and Inyo Counties, Calif., were described as consisting of assessment work only.

Wollastonite prices per short ton, works, quoted in Oil, Paint and Drug Reporter, March 30, 1970, and subsequent issues, were as follows: Fine, paint-grade, bags, carlots, $42.80; 10,000-pound lots or more, $46.80; medium, paint-grade, bags, carlots, $32.00; 10,000-pound lots or more, $36.00. These quotations were not notably different from those published throughout the last decade nor from the average per-ton

[16] Kaiser Aluminum & Chemical Corp. 1970 Annual Report. p. 13.
[17] By J. Robert Wells, physical scientist, Division of Nonmetallic Minerals.

values customarily reported by major producers. As usual, however, actual sales were carried out at negotiated prices not publicly disclosed.

Further exploration of deposits recently discovered in the Udaipur district of India's northwestern State of Rajasthan has revealed the existence of wollastonite resources in excess of 200 million tons. An analysis of this material, said to be typical, conforms closely to the theoretical composition of mineralogically pure wollastonite (calcium metasilicate), and the summation of the nonvolatile impurities listed is notably low for an unbeneficiated wollastonite ore.[18]

An outstanding contribution to the existing literature on industrial minerals became available early in 1970 when the Institute of Geological Sciences published a definitive, theoretical and practical treatise on wollastonite.[19]

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[18] Industrial Minerals (London). Wollastonite Deposits Very Large. No. 28, January 1970, p. 33.

[19] Andrews, R. W. Wollastonite. Institute of Geological Sciences (London), 1970, 114 pp.